

JNTBGRI

ANNUAL REPORT

2020-2021 & 2021-2022



KSCSTE - JNTBGRI
Jawaharlal Nehru Tropical Botanic Garden and Research Institute
Pacha-Palode, Karimancode P.O., Thiruvananthapuram - 695 562,
Kerala, India
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**KERALA STATE COUNCIL FOR SCIENCE TECHNOLOGY AND ENVIRONMENT -
JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN AND RESEARCH INSTITUTE**

Karimancode P.O., Pacha-Palode, Thiruvananthapuram-695 562, Kerala, India

JNTBGRI ANNUAL REPORT
2020-2021
2021-2022

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Cover photo: *Acranthera grandiflora* Bedd.

Photo by Dr. A. Nazarudeen

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From the Director's Desk

I joined as the 9th director of JNTBGRI on 1st June 2018 and I feel immensely happy in presenting this report as a testimony of the exciting performances and productive efficiency of the committed and enthusiastic researchers in recuperating the Garden system as well as the connected R & D activities performed during the periods 2020-2021 and 2021-2022. I hope that this report may provide useful leads to our activities and objectives fulfilled so far and I am fully confident that with the continued support of the Government of Kerala, guidance from the members of the Management Committee, Executive Committee and Research Advisory Committee, continued dedication of the members of the staff and generous funding from various National and International agencies, JNTBGRI can accomplish its cherished goals with very many promising research and development activities that can go a long way in the service of mankind. We are indebted to the Kerala State Council for Science, Technology and Environment and the Government of Kerala for financial support and advice meted out from time to time. Setting up of a conservatory botanic garden has reached with more than 50,000 live accessions belonging to nearly 5000 species. Assemblage and maintenance of such vast plant diversity at JNTBGRI was made possible only because of the constant and wholehearted efforts of the staff and the vision set by the former Directors. I am grateful to the present and former staff and Directors of this Institute, who have rendered expertise and professional assistance in the transformation of the Conservatory Botanic Garden in the present state. The memory of the legendary Late Prof (Dr.) A. Abraham, the founder Director and visionary of this Institute is gratefully acknowledged. Scientists, researchers, teachers, and professionals from different walks of life including the tribal people who have generously shared their knowledge and skills during the evolutionary process of this Institute is honoured.

Dr. R. Prakashkumar
Director

INTRODUCTION

KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute (KSCSTE – JNTBGRI) is a conservatory botanic garden and research institution established by the Government of Kerala which functions under the umbrella of the Kerala State Council for Science, Technology and Environment (KSCSTE). JNTBGRI is a premier autonomous R & D Centre of the Government of Kerala, established on 17 November 1979 with a broadened mission of conserving the waning tropical plant resources and species of India. Currently the Institute focusses conservation, evaluation, and sustainable utilization of India's tropical plant diversity. The Institute now works on in the thrust areas viz., Establishment of *ex situ* conservatories and Garden development, Integrated taxonomy and Conservation Biology, Sustainable Utilization, Biotechnology and Bioinformatics and Capacity Building and Training. The idea of establishing conservatory botanic garden and research institute was conceived after the first United Nations Conference on Human Environment, held in Stockholm in 1972. It was under the committed efforts by late Professor A. Abraham, the Founder Director, the Garden became a reality. It was established as an autonomous R&D organization The Kew Botanic Gardens played a significant role in the designing and lay-out of the garden in its initial stages.

DIVISION OF GARDEN MANAGEMENT, EDUCATION INFORMATION AND TRAINING

The Division of Garden Management, Education, Extension and Training of JNTBGRI, mainly deals with the development and maintenance of plant conservatories, landscapes, and displays of conservation, education, and aesthetic interest. Conservation gardens mainly focus on indigenous plants especially endemics and IUCN Red listed species, while the aesthetic and educational collections incorporate curious exotic species also. The plant germ plasm collections are enriched mainly through field explorations, purchase, and exchange with other conservatory gardens.

The Division is involved in developing conventional propagation protocols for species facing conservation threats and subsequent multiplication for eco-restoration of degraded natural habitats particularly in the Western Ghats, declining sacred groves and for the construction of new bio parks.

The Division remarkably contributes to income generation through plant sales and by promoting garden visits. It is also involved with other outreach programmes like exhibitions, consultancy in developing Bio-parks/ Botanical gardens for educational institutions and other government organization.

On par with the Plant Genetic Resource division, the garden Management Division maintains different thematic collections of conservation, educational and aesthetic interests. The twelve different themes/function-based units in the division are (i) Aquatic plants conservatory, (ii) Arboretum, (iii) Palmetum, (iv) Fernery, (v) Gymnosperms, (vi) Fruit Plants including lesser exploited indigenous species, (vii) Ornamental plants & landscapes (viii) Central nursery, sales & distribution, (ix) RET species park (x) Compost management (xi) Public relations, visitor's management & Extension activities and (xii) Labour management.

Aquatic Plants Conservatory

During the report period 58 new accessions of aquatic plants were done through field explorations, purchase, and exchange. *Crinum malabaricum* Lekhak & S. R. Yadav, the endemic aquatic plant with long strap shaped leaves, collected from its original habitat at Periya, Kasaragod, is the most curious accession in the report period. *Hydrocotyle umbellata*, *Rotala macrandra*, *Sagittaria guayanensis* subsp. *lappula* are new additions. A stunning change in aesthetic attraction of the aquatic plants collection is accomplished in the report period through the addition of the new cultivars of Lotus viz. 'Charming lip', 'First Fall', 'Amery Peony', 'Pink Cloud', 'Bucha', 'White peony', 'Green Apple', 'Ultimate 1000 petal' and 'Liang li' and Waterlilies viz. 'Julensab', 'Kohinsorn', 'Purple joy', 'Carlas sun shine', 'Tropical sunset', 'King of Sian', 'Pink Nangkwag', 'White Nangkwag' and 'Jakkapong'. Individual foam sheet labels were given to 36 numbers of plants in display tubs. Fifteen aquatic plant herbaria were processed, mounted, and deposited in the TBGT Herbarium in the given period.



Fig. 1. *Crinum malabaricum*, flowered in the Aquatic plant conservatory



Fig. 2. Water Plants Display, JNTBGRI

Arboretum

The Arboretum comprising of about 4000 trees belong to nearly 800 species, with two third indigenous of which about 150 are endemics and IUCN threatened species. Special groups viz. *Humboldtia* (6 species), *Terminalia* (7 species), *Ficus* (71 species), *Garcinia* (22 species), *Goniothalamus* (6 species) *Cynometra* (4 species), *Symplocos* (5 species), *Diospyros* (6 species) etc. and the Star tree garden of the 27 birth star trees are the collection attractions. During the report period 20 species in 688 accessions were made, out of which *Diospyros foliosa* (Rich. ex A. Gray) Bakh., *Trichilia connaroides* (Wight & Arn.) Benth., *Macadamia ternifolia* F. Muell. are new additions to the collection. 1476 nos. of indigenous tree saplings belong to 58 species including the endemic *Baccaurea courtallensis* (Wight) Müll.Arg., *Dysoxylum malabaricum* Bedd. ex C. DC., *Flacourtia montana* J. Graham, *Garcinia gummi-gutta* (L.) Roxb., *Garcinia indica* (Thouars) Choisy, *Hopea parviflora* Bedd., *Ormosia travancorica* Bedd., *Syzygium mundagam* (Bourd.) Chithra, *Vateria indica* L. were sold through the sales unit to promote *ex-situ* conservation as well as income generation. As a part of landscaping the Arboretum to give visitors accessibility from the biotechnology lab side, one 3-metre-wide food path is constructed to about 50m length. Twenty-six numbers of trees including the Critically Endangered (CR) species *Buchanania barberi* Gamble, were planted in the Arboretum during the two-year period.

Utilizing the Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) workers provided by the Peringammala Grama Panchayat a rainwater harvesting programme was done focussing the rivulet in between the face-to-face slopy terrines of the Arboretum and Palmetum. Many small ponds at the slope ending banks of the rivulet, collecting, and storing the run-off rainwater and the weir across causing stand stills to the water flow, done in the scheme, rejuvenate the waterbody that leads into the reservoir that could be depended in contingency of water shortage in summer.

Palmetum

The JNTBGRI Palmetum comprises of more than 180 species of palms and rattans, mainly exotics and about 30% indigenous species, including *Calamus* of conservation importance. Being mostly intolerant to intense heat, the plot under the forest canopy is selected for the conservatory. The pond for growing the mangrove palm, *Nypa fruticans*, the only palm species adapted to the mangrove biome, is reconstructed in an abstract outline that blend well in the natural forest atmosphere, enclosed in granite stone pieces of wavy variable heights.

The stone oil-exPELLER used in early days to extract coconut oil installed at one end of the pond turns to be a commemoration of the influential days of the palm in our tradition. The clay pot doll models did later attract children's curiosity. Miniature Amphitheatre style outdoor visitors seating place of about 100m² areas is developed in the Palmetum for arranging talks for visitors, particularly students. The floor is paved with laterite stone and a peripheral screen is made with Lady palm (*Rhapis excelsa*). Seating arrangements are done with laterite bound walls and drift woods. Among the three new accessions in the report period viz. *Areca* sp. (2 nos.), *Euterpe oleracea* Mart. (3 nos.) and *Phoenix loureiroi* Kunth (1 no.), the first two are new to the garden. About 60 numbers of field plantings were made during the South-west monsoon season 2020. About 2000 Palm seedlings including *Archontophoenix alexandrae*, *Areca triandra*, *Arenga wightii*, *Bentinckia nicobarica*, *Calamus andamanicus*, *Cyrtostachys renda*, *Dypsis lutescens*, *Licuala grandis*, *Licuala rumphii*, *Licuala spinosa*, *Livistona rotundifolia*, *Nephrosperma van-houtteanum*, *Normanbya normanbyi*, *Phoenix pusilla*, *Pinanga coronata*, *Ptychosperma macarthurii*, *Ptychosperma waitianum*, *Rhapis excelsa*, *Rhopaloblaste augusta*, *Thrinax parviflora*, *Wodyetia bifurcata* etc. were generated through seed germination, out of which 1080 were sold out through the general sales counter in the report period.



Fig. 3. Miniature Amphitheatre in the Palmetum



Fig. 4. Nypa pond, Palmetum

Fernery

Ferns and Lycophytes collection of JNTBGRI is one of the largest collections in India. Out of the nearly 275 species, more than 25 are endemics and 70 species are with IUCN Threatened status. 'Tree Ferns', 'Spleenworts', 'Club mosses', 'Whisk Fern', 'Fishbone Fern', 'Horsetail fern', 'Squirrel foot fern', 'Maidenhair fern' are the main attractions of the collection. *Ophioglossum reticulatum* which has the highest number of chromosomes of any organism known to science thrives well in the collection. During the report period 464 accessions of 116 species of ferns and lycophytes were made through field explorations. *Asplenium* sp., *Dryopteris approximata*, *Blechnum colensoi*, *Diplazium muricatum*, *Dryopsis ferruginea*, *Huperzia carinata*, *Lastreopsis tenera* are new additions. *Diplazium brachylobum*, five cultivar varieties of *Nephrolepis* and one *Phymatosorus* sp. etc. that are tolerant to grow outside were planted in the field with saplings developed through split out root sprouts. A natural style display of epiphytic ferns being fastened on raised drift woods and pockets and crevices created with big size rocks is constructed at the 10m broad west side interior of the Fernery.

Gymnosperms

Gymnosperm collection of JNTBGRI holds 43 species of 15 genera belonging to 9 families. Thrust is given to the tropical group Cycads, so that in the present collection holds 20 species including all the 3 species of *Cycas* reported from Kerala. Out of the total 10 Cycad genera 7 are represented in the collection. The lone conifer of South Indian origin, *Nageia wallichiana* with endangered status and its siblings raised by means of soft wood cuttings thrives well in the Cycad Garden. *Cupressus sempervirens* and garden cultivars *Callitris* 'Green' and *Callitris* 'Golden' were added new during the report period.

Lesser-known fruit plants

This garden unit aims at a very important mission of popularizing the indigenous edible fruits used by the ethnic and local people who traditionally depend on forests for their livelihood. The garden unit maintains about 180 species/variants fruit plants of indigenous and exotic origin. Along with popularizing the lesser exploited fruit plants, saplings of demanded fruit plants are also multiplied and selling for income generation. Through the production of pure breed vegetative saplings demanded variants through layer, bud and graft ensuring adaptability, purity of quality, early harvest and determined sex in case of dioecious, the unit could contribute a lot in income generation through plant sales. During the report period 50 new accessions were added to the mother stock, out of which 21 species/ variants are new to the collection.

Ornamental plants and landscapes

The Ornamental plants and landscapes unit deals with development and maintenance of aesthetic plants and gardens that catch the attention of the public, mainly focusing the main entrance, major roads and buildings. It also deals with the pot plant display indoor and outdoor. The Wild Ornamental plants collection with conservation interest, Cacti and other succulents, Bromeliads, Vinery of plants with varying climbing morphology, Vascular plants evolution display and aesthetical group collections like *Aglaonemas*, *Begonias*, *Caladiums*, *Peperomias*, *Dieffenbachias*, *Dracaenas*, *Jasmines*, *Marantas*, *Philodendrons* etc. are the major attraction of the Ornamental Garden. During the report period *Acalypha wilkesiana* cv., *Aglaonema* 'Soothing Snow White', *Aglaonema* 'Pink', *Aglaonema* 'Red elephant', *Aglaonema* 'Red gold', *Aglaonema* 'Red', *Alocasia reginula* 'Black velvet elephant ear', *Asplenium nidus* 'Bifurcated fronts', *Caladium andreanum* 'Autumn beauty', *Erythrina*

crista-galli, *Ixora chinensis* 'Siam ribbon', *Mandevilla boliviensis*, *Monstera adansonii*, *Murraya microphylla*, *Pandanus* cv., *Phylodendron brikin*, *Phylodendron solloum* cv., *Pinus virginiana* 'Golden Pine', *Syzygium myrtilifolium*, *Thuja koraiensis* and *Thuja standishii* were added to the plant collection. About 100 Roses planted and reared up in clay pots and displayed at the entrance. Other major pot displays arranged in the report period are Coleus (160nos.), Gladiolus (50), Pentas (50), Dahlias (200), Hydrangea (60), *Tabernaemontana* (32), *Ixora* (42), *Pentas* (60), *Canna* (10), *Bougainvillea* (110), *Croton* (64), *Hibiscus* (100) etc. Wild Ornamental Garden, the attempt to bring out the unexplored ornamental promising indigenous wild ornamental plants, concentrates on identifying aesthetic wild plants, their potential evaluation, multiplication and popularization. During the report period, 7 plant collection trips were conducted to Braemore, Ponmudi, Kallar, Aryankavu, Bonaccord, Pandipathu and added with 95 germplasm accessions and 41 herbaria. Fifteen species among them viz. *Alphonsea zeylanica*, *Argyreia fulgens*, *Elatostemma lineolatum*, *Erythroxyton acuminatum*, *Gomphostemma eriocarpon*, *Gordonia obtusa*, *Gyrinops walla*, *Henckelia gambleana*, *Lobelia nicotianifolia*, *Memecylon gracile*, *Osbeckia lawsonii*, *Phyllocephalum rangacharii* var. *agasthyamalayanum*, *Psydrax* sp., *Spondias acuminata* and *Tarenna alpestris* are new additions. *Alstonia venenata*, *Amomum muricatum*, *Artabotrys zeylanicus*, *Barleria* sp. *Croton malabaricus*, *Eranthemum capense*, *Garcinia morella*, *Ixora* sp., *Julostylis polyandra*, *Mallotus intercedens*, *Mappia foetida*, *Myristica beddomei*, *Pleurostylis opposite*, *Pterospermum reticulatum*, *Xylopia parviflora* etc. were planted in the field.

Garden Landscape works: As a part of landscaping the woodland garden in between the canteen and Bambusetum into a visitor's resting place a 3m wide pathway connecting the main office front to the Arboretum Road is constructed. Indoor stock mother plants were planted in informal groups in the tree shades. It is planned to construct rubble built base rings around selected trees that could also enact as seating place for the visitors. One compost pit is also done behind the canteen with vehicle access from the Arboretum Road (iv) About 800 m² guest house front courtyard is turfed with Korean grass.

Central nursery and plant sales unit

The unit deals with the propagation of plants for different garden sections and for sales and distribution promoting indigenous plant conservation. Propagation protocols are standardized for the indigenous, endemic, and threatened species facing regeneration hazards in the nature, subsequently multiplied and re-introduced for the restoration of the declining habitats. Hardening of the saplings developed *in-vitro* and maintenance of specimen plants for Bio-

prospecting studies in the research divisions are also done in the Central Nursery unit. Training and demonstration classes on plant propagation and nursery management are conducted for farmers, students, and domestic growers. The unit also maintains the landscape gardens in the premises of the Central Nursery. During the report period nearly 40,000 saplings were raised through seed propagation and vegetative means, so that approximately *Aglaonema* (800 nos.), *Allamanda* (1100), *Amherstia* (75), *Begonia* (800), *Bougainvillea* (1100), *Coleus* (2600), *Dracaena* (1400), Dragon fruit (450), *Hamelia* (810), *Hibiscus* (800), *Indigofera* (200), *Pentas* (850), Hanging pot plants (650), *Ixora* (1400), Jasmine (1300), *Kopsia* (900), *Nepenthes* (70), *Peperomia* (1600), *Pereskia* (800), *Philodendron* (400), Rambutan (200), Rose (720), *Selaginella* (600), *Tabernaemontana* (8600), Teak (400), *Tecoma* (200), *Zinnia* (600) etc. were propagated and reared up for garden use and for selling outside. Thousands of container display changes were made indoor and outdoor at the frontage, building premises and roadsides. Demonstration classes were given for 16 teams including students, farmers, and domestic growers during the period. A total amount of Rs.27, 59,607/- (Rupees Twenty-seven lakhs fifty-nine thousand six hundred and seven) is earned through sales of plants produced in the two garden divisions and in the commercial tissue culture unit during two financial year period.

RET Species Park

The RET Species Park is the fructification of the concept of bringing together of botanic garden objectives of *ex-situ* conservation, education, and aesthetics at the same spot. Therefore, the IUCN Red listed species, mostly trees are brought together in an aesthetically designed landscape, provided with detailed display boards convincible to common people. The project started in 2009 with MoEF&CC funding is flourishing well with about 145 species in more than one thousand and five hundred accessions through keen and dedicated routine maintenance. During the explorations to enrich the collection in the report period scientists could rediscover three critically endangered species *Dialium travancoricum* (Fabaceae), *Madhuca diplostemon* (Sapotaceae) and *Drypetes travancorica* (Euphorbiaceae) of which the latter two are located after a gap of over one hundred years.

Compost unit.

The unit functions to manage the garden generated bio-waste by producing compost, used as potting ingredient and manure for field plants. During the report period, 10 mini lorry (15

tons) loads of processed compost were supplied to other garden units for potting and manure purpose.

Visitors Management Centre

The unit arranges garden visits for students and public, guided by graduate/post graduate staff, generating botanical knowledge and conservation awareness along with entertainment. Despite of the months long closure under Covid 19 restrictions, Rs.3,84,425/- (Rupees three lakhs eighty-four thousand four hundred and twenty-five) was collected through 9811 garden visits in rest of the two-year report period 2020-22. The unit also co-ordinates the exhibitions and outreach programmes giving exposure to the institute activities. Even though the worldwide Covid 19 restrictions curbed extension activities in the early months of the report period later retained normalcy to participate all the important exhibitions organized by the government institutions and firms of public involvement.

Labour Management

Arranging the daily required labourers and skilled workers for the garden works from the existing muster roll and if the requirement exceeds the list, from the local people is the prime responsibility of the labour management unit. The labour supervisor responsibly arranges workers for holiday watering prepare and submit documents for their payment. With the co-operation of the local bodies the non-availability of sufficient members in the muster roll was overcome through arranging Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) workers. Even though the MGNREGA worker distribution was also affected with Covid 19 restrictions nearly 2000 works were arranged in the latter half of the period. Relandscaping of the Biotechnology lab side entrance of the Arboretum, construction of small ponds and weirs focussing the rivulet leading to the dam reservoir were done in the MGNREGA scheme.

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 the existing resources in the garden.

Medicinal, Aromatic & Spice Plants Unit

Ex-situ conservation of genetic resource of selected medicinal plants and assessment of intraspecific variability is an ongoing programme through which characterization of selected medicinal plants are being carried out. A tour was conducted to Eravikulam National Park, Munnar and introduced *Elettaria cardamomum*, three *Peperomia* sp. and seeds of *Ocimum* sp, and *Aristolochia* sp. Introduced *Rubia cordifolia* from Wayanad and well established in the Conservatory. Medicinally important trees like *Dysoxylum malabaricum*, *Hydnocarpus pentandra*, *Barringtonia acutangula*, *Semecarpus anacardium* and *Pterocarpus santalinus* were planted in suitable positions. The ‘Spice Corner’ is enriched with one more *Myristica fragrans* and the ‘Vinery’ by adding *Naravelia zeylanica*. The germ plasm collection of *Myristica* was enhanced to six species, by planting *M. beddomei*, *M. magnifica*, *M. trobogarii* and *M. andamanica*. Planted *Barringtonia racemosa*, *Acorus calamus*, *Lagenandra* sp. and *Crinum* sp., *Maranta* sp. and *Rotula aquatica* in Itty Achuthan Vaidyan’s Garden, *Commiphora mukul*, *Euphorbia nivula*, and *Ricinus* sp. (red) in the Succulent Garden, *Santalum album* near the entrance of the Medicinal Garden. Planted *Hedychium* sp., *Azima tetracantha*, *Jatropha curcas*, *Aristolochia indica*, *Artocarpus incisa*, *Acorus calamus*, *Rouvolfia serpentina* and *Myristica trobogarii* in pots.

Sowed the seeds of *Ocimum* sp., *Aristolochia* sp., *Datura metal*, *Clitoria ternatea*, *Indigofera tinctoria*, *Abelmoschus moschatus*, *Cymbopogon martinii*, *Gossypium herbaceum* and *Ensete superbum*. Cuttings of 17 species were planted which include *Acalypha fruticosa*, *Adhathoda vasica*, *Justicia gendarussa*, *J. zeylanica*, *Adhathoda zeylanica*, *A. beddomei*, *Lawsonia inermis*, *Ehretia* sp., *Plumbago auriculata*, *P. zeylanica*, *P. rosea*, *P. indica*, *Vitex negundo*, *Premna serratifolia*, *Azima tetracantha*, *Pogostemon heyneanus*, *Piper chaba* and *Plectranthus vetiveroides*. *Evolvulus alsinoides*, *Garcinia indica*, *Garcinia gummi-gutta*, *Dalbergia latifolia*, *Flemingea* sp., *Alstonia venenata*, *Desmodium gyrans*, *Helicteres isora*, *Aegle marmelos*, *Ocimum basilicum*, *Plumbago indica*, *Allophyllus cobbe*, *Indigofera tinctoria* and *Phrynium* sp. were transferred to pots. *Asparagus densiflorus* displayed in the main entrance of Medicinal Garden. Pruned the turf in the vinery and renovated the Ginger House. Routine maintenance of all the terraces, conservatories, nursery and field were done.

Field Gene Bank and Conservatory Garden for Andaman Flora

The Field Gene Bank for Medicinal and Aromatic Plants was established as part of the National Gene Bank for Medicinal and Aromatic Plants, a programme sponsored by Dept. of Biotechnology, Govt. of India. Now it is an ongoing plan funded programme.

Plant exploration trips were conducted to Ponmudi, Chemungi, Moozhiyar forest areas & Silent Valley National Park and introduced 52 accessions of 52 species. Herbarium specimens of 20 species were processed. 12 accessions of *Murraya koenigii* was morphologically characterized.

Different accessions of *Trichopus zeylanicus*, *Naravelia zeylanica*, *Abrus precatorius*, *Geophila reniformis*, *Adenanthera pavoniana*, *Anaphyllum wightii*, *Crotalaria retusa* and *Garcinia imbertii* were propagated through seeds. Selected accessions of 13 species including, *Plumbago zeynalica*, *Cinnamomum malabattrum*, *Rotula aquatica*, *Acorus calamus*, *Vitex negundo*, *Murraya koenigii*, *Adhatoda beddomei*, *Cissus quadrangularis*, *Tinospora cordifolia*, *Piper nigrum* ‘PMM’ & ‘PAJ’, *P. barberi*, and *P. crocatum*, were propagated through vegetative methods. As part of the multiplication of germplasm of Andaman plants, 12 species were propagated (*Calamus andamanicus*, *Parishia insignis*, *Piper betle* cv., *Podocarpus neriifolius*, *Freycinetia insignis*, *Korthalsia laciniosa*, *Endocomia macrocoma*, *Leea guineensis*, *Knema andamanica*, *Myristica andamanica*, *Eulophia andamanensis* and *Strobilanthes andamanensis*). Repotted *Cynometra iripa*, *Ochna integerrima*, *Goniothalamus malayanus* and *Ardisia littoralis*. Seedlings of *Trichopus zeylanica*, *Cinnamomum verum*, *Garcinia gummi-gutta*, *Myristica malabarica*, *Coscinium fenestratum* were transferred to polybags. Air layered accessions of *Murraya koenigii*, *Mimusops andamanensis*, *Ficus costata*, *Piper nigrum* ‘PMM’ were transferred to pots. Two accessions of *Endocomia macrocoma* planted to the Andaman plot. 12 species flowered in the Andaman field conservatory were identified. Fenced around Demonstration of Andaman Plants. Pots of Andaman plants maintained in the conservatory house were painted and 60 species were labelled using metallic boards.



Fig. 5. *Endocomia macrocoma* seedlings for supply (Andaman Plants Conservatory, JNTBGRI)



Fig. 6. *Calamus andamanicus* seedlings for supply (Andaman Plants Conservatory, JNTBGRI)

Bamboo Biology Unit

Conservation of Bamboos at JNTBGRI is an ongoing plan funded project through which the Bambusetum of the Institute is being developed and maintained. Five plant explorations were carried out, and collected 20 bamboo species, of which 6 are new additions (*Gigantochloa albociliata*, *G. auriculata*, *Dendrocalamus calostachys*, *Thyrsostachys* sp. and two unidentified spp.). The offsets of Sub-Himalayan bamboo, *Chimonobambusa callosa* collected from Kohima, Nagaland and transferred to the KFDC Wagamon Orchidarium for acclimatization. The fruiting of *Thyrsostachys* sp. and *Dendrocalamus calostachys* was observed for the first time in the Bambusetum. Mature seeds were collected and reared the seedlings. As part of the hybridization studies, 141 crosses were performed among different flowering accessions. Eight new hybrids were successfully established (*Gigantochloa albociliata* × *Bambusa balcooa*, *G. albociliata* × *Dendrocalamus stocksii*, *G. albociliata* × *Dendrocalamus* sp., *G. auriculata* × *Dendrocalamus* sp., *G. auriculata* × *D. stocksii*, *G. auriculata* × *G. albociliata*, *G. auriculata* × *B. bambos*, *B. tulda* × *G. albociliata*).

Construction of a Bamboo Craft Centre funded by Kerala State Bamboo Mission was initiated. Micropropagation protocol for the potential bamboo *Bambusa balcooa* was standardised and the plantlets reared are undergoing various stages of hardening. On the World Bamboo Day 2020, Director, JNTBGRI planted an offset of *Bambusa rangaensis* in the Bambusetum. As part of commercial propagation, 47,704 bamboo saplings were planted, and distributed 22,600 saplings among farmers, Governmental and Non-Governmental agencies and generated Rs.6,40,859/- through sales.



Fig. 7. Minister P. Rajeev visiting the stall of JNTBGRI on 19 December 2021 at Marine Drive, Ernakulam, as part of the 'Kerala Bamboo Fest 2021 (19 to 23 December 2021)



Fig. 8. Dr. R. Prakashkumar planting *Bambusa rangensis* in the Bambusetum on the World Bamboo Day 2020.

Orchid Biology/ Carnivorous Plant Unit

The Unit deals with germplasms of Orchids, Carnivorous Plants and Anthuriums. 'Establishment and Upkeep of a National Collection of Orchids' is an ongoing plan funded programme through which daily maintenance and upkeep of the orchidarium are continued. Plant collection trip was conducted to Periya, Wayanad & Eravikulam forest areas and introduced 53 species/varieties which includes Orchids, Anthuriums and Carnivorous plants. Thirty-seven plants received as exchange from GBS Periya, which include 11 carnivorous plants, 19 Anthurium plants, and 7 orchids. About 600 orchid hybrids were purchased and added to the present collection. 'Tiger Orchid' *Grammatophyllum speciosum* was in full bloom in the Orchidarium which attracted numerous visitors. To extend the display, six boxes were constructed along the side of Prof. A. Abraham Open Orchidarium and planted *G. speciosum*. *Paphiopedilum philippinense*, *Nepenthes truncata* flowered during the period in addition to regular bloomers. Hybrids of 300 orchids, 1000 *Anthuriums*, 150 *Nepenthes* and 300 *Spathoglottis* were replanted.



Fig. 9. Tiger Orchid' *Grammatophyllum speciosum* in full bloom, JNTBGRI Orchidarium

Orchid breeding is an important activity of the Unit. Seventy-four interspecific / intergeneric crosses were carried out. Ten hybrid capsules were harvested; establishment of cultures is in progress in the Tissue Culture lab. One culture produced protocorms and plants. One cross was done in *Nepenthes* using JNTBGRI hybrids. Other than routine maintenance, fertilizer application and pest management were carried out. The community pot centre was renovated.

Two Orchidara, one for native orchids for Eravikulam Park and the other for commercial orchids were designed and constructed. The former comprises 56 species under 29 genera and the latter with hybrid orchids including 100 *Cymbidium*. Field survey on native orchids and documentation was completed. A matter for the educational display boards for the interpretation centre was prepared. A handbook on 'Orchids of Eravikulam National Park, Munnar' was released. One week training on 'Orchid planting and maintenance' was offered to two Forest Protection Tribal Watchers at JNTBGRI during 9th -13th August 2021. Training imparted to 6 staff members on 'Orchid cultivation, plant care and green house management' at Eravikulam National Park during 15th -16th September 2021.



Fig. 10. Book Release – ‘Handbook on the Orchids of Eravikulam National Park’ by Dr. T. N. Seema at the Kerala Arts and Craft Village, Vellar, Kovalam (29 June 2022)

A collection of foliage *Anthuriums* was initiated as part of germplasm enrichment with a collection of 12 species/ varieties. Presently the collection holds 12 species/varieties. Breeding trials were carried out and raised about 150 plants of *Anthurium crystallinum* and 50 plants of *Anthurium clarinervium* through seeds produced by self-pollination.

‘Building up of a Conservatory for Carnivorous Plants’ is another notable ongoing programme. The conservatory holding Carnivorous plants is one of the most appreciated centres in JNTBGRI, where an array of insectivorous plants is being maintained and displayed. Ten more accessions were added to the collection among which *Drosera paradoxa*, *D. peltata* and *Heliamphora* sp. are new additions. Maintained 2500 seedlings of *Nepenthes* hybrid and initiated the sales. Carried out repotting of 900 *Nepenthes* plants.

Butterfly Garden

As butterflies are being a notable component of plant animal interaction, a Butterfly Garden is being maintained. So far 65 species of butterflies under 5 families were recorded within the site. The 'Budha Peacock' or Budhamayoori -*Papilio buddha*, the designated State Butterfly was recently located in the butterfly garden. The Butterfly Garden comprises 109 species including 23 host plants for caterpillar, 62 nectar plants and 24 species both host as well as for nectar. This includes *Zanthoxylum rhetsa*, the host plant of *Budhamayoori*. A small butterfly hatchery was established for studying the developmental stages of butterfly, where the emergence of *Chocolate albatross* and *Appia slyncida* was successfully hosted.

Tissue Culture Unit

The Tissue culture Unit of the Division is working on non-conventional propagation of selected commercially important plants as part of institute's Lab to Land Programme and generating income. Under mass multiplication programme for ornamentals, micropropagation is being carried out in 23 potential taxa comprising hybrids of *Anthurium* and Orchids such as Caesar Violet, Hawaii Orange, Dora and *Phalaenopsis* white, pink, *Dendrobium* New coyote, Airy hybrid, Burana splash, Bangkok fancy, Venus, Triple fantasy, fluorescent pink, white, Pink, *Spathoglottis* and *Rhynchostylis*.

Explants collected from Palode, Nedumangadu, Vithura, Aryanadu, Neyyattinkara, Thiruvananthapuram, Idukki, Mangalore & JNTBGRI Campus subjected for culture initiation. A total of 1,00,195 culture bottles were inoculated aseptically through specific protocols including fresh culture and subculture. During the period, 1,50,901 tissue cultured ornamental plants and bananas were deflasked and transferred for hardening. The Unit harbours about 28,216 bottles with cultures in the lab at different stages of development and 15,000 plants in the greenhouse.

As part of banana micropropagation programme, 15 cultivars such as *Nendran*, *Poovan*, Red Banana, CV Rose, *Nagapoovan*, *Matti*, *Ambalakadali*, *Grandnaine*, *Rasakadali*, *Palayancodan*, *Jawari* and *Karimkadali* were multiplied/initiated from disease free suckers. Most of them are ready for sale. With an aim to promote innovative farmers/nurserymen, a contract production facility for multiplying plants of their choice was introduced in the Unit. During the period, four growers used the facility to procure two orchid hybrids, two banana varieties, and a ginger cultivar, on payment. District Agriculture Farm, Mavelikkara, Onattukara Regional Agriculture Research Station (ORARS), Kayamkulam & Arshasree Orchid farms, Trivandrum were the major beneficiaries.

Income generated.

An income of Rs. 15,91,285 /- (Fifteen Lakh Ninety-One Thousand Two Hundred and Eighty-Five Only) generated from sales and Rs. 10,000/- (Ten Thousand Only) from training, through various units of PGR Division.

DIVISION OF BIOTECHNOLOGY AND BIOINFORMATICS

The mandate is intricately woven around spearheading ex situ conservation efforts for plant genetic diversity, with a pivotal focus on the Western Ghats region of Kerala. Simultaneously, the overarching goal is to pioneer sustainable utilization technologies, harnessing the principles of Biotechnology and Bioinformatics. These groundbreaking innovations are channelled towards the noble pursuit of enhancing societal well-being. The meticulous execution of this mandate unfolds through the seamless operation of five specialized units: Conservation Biotechnology, Bioproduction, Molecular Biology and Bioinformatics unit. Additionally, the division has undertaken the responsibilities of the Saraswathy Thangavelu Extension Centre of KSCSTE-JNTBGRI. Here, major activities include floriculture, the production and supply of planting materials and vegetable seeds, consultancy services in gardening, various plant cultivation practices, and human skill development in novel technologies, all while maintaining an ornamental garden. The overarching objective remains steadfast: to safeguard plant genetic diversity and propel the development of sustainable technologies. In doing so, the division aims to contribute significantly to the harmonious coexistence of the environment and the economic prosperity of society, achieved through the preservation and utilization of the distinctive flora of the region.

Conservation Biotechnology

Acorus calamus L. is a traditional medicinal herb distributed both in the temperate and tropical regions of India. The calamus oil, extracted mostly from the rhizome of the plant, is highly medicinal. There are many pharmacological products with *A. calamus* as an active ingredient, currently available in the Indian market. Among the 145 phyto-constituents identified in the oil, the main compounds attributed to the observed pharmacological activities are the asarone and eugenol. However, asarone exists in three isomeric forms viz., α , β and γ of which, β -asarone is the significant component as its concentration varies with the plant part as well as the ploidy of the taxa. Although β -asarone has much therapeutic potential, higher concentration of β -asarone is considered unsafe on account of its toxic and

carcinogenic property. Therefore, FDA has banned the use of calamus oil in food and therapeutic preparations. Similarly, CEFS and the European Commission has recommended the usage of only those varieties which are low in β -asarone content in the preparation of medicines, foodstuff and alcoholic beverages. The commercial utilization of this medicinal herb is dependent on the variety with low β -asarone content. Besides, no valuable report is available concerning the elite lines or development of any suitable alternative system for scale up production of plants for cultivation of elite genotype of this plant so far. The investigations in previous years identified the elite genotypes among all accessions across the Western Ghats, lowest β -asarone (1.35 mg/g) content was observed in *A. calamus* accession collected from Munnar region of Idukki District followed by accession collected from Nelliampathy region of Palakkad District with a concentration of 5.54 mg/g. An efficient in vitro regeneration protocol for mass propagation of the elite genotype(s) is standardized.

Utility of semiochemicals and exploitation of *Etilingera fenzlii*, an endemic plant species of the Andaman and Nicobar Islands in pest/insect management – *Etilingera fenzlii* is an endemic plant from Andaman Nicobar Islands which has a reported insecticidal activity that coincides with the traditional knowledge obtained from Shompen tribes who dwells the area. The 2004 tsunami caused irreparable losses in the Nicobar group of islands particularly in the Great Nicobar Islands losing many plants., taking this alarming condition under consideration, JNTBGRI has selected the plant *E. fenzlii* as one of the insular endemic species selected for conservation and bioprospecting and to portray the plant's importance. GC-EAD analysis coupled with olfactometer assays proved the plant's efficacy in tranquilizing honeybees and mosquitoes viz., *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*. The studies performed on analysing its larvicidal, pupicidal, oviposition deterrence broadcasted a mortality of the said stages in a very low concentration. These characteristics along with the less toxicity imparted by the plant's essential oil can take the study in developing a product based on its repellent trait in the previous year's study. The documented positive review made us undertake the study to analyse the plant-based products gel/aerosol/semiochemical blend efficacy in killing mosquitoes and to deliver a safe hand in achieving the target. Different phytoconstituents elucidated from GC/MS of its leaf/flower show significant GC/EAD elicitations that were constituted into a cocktail of semiochemicals which when probed for behavioural analysis of mosquitoes showed significant repellency. As an extension to the essential oil studies, accomplished different extracts of the plant for its mosquito repellency along with the behavioural study of semiochemical blend against the mosquitoes. A repellent

formula from the essential oil of plant is processed and efficacy/reliability/CPT/Outdoor-Indoor field trials are in progress.

Salacia species are potential medicinal plants with proven antidiabetic and related beneficial effects in the Indian Ayurvedic system. *Salacia* belongs to Celastraceae family, are endangered woody plants distributed throughout India and Sri Lanka. In India, they are found in the rain forest of the Western Ghats from Konkan Southwards to Kerala. This genus is represented by 21 species in India, among them eight species are recorded from the Western Ghats of India. The root, stem, and leaves of *Salacia*, (especially *S. oblonga*, *S. reticulata* and *S. chinensis*) have been extensively used in Ayurvedic medicine to treat diabetes mellitus. Besides its antidiabetic uses the plant is known for its antimutagenic, nephroprotective, antimicrobial, anti-inflammatory and antioxidant activities. The plant is known to be the best source of potential antidiabetic compounds such as, salacinol, kotalanol and mangiferin. All species of *Salacia* containing various active metabolites have been found to meet multiple targets to cure diabetes, obesity and heart disease via inhibiting α -glucosidase, pancreatic lipase, aldose reductase and modulating peroxisome proliferator-activator receptor- α / γ mediated lipogenic gene transcription, angiotensin-1 signalling, and glucose transporter 4—mediated glucose uptake. Although the multiple target regulatory activities of this unique Ayurvedic medicine have been clearly shown to be of benefit, there are several reports available for huge and consistent demand for the plant species and many pharmaceutical companies are already in search of procuring the plant in bulk quantities.

Taking this alarming condition under consideration, JNTBGRI has selected the high value species selected for conservation and bioprospecting under the financial support of Ministry of Ayush, Govt. of India and to portray the plant's importance in traditional and modern medicine. Species distribution modelling (niche modelling - ENM), the performed antidiabetic potential, screening of elite genotypes concerning potential antidiabetic compounds such as salacinol, kotalanol, and mangiferin, optimization of regeneration protocol of elite species and carrying out genome-wide transcriptome profiling, functional annotation and qPCR validation of differentially expressed genes *Salacia* species and identification of active molecules made us undertake the study to develop efficient methods to meet species' identification requirements for quality raw material source for the pharmaceutical industry.

Bioproduction Unit

In vitro secondary metabolite production involves cultivating isolated cells or tissues or organs in a controlled environment to produce organic compounds not directly involved in an organism's basic functions. The process includes cell culture, bioreactor use, and elicitation to induce metabolite production, harvesting, and purification. This method is valuable for controlled and optimized production of bioactive compounds, commonly used in pharmaceutical and biotechnological applications. The major achievement includes.

1. Accomplished enhancement of anthocyanin production in suitable *in vitro* culture system (cell / root) of *Ipomoea batatas* (L.) Lam.
2. *In vitro* regeneration studies and bio prospecting of all accessions of *Salacia* species across the Western Ghats.
3. Accomplished auxin induced root culture system in *Rubia cordifolia* L., an important medicinal plant.

To get more acceptability standardisation of hydroponic system for large scale production of root biomass and essential oil is demonstrated and its pilot scale production system standardisation is progressing.

Molecular Biology Unit

Genetic association mapping for major quantitative traits in *Centella asiatica* (L.) Urban

In the past few years, association mapping technique has been exploited for dissecting genetic architecture of complex traits in plants. This powerful technique can be used to find the association between genetic markers and traits of interest. Advancement of the sequencing technology opens the gate to high-quality and reproducible genotyping methods such as Genotyping by sequencing (GBS), which allows performing efficient genome-wide association studies (GWAS). The present study involves the identification of GBS based single nucleotide polymorphisms (SNPs) and their association with quantitative traits related to two active triterpenoids and phenotypic characters in *Centella asiatica* (L.) Urban (Apiaceae). It is one of the important medicinal plants widely used in many medicinal systems worldwide and possesses vast applications. Performing association mapping in these kinds of plants paves the way for the improvement in the medicinal plant breeding strategies and wise utilization. The present study is the first attempt on association studies in *C. asiatica*

using GBS. Accessions of *C. asiatica* from Tamil Nadu and Kerala states were collected and cultivated in an experimental field to conduct the study. Totally, 83 accessions were selected for the present investigation. Eleven quantitative traits viz. leaf length, leaf breadth, leaf area, number of leaves per node, leaf thickness, petiole length, petiole diameter, number of dentations per leaf, asiaticoside content, madecassoside content, and dry matter were estimated. Two seasonal data of the phenotypic traits from 83 accessions were subjected to analysis of variance and other genetic variance estimates indicated the presence of significant variation and good heritability. Asiaticoside and madecassoside content were quantified through HPLC showed the variation of content among the accessions. Pearson correlation among the 11 traits, showed a strong correlation among phenotypic traits except for number of leaves per node and weak correlation between phenotypic and phytochemical traits. GBS method was used to genotype the accessions and association mapping was conducted using 2168 SNPs based on phytochemical data from 80 accessions and 2170 SNPs for Season I and Season II data from 83 accessions by correlatively with quantitative traits' data. General Linear Model and Mixed Linear Model based association analyses were conducted with respect to phenotypic data from 2 seasons and phytochemical data for one season as three separate analyses. Among the studied traits, 73 QTLs were identified for three MLM and GLM analysis and seven of the traits (leaf area, asiaticoside content, leaf length, leaf breadth, leaf thickness, petiole diameter, number of dentations per leaf) have shown significant associations in the studied *C. asiatica* accessions. The identified QTLs in the present findings will support the development of markers and identification of genes that could be used in *C. asiatica* breeding programmes.



Fig. 11. Germplasm of *Centella asiatica* established at JNTBGRI.

Identification and profiling of miRNAs regulating triterpenoid biosynthetic pathway in *Centella asiatica* (L.) Urb.

Plant microRNAs (miRNAs) are 20 to 24 nucleotides small RNAs that post-transcriptionally regulate gene expression of mRNA targets. Although sufficient data is available on the identification and functions of plant miRNAs, research highlighting the role of miRNAs in the regulation of secondary metabolism in medicinal herbs has been scarce. Here, we present the profiling and characterization of the miRNAs of a high-valued medicinal plant, *Centella asiatica*. Small RNA libraries were constructed from the leaves of *C. asiatica* by using Illumina high-throughput sequencing technology. A detailed data analysis of the raw sRNAome data identified a total of 227 miRNAs belonging to 37 conserved miRNA families. Subsequent analysis from *C. asiatica* transcriptome confirmed precursor sequences of 109 potential novel miRNA candidates. The identified miRNAs were used to predict their potential roles in regulating genes involved in centelloside biosynthetic pathway specifically. In addition, several transcription factors were found to be the target of miRNAs, which suggested their role in plant growth and development. Differential expression of miRNAs in different tissues of the plant such as leaf, root and petiole were analysed using real-time PCR.

The validation of the *in-silico* predicted targets were executed through RNA ligase-mediated 5' rapid amplification of cDNA ends (RLM-RACE). Besides, a comparative analysis of various plant growth elicitors for their influence on biomass and the accumulation of triterpenoid saponins in *C. asiatica* was done using *in-vitro* multiple shoot cultures of the plant to select the most potent elicitors among them. To validate the molecular changes happening in elicitor-induced *in-vitro* conditions, gene expression analysis was carried out to find out the transcriptional changes among the miRNAs and genes which code for rate-limiting enzymes in the triterpenoid biosynthesis pathway. The outcome of this research could help understand miRNA dependent regulation of centelloside biosynthesis and to design further metabolic engineering experiments to enhance their content in this important medicinal plant.

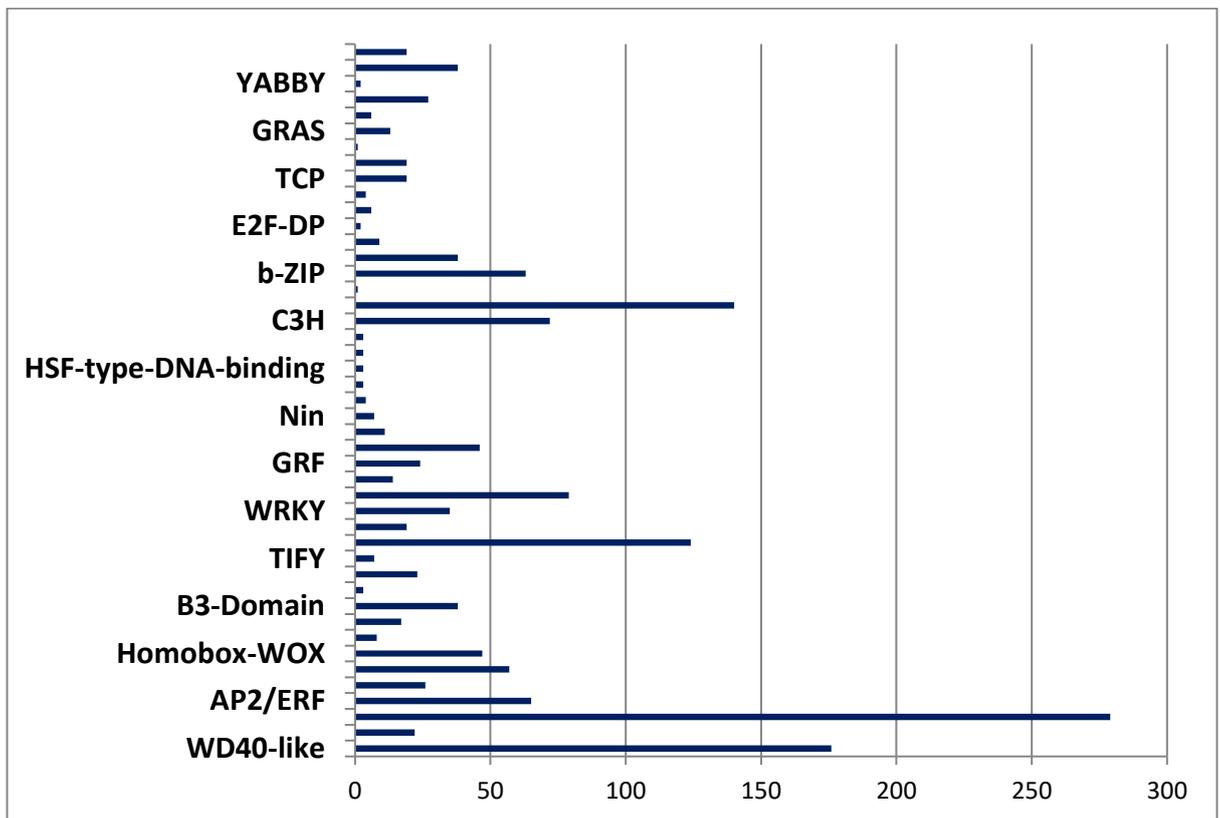


Fig. 12. Distribution of transcription factor families as miRNA targets identified in *Centella asiatica*

Population structure and genetic variability analysis of *Cullenia exarillata* populations in Western Ghats

Intra-specific molecular genetic diversity analyses of *Cullenia exarillata* from Kerala's Western Ghats region indicated limited genetic variability within populations and that there was moderate gene exchange between the populations in a district. Within all populations from all districts, there is an average genetic similarity of about 90% within districts; between districts, it is 78%. These analyses highlight the need for developing aggressive conservation strategies that should not only strive to preserve genotypes from one specific area but also numerous populations from various locales. This will be the first study to reveal the genetic diversity of the *Cullenia exarillata* population in the Western Ghats. The study will have a significant impact not just on the conservation and management of genetic diversity in the *Cullenia* population, but also on endangered species such as the lion-tailed macaque and the Nilgiri langur.

Analysis of genetic diversity, development of sex-linked SCAR markers and marker-assisted selection of Asian palmyra palm (*Borassus flabellifer* L., Arecaceae)

Forty-two young leaf samples of Palmyrah palm trees were collected from four different locations of Kerala (Palakkad) and Tamil Nadu (AC&RI - Killikulam, Sankarankovil, and Kaliyakkavilai) states of South India which will be employed for bulked segregant analysis, aiming the early identification of sex at juvenile stages. A total of 1000 primers targeting the amplification of SSRs mined from the transcriptome data (SRA acc. no. SRR5809675) were designed using WebSat. Out of 1000 primers analysed, 78 primers that showed 100% rating were shortlisted for further study. Out of 20 primers synthesized and tested in bulked DNA samples, none of the markers generated sex specific amplicons. Due to the absence of distinguishing bands among the male and female accessions using EST-SSR primers, other marker systems such as Start codon targeted (SCoT), Sequence related amplified polymorphism (SRAP), Random Amplified Polymorphic DNA (RAPD), etc were also tested. However, further screening to identify specific sex specific bands using all possible marker systems ended in vain.

Bioinformatics Centre

The Bioinformatics Centre, located at the Saraswathy Thangavelu Extension Centre of JNTBGRI in Puthenthope, Thiruvananthapuram, is dedicated to organizing biodiversity

databases for plant genetic resources and conducting bioprospecting of medicinal plants. The centre's focus includes identifying multi-targeted leads against various health challenges such as snake venom, tuberculosis, diabetes, hepatitis B, C, and D, as well as dengue viruses.

The development of software application packages and biodiversity database tools, along with meticulous data documentation, plays a crucial role in achieving these objectives. Notable accomplishments include:

Plants, Chemicals, and Therapeutics: Developed a database application package and documented details of 630 phytochemicals derived from 25 plants. URL: www.jntbgri.in/plantchemicals.

MBG-Germplasm: Developed database application tools and digitized plant resources of Malabar Botanic Garden and Institute for Plant Sciences, Kozhikode (MBG & IPS). The database provides information on 1629 accessions.

Anti-snake Venom Plants: Developed a database application package and documented data on anti-snake venom plants, including taxonomic details, mode of administration, and phytochemical lists. URL: www.jntbgri.in/antislake.

Virtual Herbarium of KU: Customized software application tools for JNTBGRI herbarium digitization, documenting 10,500 herbarium specimens of the Department of Botany, Kariavattom, University of Kerala. The project generated a total income of Rs. 5.0 lakhs towards the cost of the application package handed over to the Kerala University.

Visitors Management and Billing Tool-Version-1.5: Developed an application package for managing visitor data at JNTBGRI and for entry fee billing purposes. This standalone package is utilized by the Visitors Management Centre of JNTBGRI.

Database/Web Portal Updates: Maintained and updated various databases and web portal sites on the server, including:

Fungal database Meliolales; Wild Ornamental Plants; Endemic Plants of Western Ghats; Mushrooms of Wayanad; Germplasm of JNTBGRI; Follicolous fungi of JNTBGRI and Database on rice in Kerala

These initiatives demonstrate the Bioinformatics Centre's commitment to advancing research, cataloguing biodiversity, and contributing to the scientific community's knowledge base.

Bioprospecting in medicinal plants

***In silico* evaluation of anti-cobra venom activity in selected medicinal plants**

A total of 1357 phytochemicals derived from 21 medicinal plants (*Abelmoschus moschatus*, *Abutilon indicum*, *Acalypha hispida*, *Acanthus ilicifolius*, *Acacia nilotica*, *Aerva lanata*, *Aeschynomene indica*, *Ailanthus excelsa*, *Alangium salviifolium*, *Albizia amara*, *Alternanthera sessilis*, *Allium sativum*, *Allamanda cathartica*, *Alysicarpus monilifer*, *Anacardium occidentale*, *Anisomeles malabarica*, *Areca catechu*, *Bacopa monnieri*, *Biophytum sensitivum*, *Bixa orellana*, *Blepharis mederaspatensis*) were docked with each of the 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) and lead molecules were identified. The lead molecules with least binding energy were further analysed for drug-likeness property and ADMET property and the best lead molecules were identified. The results revealed that all the foregoing plants have potential phytomolecules with inhibitory activity on venom proteins and several compounds like β -sitosterol, α -tocopherol, lupeol, stigmasterol, ursolic acid etc can inhibit all the venom proteins tested.

***In silico* evaluation of anti-tuberculosis activity**

Completed *in silico* evaluation of anti-tuberculosis activity in ten plant species (Table 1). The selected four target proteins of *Mycobacterium tuberculosis* for the study were 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 819 phytochemicals derived from ten plant species were docked with the target proteins using the tool, Autodock Vina. Docked results were analysed based on free energy of binding (ΔG), hydrogen bond analysis and ADMET properties. The top hit molecules were subjected to Extra Precision (XP) Glide Docking and Quikprop analysis. The best lead molecules obtained among the tested plants against *Mtb* includes β -sitostiol, rutin, homoorientin, garcimangosone D, kaempferol, kaempferol-3-o-rhamnoglucoside 1,2,4-tri-o-

galloyl- β -gluco-pyranose, pomegranate, jacoumaric acid, guajavarin, and quercitrin. Isolation and characterization of these molecules from the plants is in progress.

Table 1. List of plants screened against tuberculosis through *in silico* method.

SI. No	Name of the plant	No. of phytochemicals screened	Selected targets
1	<i>Annona reticulata</i> L.	94	Ag85C, DprE1, PanK, FtsZ
2	<i>Azadirachta indica</i> A. Juss.	335	DPrE1, RmlC epimerase
3	<i>Curcuma longa</i> L.	211	DprE1
4	<i>Elettaria cardamomum</i> (L.) Maton	54	DprE1
5	<i>Garcinia mangostana</i> L.	83	Ag85C, DprE1, PanK, FtsZ
7	<i>Plectranthus vettiveroides</i> (Jacob) N. P. Singh & B. D. Sharma	42	DprE1, FtsZ, PanK, Ag85
Total phytochemicals		819	

***In silico* evaluation of anti-SARSCoV-2 activity**

A total of 2500 phytochemicals from the selected nine plants viz. *Aegle marmelos* (L.) Correa, *Ananas comosus* (L.) Merr. *Annona squamosa* L., *Artocarpus heterophyllus*, *Carica papaya* L., *Citrus limon* (L.) Osbeck, *Punica granatum*, *Syzygium aromaticum* (L.) Merr. & L. M. Perry and *Tamarindus indica* L. were used for *in silico* screening against four selected targets of SARS-CoV-2 such as Main protease (M^{pro}) (PDB id:7BUY), Spike protein (PDB id: 6M0J), RNA dependent RNA polymerase (RdRp) (PDB id:7BV2), and Angiotensin-Converting Enzyme-2 receptor (ACE2) PDB id:1R4L) using the tool AutoDockVina integrated with PyRx 8.0 version. The top ranked lead molecules based on least binding energy were further subjected to drug-likeness prediction and ADMET prediction using various *in silico* tools.

In silico analysis revealed that the molecules hesperidin, a bioflavonoid from *Carica papaya*, bicornin, a naturally occurring ellagitannin from *Syzygium aromaticum*, and cycloartomunin, a pyranoflavanoid from *Artocarpus hetrophyllus* showed promising inhibitory activity against all the four target proteins. However, hesperidin showed interaction with both the catalytic

dyads of M^{Pro} and also showed favourable ADMET properties. Therefore, hesperidin is considered the best lead molecule against SARS-CoV-2 among the selected phytochemicals.

***In silico* evaluation of anti-dengue virus activities in selected plants (P 001E)**

Screened 2001 compounds against two biological targets (DENV-NS5 & Human IMPDH2) of dengue virus and identified 39 lead compounds.

Table 2. List of plants screened against dengue virus and identified leads.

SI. No	Name of the plant	No. of Ligands	Leads against Dengue virus. (Targets: NS5 Mtase & Human IMPDH-II)
1	<i>Acacia nilotica</i> L. Delile	51	(+)-Catechin, Chlorogenic acid, Quercetin, (+)-Mollisacacidin
2	<i>Adhatoda vasica</i> (L.) Nees	45	Apigenin, Quercetin, Vasicinolone
3	<i>Aegle marmelos</i> (L). Correa	88	Quercetin, Rutin
4	<i>Anacardium occidentale</i> L.	75	Naringenin, P-Coumaric acid
5	<i>Aristolochia indica</i> L.	71	Terpenyl acetate, Ishwarol
6	<i>Averrhoa bilimbi</i> L.	38	Dihydromyrcetin,
7	<i>Azadirachta indica</i> A. Juss	335	Nimolinone
8	<i>Carica papaya</i> L.	153	Avenasterol
9	<i>Cassia fistula</i> L	70	Dihydrokaempferol
10	<i>Catharanthus roseus</i>	103	Gomaline
11	<i>Cissampelos pareira</i> L.	40	Oleanolic acid
12	<i>Citrus lemon</i> (L.) Burm. f.	85	Dihydrokaempferol, Aureusidin
13	<i>Coriandrum sativum</i> L.	56	Ellagic acid, Myristicin
14	<i>Curcuma longa</i> L.	140	Ferulic acid, Ascorbic acid
15	<i>Cymbopogon citratus</i> (DC.) Stapf	137	Betasitoterol
16	<i>Phyllanthus amarus</i> Schumach. & Thonn	80	Ursolic acid, Oleanolic acid
17	<i>Plectranthus vettiveroides</i> (Jacob) N.P. Singh & B.D. Sharma	78	Globulol
18	<i>Psidium guajava</i> L.	164	Ursolic acid, Betasitoterol
19	<i>Silybum marianum</i> L.	47	Aromadendrine
20	<i>Solanum nigrum</i> L.	40	(+)-Catechin

21	<i>Tamarindus indica</i> L	105	Epicatechin, Ascorbic acid
Total phytochemicals		2001	

Screened 1320 compounds against two biological targets (HCV-NS3-4A & HCV-NS5-RdRp) of Hepatitis C virus and identified 22 lead compounds for pharmacological evaluation.

Table 3. List of plants screened against hepatitis C virus and the identified leads.

SI. No	Name of the plant	No. of Ligands	Leads against Hepatitis C (Targets: HCV-NS3-4A & HCV-NS5 RdRp)
1	<i>Acacia nilotica</i> L.	51	Acacetin, P-coumaric acid, Quercetin
3	<i>Aegle marmelos</i> (L). Correa	88	Moupinamide
4	<i>Anacardium occidentale</i> L.	75	Leucocyanidin, Naringenin
5	<i>Aristolochia indica</i> L.	71	Ishwarol
6	<i>Averrhoa bilimbi</i> L.	38	Dihydromyrcetin,
8	<i>Carica papaya</i> L.	153	Dehydrocarpaine, Carpaine
9	<i>Cassia fistula</i> L	70	Citreorosein, Rhein
10	<i>Catharanthus roseus</i>	103	Oleanolic acid, Sitsirikine
11	<i>Cissampelos pareira</i> L.	40	Ascorbic acid
12	<i>Citrus lemon</i> (L.) Burm. f.	85	2-carboxyarabinitol, 6,7-dimethoxycoumarin
13	<i>Coriandrum sativum</i> L.	56	Ellagic acid
14	<i>Curcuma longa</i> L.	140	Isoborneol
16	<i>Phyllanthus amarus</i> Schumach. & Thonn	80	Betasitoterol
17	<i>Plectranthus vettiveroides</i> (Jacob) N. P. Singh & B. D. Sharma	78	Globulol, Caryophylleneoxide
19	<i>Silybum marianum</i> L.	47	Aromadendrine
20	<i>Solanum nigrum</i> L.	40	(+)-Catechin
21	<i>Tamarindus indica</i> L	105	Epicatechin
Total phytochemicals		1320	

Phytochemical profiling and pharmacological investigation in *Plectranthus vettiveroides* (Jacob) N. P. Singh & B. D. Sharma

The GC-MS analysis of the essential oils revealed that it is a mixture of monocyclic and bicyclic sesqui-terpenoids, polycyclic hydrocarbons and fatty acids esters. A total of 102 phytochemicals were identified by comparing with NIST database. The major identified compounds were myrtenyl acetate (17.95%) and farnesyl acetate (15.91%).

To find out anti diabetes property of the essential oil, all the phytochemicals were docked with each of the three targets proteins namely Dipeptidyl peptidase IV (DPP IV), Protein-tyrosine phosphatase 1B (PTP1B) and 11 β -hydroxysteroid dehydrogenase-1 (11 β -HSD1), which were selected based on their roles in glucose homeostasis and insulin signalling pathway to control type II diabetes mellitus. The compound bicyclo[4.4.0]dec-5-ene, 1,5-dimethyl-3-hydroxy-8-(1-methylene-2-hydroxyethyl) showed good inhibitory activity against two of the three selected target proteins, DPP IV(-6.688) and 11 β -HSD1(-8.065) and the compound 4-(2,6,6-trimethyl-cyclohex-1-enyl)-butyric acid showed inhibitory activity on PTP1B. The ADMET and drug-likeness analysis indicated that these phytochemicals can be recommended as a best lead molecule for further *in vitro* and *in vivo* studies.

Similarly, antihepatitis B activity of the phytochemical constituents was screened against the target human hepatitis B viral capsid (PDB id: 1QGT) and find out that the compound 6-(1,3-dimethyl-but-1,3-dienyl)-1,5,5-trimethyl-7-oxa-bicyclo [4.1.0] hept-2-ene have significant inhibitory activity on hepatitis B viral capsid.

Saraswathy Thangavelu Extension Centre of JNTBGRI, Puthenthope

The completion of compatibility studies among six wild orchid species (*Vanda tessellata*, *Vanda spathulata*, *Rhynchostylis retusa*, *Spathoglottis* spp. - *Spathoglottis albida*, *Spathoglottis unguiculata*, *Spathoglottis gracilis*, and *Spathoglottis plicata*), *Aerides ringens*, and *Arundina graminifolia* was completed. Produced 18 distinct varieties of vegetable seeds, which have been made available to farmers at a nominal rate through Agro Bazaar, facilitated by Kerala Agro Industrial Co-operation Ltd. Additionally, the initiative involved the production and distribution of elite varieties of coconut seedlings to farmers at affordable prices. The project also focused on the propagation of various ornamental plants, resulting in a total income of Rs. 5.0 lakhs through the sale of this products. This comprehensive effort demonstrates a successful combination of scientific research, agricultural production, and

economic support for local farmers, contributing to the advancement of horticulture and sustainable agricultural practices.

DIVISION OF CONSERVATION BIOLOGY

Conservation biology is concerned with the protection and restoration of our biodiversity. By pronouncing the importance of diversity and threats faced by coexisting organisms, conceptualizes practical approaches to reduce or eliminate threats and restore biological diversity and ecosystem health. The Division of Conservation Biology at JNTBGRI, broadly targets studies related to scarcity and prospects of diversity about the tropical biota in general and that of the Western Ghats in particular.

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

Genus *Lilium* (family Liliaceae) contains approximately 100 species of herbaceous perennials, which have been classified into 5 to 10 sections or subgenera, geographically distributed in the northern hemisphere. The importance of the genus in the world flower market is well known due to the diversity and the large number of commercially available hybrids and cultivars. However, some species are also known for medicinal and food value. *Lilium neilgherrense* 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 and human interference the lily is restricted to steep stony fragments of land. Exploitation for its large showy and scented flowers from natural habitat has largely caused its population depletion. The project focus on habitat analysis, status assessment, phenology, morphological variability, seed collection and storage and to develop propagation protocols for *L. neilgherrense*.

During the survey two populations is reported from Munnar and Wayanad in Idukki and Wayanad district respectively. The plant emerges aboveground during April-May and flowers during August-September and senescence during October-November. Population estimation and threat category assessment was conducted by establishing 100x100 m plot in Munnar. Further, ten quadrates of 1x1 m were laid in the plot. Morphological parameters (plant height,

leaf number, leaf length, flower length, bulb length and root length) of flowering individuals were sampled randomly. Plants brought from the field were maintained and observed for growth in garden. Few seeds were collected and used for preliminary germination study. We plan to collect ample seeds next year for propagation study.

***Ex-situ* conservation of five Critically Endangered plants of the Western Ghats, India**

Seed banking is one of the most effective ways to conserve plant diversity. Its practical method for preserving large amount of genetic material in a small space with minimum risk of loss. The aim of the present project is to collect and store seeds of IUCN Red Listed five Critically Endangered and endemic tree and shrubs i.e., (1) *Cinnamomum chemungianum*, (2) *Dipterocarpus bourdilloni*, (3) *Ixora johnsonii*, (4) *Syzygium travancoricum* (5) *Utleria salicifolia* from the Western Ghats. The project is supported by Botanic Gardens Conservation International, UK.

To identify the location of target species, local guidebooks, digitised colour images of herbarium specimens, and discussion with field botanists were carried out. Phenology of species (particularly flowering and fruiting) has been recorded from the literature. To conduct field work application was submitted to Kerala Forest Department. Due to Covid-19 we received permission after 8 months for forest entry. Thus, we requested one year extension to funding agency and its granted.

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

Santalum album is the second most expensive wood in the world (Rs. 300,000/kg). Sandalwood oil is commonly used for common cold, bronchitis, fever, dysentery, piles, scabies and infection of the urinary tract. The oil has been used for therapeutic effects in Ayurveda, Chinese and Tibetan medicinal system. One of the major causes of decline in populations of sandalwood has been smuggling. However, other threats identified by IUCN Red List 2018 are forest fire, grazing and most importantly exploitation of the wood for fine furniture, carving and oil. Other reasons of paucity of sandalwood are absence of adequate number of seed-bearing trees, lack of established plantations and heavy demand by the sandalwood oil factory. All these factors are responsible for the inclusion of *S. album* under

vulnerable status by IUCN Red List (IUCN 2018). The project involves seed storage and germination experiments with raising quality planting material and transplantation in natural habitat.

Seed moisture content was measured as 7.71%. To observe the impact of storage condition on viability of sandal seeds, seeds were stored in refrigerator ($4\pm^{\circ}C$) and room temperature ($30\pm^{\circ}C$). Further, the seeds were stored in airtight polythene bags and cotton gunny bags in both conditions. Among the storage conditions, seeds stored at $4\pm^{\circ}C$ (both gunny and polythene bag) remains viable up to above 20% (Gunny bag 30%, Poly bag 20%). But less than 10% stored seeds were viable at $30^{\circ}C$ after ten months of storage. During our experiments we found <1% polyembryonic (duplets) seeds in our study population. One radicle emerged 2-3 days earlier than the other and grew faster and healthy as compared to radicle emerged from monoembryonic seeds. Second (smaller) seedling from polyembryonic seed begins to degenerate, if not separated; however, survived well (albeit with low growth potential) once transplanted in a separate polybag.

Population dynamics and agroecology of *Trichopus zeylanicus* Gaerten. subsp. *travancoricus* (Bedd.) Burkil ex Narayanan – Arogyapacha

Trichopus zeylanicus subsp. *travancoricus* (Dioscoreaceae) is an ethnomedicinal herb of the southern Western Ghats, commonly known as ‘*Arogyapacha*’ or ‘*Sathankalanga*’. In Kerala the species is mainly distributed in the Agasthyamala Biosphere Reserve (ABR). During the period under report, cultivation practices were done in natural and laboratory conditions. Propagation trials were carried out with mature seeds and vegetative parts of *Arogyapacha* with different conditions. In the natural habitat seed germination percentage documented as 45- 55 %. Seed germination studies were carried out in natural as well as laboratory conditions. Natural seed germination occurs in 6-7 months after dehiscence. In the laboratory conditions, seed germination studies were carried out with pre-treated seeds. The methods adopt for germination studies are soaking (normal, cold and hot water) of seeds up to 24 hrs, seeds pre-treated with different concentrations of GA₃ (50, 100, 250, 500, 1000, 2000, 3000, 4000 and 5000 ppm). Non-treated seeds in the seed germinator took 5-6 months to germinate. Overall outcome of these experiments revealed proactive effect of 1000 ppm GA₃ pre-treatment. Seed germination trials were carried out with different soil samples (Forest

condition- Forest soil–control& Nursery soil) and Nursery condition (Nursery soil–control &Forest soil). From the studies forest soil was best which prompted further physicochemical and mycorrhizal soil factors. In vegetative propagation method the roots and stem including leaves were separated from the mother plant used for studies. Vegetative propagation trials were also carried out with different soil samples (Forest condition- Forest soil–control & Nursery soil) and Nursery condition (Nursery soil–control & Forest soil). Mainly the propagules were selected from the reproductively mature plants. By this method 60-70% of the propagules show good vigour. In large scale multiplication, the study observed some limitations in the seed germination method. *i.e.* 1. Collection of mature seeds (dehiscid seeds) from natural habitat is difficult. 2. Dormancy of the seed, delay the germination (Dormancy can break through 1000ppm GA3 treatment). 3. Slow growth of seedling (took 1-2 years attain normal plant size)

Due to these limitations vegetative propagation is the good technique for large scale production. In this method the roots and stem including leaves were separated from the mother plant used for multiplication. The site selection is very important in this case. The plant is growing in the humus soil with low light intensity. This plant grows well under the shade. Also, the distance is important for their establishment. The planting material with the space of 1 x 1 feet is better. Repeated irrigation also helps to speedy growth. After some period, the plants become stunted in growth and become reproductively inactive. To overcome these issues, simulate the soil conditions as forest soil by adding microbial supplements such as species of *Acaulospora*, *Glomous etc.*, and other soil nutrients. Also, preventive measures are to be adopted to protect the attacks from the animals. The cultivation under wide fencing area is preferred.

In connection with the People participatory Programme, one day workshop was conducted at Elavupalam, Forest Section Head Quarters for Vana Samrashana Samithi (VSS) members on 18-06-2022. Dr. R. Prakashkumar, Director, JNTBGRI, Mr. Selvaraj C, Range Officer, Kulathupuzha; Mr. Sajeev Kumar, Deputy RO, Elavupalam; Officials from Forest department, Research Scholars from JNTBGRI and 36 VSS members were participated in the Programme.

Reproductive Biology of *Humboldtia brunonis* Wallich

It is a dominant understory tree in the evergreen forest areas of Western Ghats of northern Kerala and Karnataka. This plant grows in shady moist areas between altitude 300-800 m asl and associated with trees like *Hopea parviflora*, *Syzygium luetum*, *Memecylon lawsonii* and *Litsea wightiana*. Honeybees, stingless bees, butterflies, and ants are the pollinators. Pollen, nectar, visual signals and brooding sites constitute primary rewards for the visitors. An ant *Vombisidris humboldticola* play a significant role in pollination by inhabiting the domatia. Domatia/ cauline domatia are the specialised structures formed inside the hollow stem and internodes of myrmecophytic plants, which forms a shelter for ants. Such shelter structures were reported in *H. brunonis*, as the leaves possess extra floral nectaries to attract nectar gathering ants to prevent herbivory. The plant offers both brooding site and nectar as reward for ants to act as predator or defender. *Vombisidris humboldticola* patrol for 24 hrs along the plant for extra floral nectaries. This ant species has been predominantly residing in the domatia of *H. brunonis* as they are mutually benefited.

Humboldtia brunonis possess very low percentage of fruit set in its natural habitat. Fruit development took 2-3 months from initiation to maturation. Young pods are green, which turn brown and rigid on drying. Seeds per pods varies from 3-4, brown and exalbuminous. Pre-mature fall of young fruits was noticed in some trees. Fruits are predated by Malabar giant squirrels and monkeys. Some insects may also damage the fruits during its juvenile phase; this will also affect the survival of the candidate species in their natural habitat. Nanism or natural dwarfism of seeds may also observe in some populations of *H. brunonis* located at Calicut. This may also be one of the reasons for their population reduction in its natural habitat.

Seed biology of the candidate species reveals that, the initial moisture content at the time of dehiscence was noticed as 52% and reduced to 20% at the end of one month. Seed viability test indicated that seeds with higher moisture content exhibit higher percentage of seed viability. In TTZ test the cotyledons and embryos are stained well. The seeds are recalcitrant. The mode of germination is epigeal and the percentage of seed germination was 26%.

This species is poorly distributed in the wild mainly because of its reproductive constraints such as low percentage of fruit set, recalcitrant nature of the seed, fruit predation by the monkeys and Malabar giant squirrels and infestation of fruits by insects. In this context, there is an urgent need to conserve this economically important plant from endangerment. In the

coming year, we will concentrate the detailed seed biology and conservation program of candidate species.

Reproductive biology of *Humboldtia bourdillonii* Prain

Humboldtia bourdillonii is a riparian species found along streamlets and water courses of the evergreen forest areas about 800-900 m asl. It is a medium sized tree about 25-30 m high, flushes throughout the year. But peak flowering was noticed in November to February. Mature fruits are available from March to May. In the previous year, the study mainly focused on pollination system of the species. This year the study mainly concentrated on breeding system. In *H. bourdillonii* pollen grains are light and powdery, favours anemophilous pollination. The insects were not seen in the peak period of flowering, only bees were found (*A. cerana*) visiting some flowers during morning and evening time but they do not carry out pollination.

Breeding system in *H. bourdillonii*: In open pollination (natural) 20% fruit was noticed. Bagged and emasculated flowers did not produced fruits which indicate the absence of apomictic fruit development in the candidate species. Fruit set was not observed in geitonogamy (pollination between different flowers of the same plant) and autogamy. But xenogamous pollination enhanced fruit set rate up to 36%. The above experiments showed that the species is self-incompatible. Self-incompatibility may be one of the reasons for low percentage of fruit set in the candidate species. Wind pollination seems to be inefficient in the case of *H. bourdillonii* by tracing enough pollen grains between flowers and trees and hence the low percentage of (20%) fruit set. Fruit development took 2-3 months from initiation to maturation. Young pods are crimson red, pubescent with thick sutures, which turn brown and rigid on drying. Seeds per pods varies from 3-4, brown and exalbuminous. Pre-mature fall of young fruits was noticed in some trees. Some fruits are destroyed by giant squirrels and monkeys. Dry dehiscent pods blast open dispersing the seeds besides the mother tree which indicates short distance gene flow.

Infestation of seeds: The reproductive phase of selected plant, the insects interact in two stages; one in the inflorescence stage and young fruit stage and the second at the maturation stage of fruit. Sometimes thrips colonize inside the inflorescence and multiply. They suck the juice of young fruits. Major portion of the young fruits are lost in this condition. The weevils also attacked the young fruits. It pierces the fruit wall and lay eggs in the cotyledons of

young seed. The larvae eat the cotyledons quickly and grow. At the time of seed dispersal, the adult emerges out. The peak period of seed damage by weevils was noticed in April-May. The percentage of seed germination was found to be 32.6%. The poor germination percentage of seeds may be due to the recalcitrant nature of seeds (MC 66%) and highest percentage of infestation by insect larvae. In the present study, this species is poorly distributed in the wild mainly because of self-incompatibility and lack of compatible pollen grains leading to reduced rate of cross pollination and fruit set.

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

Xanthophyllum arnottianum is an evergreen endemic tree of the southern Western Ghats and is distributed along the riparian belt of altitudes between 600-1200m MSL. The plant belongs to the family Polygalaceae and shows various morphological transition traits within and among neighbouring families. In this genus, the relationships and infra-generic classification have remained largely unresolved. Because of morphological variation, plant identification is often obscured by high inter and intra-population variation. Thus, evaluation of variation within populations is necessary for understanding the role of the plant in its ecological community. The present study focuses on how the various characterizations like phenology, morphology, reproductive biology, and genetic structure of the plant population contribute to its holistic existence.

The plant showed notable variations in morphology within and among populations. The plant identification was done using herbarium references. The study locality was selected through various collection trips to the different forest areas of the southern Western Ghats. The phenological events like leaf flushing, bud initiation, bud development, bud maturation, anthesis, etc., were studied and correlated with the climatic factors. The flower structure and its significance in pollination were also studied. The various morpho-functional adaptations of the flower are related to pollination. The plant showed autogamy as well as xenogamy. The reproductive success of the plant was checked using pollen viability tests such as the ACT, FCR, DAB, and stigma receptivity tests like the hydrogen peroxide test and DAB test. The pollen samples were assessed for viability at various developmental stages of the flower. The stigma was receptive in mature buds and showed maximum receptivity on the day of anthesis. The pollinators were identified using an insect manual and their pollination

behaviours were observed. The fruiting period was noted, and the fruits are under predation of gnawing mammals.

Breeding experiments were conducted for understanding the mating behaviour of the plant and the resulting fruit set percentage was calculated. The results were tabulated and compared. Maximum fruit set was observed under natural conditions followed by xenogamy within population and geitonogamy. The fruit set percentage was '0' in control population. More than 7% of fruit set was observed in autogamy revealing the possibility of establishing a viable population under stress condition through self-fertilization. The high percentage of xenogamy may be the result of frequent intermixing of the gametes from the same population or intra-hybridization within the population. This may be the reason for the morphological diversity existing within the population to a larger extent.

Table 4. Percentage of fruit set in breeding trials of *X. arnottianum*

Treatments		Fruit set (%)		
Type	Nature of Bagging	Population I	Population II	Population III
Autogamy (self-pollination)	Cheesecloth	10.09 ± 4.82	7.69 ± 4.98	9.81 ± 3.21
Geitonogamy (Pollination between flowers of the same plant)	Cheesecloth	12.39 ± 1.89	10.12 ± 3.08	11.76 ± 2.03
Xenogamy (within population)	Cheesecloth	30.23 ± 4.37	22.02 ± 3.29	25.21 ± 2.92
Xenogamy (between population)	Cheesecloth	7.02 ± 3.92	5.04 ± 4.23	6.88 ± 2.68
Natural (control for biotic vector)	Mesh/Net	02.32 ± 0.68	1.72 ± 0.82	02.09 ± 0.32
Natural (control for biotic and abiotic vector)	Cheesecloth	0	0	0
Natural (without any pollination barriers)	None	36.69 ± 2.47	32.51 ± 4.09	34.89 ± 3.15

The fruits were drupes with a single seed. The seeds on falling, begins to develop radicle, and the cotyledons open up exposing the emergence of plumule. The first pair of leaves shows up after 20-30 days and by the end of 45 days the seedlings attain 'four-leaves' stage. The

seedlings grow normally in its wild habitat with minimum stress and establish a local population with good percentage of seedling survival. The herbivory is prevented to a certain extent by its association with certain ant groups. The tree attains reproductive maturity after 2-3 years and begins to develop flowering shoots. The young leaves are characterized by the presence of extra floral nectaries which again act as an added advantage to attract pollinators.

Reproductive biology of *Syzygium myhendrae* (Bedd. ex Brandis) Gamble: An Endemic and Endangered species of the Western Ghats.

Myrtaceae, the Myrtle family of the order Myrtales, comprises about 130–150 genera and 5650 species. The genus *Syzygium* is characteristically trees or shrubs and glabrous in nature. Being an economically important genus, most of the species of *Syzygium* are over-exploited for their valuable compounds from parts like leaves, barks, and seeds and thereby, they are under severe threat of extinction. *Syzygium myhendrae* was located from the shola forest areas of Ponmudi, Thiruvananthapuram district, Kerala is the plant material selected for the present study. Floral visitors/ pollinators were captured by using insect traps, pan traps, bee bowls; sweep net etc. and the captured insects were identified with the help of expert consultation and insect manual. *Syzygium myhendrae* produce small white flowers which shows diurnal anthesis. Insects belonging to Hymenoptera, Diptera and Lepidoptera were trapped. GC-MS analysis of flowers was carried out and it revealed the presence of 11 compounds in the floral scent analysis which attracts these different pollinators. Nectar is present in the nectar cup and the exudates show pH of 5. The nectar volume gets reduced with a raise in sugar concentration due to the evaporation of water content in it. Flowers attract a broader spectrum of visitors that one might expect based on their syndromes and that flowers often diverge without excluding one type of pollinator in favour of another. Fruits of *Syzygium myhendrae* is globose, dark purple, juicy and crowned by persistent calyx limb at its ripened stage. The fruits are edible, and which have sweet, acidic taste with a tinge of mango flavour. The fruit nutritive analysis as per the standard protocol reveals that the fruit is rich in vitamins, carbohydrates, and protein. The study on phytochemical constituents indicated that, the trees were reported as medicinally promising. Seedling establishment of the candidate species was very difficult in *ex-situ* as well as *in-situ* trials. Illegal collection of wood for timber purpose and other commercial importance, several mature individuals of the trees were completely eradicated from the forest. In this context, the present study will help to form a base line data which is essential for the conservation of this endangered species.

Reproductive biology of *Elaeocarpus munroii* (Wight) Mast (Elaeocarpaceae) the Western Ghats Endemic.

The genus *Elaeocarpus* has more than 360 known species worldwide and is one of the largest genera of the family Elaeocarpaceae. In Peninsular India, 13 species were reported; of which 6 species are endemic to the Western Ghats. *Elaeocarpus munroii* is a tree endemic to Western Ghats and included in IUCN red list as Near Threatened. The plant flowers twice in the year. By comparing flowering season peak flowering was observed in August to October. The stony endocarp started to develop from the four months onwards. 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 arista bends back producing an apical slit. Qualitative localization of stored food shows the presence of lipids and proteins. Comparatively pollen grains contain more protein bodies. The head space analysis of floral volatile gives the major floral volatiles are Benzaldehyde and benzyl alcohol. These floral volatiles help in attracting the flies towards the flower. A single flower produced $1.40 \pm 0.24 \mu\text{L}$ of nectar with sugar concentration of 4.2 ± 0.3 brix/ μL . The HPLC analysis of nectar showed the presence of sugar constituents like sucrose, glucose, and fructose. Hence the nectar provides adequate energy for the pollinators. Fruit development starts by the end of flowering. The seed took 6-month duration for maturation. The mature seed have the moisture content about $25 \pm 1.46\%$. The TTZ test resulted in 95% of initial viability. After shedding the embryo slowly reaches a state of more active and ready to germinate. Measuring the DHA activity and conductivity indicate the same. Nearly 20 percentages of seeds germinated. In case of seed viability, the viability and moisture contents are directly proportional. The viability gradually decreased with decrease in moisture content. During the observed period the DHA activity of the seed is also declining. While conducting the breeding experiments, the plant scores more seed set-in crossing than selfing. No seed set was scored through selfing and apomixes. Sixty-nine percentage of seed set occurred through xenogamy. The seed exhibit dormancy and further physical and chemical treatments has to consider for breaking the dormancy. The dormancy breaking physical treatment such as water soaking, and scarification resulted in significant percentage of seed germination. Treating with H_2SO_4 damages the embryo.

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

Thottea is an Indo-Malayan medicinal genus of the Birthwort family Aristolochiaceae. It is represented by about 45 species worldwide. There are 14 species of *Thottea* in India, of which 10 are endemic to the peninsular India. Gynostemium in *Thottea* is a very significant and interesting feature. Here, the gynostemium is partial in nature, as it is 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.

Field studies were conducted to study the floral phenology of *T. ponmudiana* from the month of January to March. Temporal details of flower development and flower anthesis from its initiation to completion was recorded by continuous observation. The procedure was repeated for several times. Histological studies of gynostemium of *T. duchartrei*, *T. Ponmudiana* and *T. siliquosa* were carried out by taking hand sections and microtome sections. Hand sections of the gynostemium (C.S. and L.S.) were taken, stained with Safranin, observed under a trinocular microscope (ZEISS Axio Vert.A1, Germany) and photographs were taken. The C.S. and L.S. of flower were taken. The preparations were analysed with a light microscope (ZEISS Axio Vert.A1, Germany) and photomicrographs were taken. Developmental studies were carried out by analysing the SEM of the buds of *T. duchartrei*, *T. siliquosa* and *T. ponmudiana*.

Population structure and reproductive biology of *Goniothalamus wynaadensis* (Bedd.) Bedd. (Annonaceae): an Endemic tree species of Western Ghats

Goniothalamus wynaadensis (Bedd.) Bedd. (Annonaceae) is an endemic tree species of Western Ghats. Field survey and exploration trips were conducted and located the population of *Goniothalamus wynaadensis* at Thamarassery churam and Periya of Kozhikode and Wayanad districts respectively. The plant was found at an elevation ranging from 370 m asl to 750 m asl. Phenology of plant concerning flowering was observed and the data was recorded. Flowering starts in the month of December and extends up to half of February. Peak flowering lasts from mid of December to mid of January. Floral morphological studies were conducted, and measurements were taken by using a digital vernier calliper. *Goniothalamus* flowers are bisexual, hanging with tripartite perianth consisting of a trimerous

calyx and two whorls of three petals. The inner petals are apically fused with three apertures located at the base of the petal near the floral receptacle. These apertures are blocked by alternatively placed outer petals and thus forming a closed pollination chamber. The flower is protogynous with an average floral length of 20 ± 3.17 mm and width of 11.2 ± 1.17 mm. The mean number of stamens in a flower is found to be 90.14 ± 6.52 and the stigma average number is 13.86 ± 1.07 . The morphological analysis of pollen grains revealed that pollen grains are monosulcate and dehisce as tetrads. Duration of anthesis is 28 hrs. The different stages of flowering in *G. wayanadensis* are pre-receptive phase, receptive phase, interim phase, and staminate phase. The floral bud emerges as a small round bulge covered with brownish sepals. During pre-receptive phase the sepal changes from green to red colour while petals changes from green to yellow. At this stage the outer petals are found to be compressed against the inner dome blocking the aperture of the chamber preventing pollinators from accessing floral reproductive organs. During the pistillate stage, the flower produces a strong fruity scent and outer petals are spread out to expose basal apertures. Insect visitation time is found to be correlated with the time of release of floral scent. The end of the pistillate phase is known as the interim phase which is indicated by the drying of stigmatic exudate. Anther dehiscence occurs at the staminate phase along with the abscission of the corolla.

Ecological attributes such as atmospheric temperature, humidity as well as soil temperature were noted, and the data was recorded. *Goniothalamus* flowers, which are mostly pollinated by beetles, exhibit unique features of cantharophily. Flowers of *G. wyanaadensis* exhibit circadian trapping of pollinators. Assessment of floral visitors was done and identified with the help of entomologists at the Natural History Museum London. *Carpophilus* and *Urophorus* belonging to Curculionidae family were found to be the major pollinators. Insect abundance and activities on flowers were recorded. Stigmatic receptivity was assessed using hydrogen peroxide and esterase tests. When compared to other phases, the pistillate phase showed relatively strong reactivity. Pollen fertility was calculated using the acetocarmine-glycerine test. Pollen histochemistry was analysed by IKI and Sudan IV tests. Pollen viability studies were done by FCR and DAB tests. Pollen grains were mostly viable during the staminate phase. GC-MS was done to analyse floral volatiles. The compounds discovered using GC-MS analysis includes ethyl butyrate, isoamyl acetate, 2 methyl butyl acetate, and ethyl isovalerate. These chemicals give the flower its distinctive fruity odour and play an important role in pollinator attraction. Fruit initiation was observed in April, and maturation was found in November to December. Fruit is an aggregate of monocarps. Ripened fruits

were orange to red in colour. Average fruit weight was 0.9738 ± 0.0749 gm and seed weight was found to be 0.3295 ± 0.0280 gm

Reproductive Biology and Conservation of Two Endemic Balsams: *Impatiens maculata* Wight and *Impatiens elegans* Bedd. (Balsaminaceae) of the Western Ghats

The detailed studies on reproductive biology and conservation of 2 rare and endemic balsams viz., *Impatiens maculata* Wight and *Impatiens elegans* Bedd. were carried out during the period from July 2021 to January 2022. The present study has been conducted in the shady area of Mankulam, Idukki District where enough populations of candidate species were located. Seven populations (2115 plants) of *Impatiens maculata* and two populations (200 plants) of *Impatiens elegans* were selected for the present investigation. Twenty healthy plants were selected from each population and observations were made on day-to-day basis on flowering phenology which includes flowering season, flower initiation and development, anthesis and anther dehiscence. Floral morphology was studied by using a hand lens and dissecting microscope.

Impatiens maculata starts flowering in the second week of July and extends up to December with maximum bloom in September. Flower bud takes 5-8 days from initiation to full bloom and total flowering days extends up to 160 days in a year. The average life span of each flower is from full bloom to drooping stage is 2-3 days only. Each plant produces 3-5 inflorescences, and each inflorescence produces 3-10 flowers. Flowers are in terminal and axial racemes and an average length of inflorescence is 12cm. Anthesis commenced between 05.00-07.30h. Anther dehiscence was observed one day before anthesis, which in turn confirmed the protandrous condition of the flower. Each flower measures an average length of 2.5 cm. Flowers are pink, lateral sepals ovate, large lip conic; spur slender, curved upwards with an average measurement of 4.5 cm. Standard petals are orbicular and acuminate. Wings are 2-lobed, basal lobe minute, distal lobe sub-orbicular and larger. Fruit is a capsule which is ellipsoid, beaked with an average length of 8mm. Pollen grains are round and an average of 68 ± 26.34 μm in diameter. The acetocarmine staining technique revealed that 74% of the pollen grains were fertile. Pollen viability by FCR and IKI test indicated that 68-72% pollen grains are viable on the day of anthesis, and its viability gradually decreased on successive days after anthesis.

Impatiens elegans starts flowering in the second week of July and extends up to December with maximum bloom in September. The flower buds take 7-12 days from initiation to full

bloom. The average life span of each flower is 2-3 days. The plants were in flower for a total of 180 days in a year. Anthesis commenced between 05.30-07.30h. Anther dehiscence was observed one day before anthesis, which in turn confirmed the protandrous condition of the flower. Flowers with an average length of 3cm, in axillary or terminal racemes or umbels. Flowers are pale rose with a purple eye. Lateral sepals ovate, lip cymbiform, small; spur absent. Standard orbicular-ovate, apiculate with a ridge on dorsal side. Wings 2-lobed; basal lobe small, rounded, vaulting over stamens. Distal lobe larger, obliquely ovate, acute, Fruits are capsules ellipsoid, beaked with an average length of 1.3 cm, turgid in middle; seeds sub globose, hairy. Pollen grains are round and an average of $73 \pm 28.34 \mu\text{m}$ in diameter. The acetocarmine staining technique revealed that 82% of the pollen grains were fertile. Pollen viability by FCR and IKI test indicated that 74-78% pollen grains are viable on the day of anthesis, and its viability gradually decreased on successive days after anthesis.

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

Humboldtia unijuga Bedd. var. *trijuga* J. Joseph & Chandras. is a small tree of Leguminosae (Ceasalpinioideae) highly restricted to the southern Western Ghats region and is of medicinally and potentially important ornamental tree. The main objectives of this SERB, Govt of India sponsored project are to study the spatial distribution, population structure and dynamics, study the genetic variation among and within populations employing molecular markers and to address the conservation issues related to seed set, recruitment, biotic and abiotic interactions and seed biology. During the period, 16 field trips were conducted to study sites of Agasthyamala biosphere reserves and area of occupancy was found out. This endemic species occupied an area of 0.0742 km² in Chemunji and 0.0405 km² in Bonacaud. Studied the population and phytosociological parameters of this candidate species. Soil characters were also studied. As part of biotic interactions, phylloplane fungal flora of this species was studied and recorded four species of fungi such as *Lembosia humboldticola*, *Hansfordiellopsis lichenicola*, *Prillieuxina* sp. and *Spiropes* sp. For genetic diversity study 33 samples from each study sites viz. Chemmunji, Bonacaud and Koviltherimala were collected. The DNA extraction and ISSR analysis is progressing.

As part of *ex situ* conservation, conventional propagation techniques such as stem cuttings and air layering techniques were carried. For air layering randomly selected 28 shoots (shoot

with 5-7 cm thickness) from 16 different mature trees were selected. About 5 cm bark and phloem removed as a ring with a sharp knife. These shoots were covered with 1:1 ratio of coco peat and moist sphagnum moss and applied different concentrations of IAA (250ppm, 500ppm, 1000ppm and 1500ppm) for the initiation of rooting and wrapped with polythene tape and thread. They were observed for 6 months for the rooting. It showed 32% success using 500ppm IAA. Stem cuttings treated with 1000ppm IAA showed 22% success. Even though, they produced few seeds, seed germination is normal and epigeal. Mature seeds have moisture content of 56%. Germination studies showed that 58% of seeds germinated in seed germinator condition (28°C, 80 RH). It took 21 to 27 days for germination. Those which are sowed in the soil, 7 seeds germinated after 39 days (70%). Seeds are recalcitrant. One of the major observations on germination revealed that only fully mature brown seeds germinated. Almost all the seeds were predated by arboreal animals during mature stage while some infected by insect larvae.

Reproductive biology of *Goniothalamus keralensis* ESS Kumar et al.

Goniothalamus keralensis is an endemic species of Annonaceae family. It is restricted to three sites of Idukki district and survived with less than 200 plants. It is a wild relative of medicinally important *Goniothalamus* species. As part of conservation aspects of this species, we studied the phenology and floral morphology of this species. Detailed vegetative and reproductive phenological observations were carried out in one population at Valara. Leaf flushing initiated in May and continued up to August. Flower buds initiated in mid – October and continues up to January. A flower bud took about 45 to 50 days to become a flower. Fruit set was recorded from December to April. Flowers are large and borne on leaf axis or cauliflorous. They are solitary and possess trimerous calyx with two whorls of petals. Inner petals are fused apically and form pollination chamber. Flowers are bisexual and protogynous. Flowers pass through characteristic pistillate and staminate stages. Fruits are berry and are green change to orange on ripening. Each fruit contain a single seed. Further works on pollination, pollen viability, seed germination etc. is progressing.

Systematics and conservation of natural populations of *Phyllanthus emblica* L. (Amla) in the southern Western Ghats

The Indian gooseberry or amla (*Phyllanthus emblica* L.) has several culinary and medicinal uses. They are the treasure trove of ascorbic acid- the vitamin C. Naturally there are different variants, differ in terms of taste, size, colour differences, and texture of flesh. Even though,

we use many hybrid varieties for culinary purpose, traditional medicinal sector rely heavily on our wild fruits. Due to habitat destruction coupled with over exploitation in an unscientific manner, this highly sought medicinal tree is facing a constant threat of extinction. The present research programme aims to characterize different forms of Indian gooseberry growing naturally in the southern Western Ghats through morphological, phytochemical, and molecular techniques and to find plus trees and their conservation and popularisation.

Seed biological study of Kerala Flora

As part of the above programme seed germination and storage studies of the following species were carried out:

- a. *Antidesma montanum* Blume: It is an evergreen tree of Peninsular India with poor seed germination. Effect of desiccation and storage at different conditions ranging from -10 to 30°C for short term of one week and at -4°C for long term of more than 36 months without losing seed viability was determined. The dormancy type was confirmed as non-deep physiological dormancy since germination percentage was increased by cold storage. The collected data were published in the International Journal of Research and Analytical Reviews (IJRAR).
- b. *Memecylon macrocarpum* Thwaites: *Memecylon macrocarpum* (Melastomataceae) is a small tree/ large shrub found as rare undergrowth in low elevation wet evergreen forests, ca. 600 m. Its fruits are globose-oblong berries, deep violet coloured having 16.74 ± 0.5 mm length, 15.4 ± 0.3 mm breadth, 14.25 ± 0.29 mm thickness and 2.04 ± 0.28 gm weight, single seeded. Seeds are globose- sub globose, smooth, brown coloured with cream patches having 10.69 ± 0.39 mm length, 12.4 ± 0.27 mm breadth and 0.85 ± 0.04 gm weight. Initial moisture content recorded as 18.31 ± 0.5 % with 85 ± 1.3 % germination percentage. Seedlings given to systematic garden for field enrichment.
- c. *Putranjiva roxburghi* Wall.: *Putranjiva roxburghii* is an ever-green tree generally grows on alluvial soil along the rivers, swamp, or evergreen forests. The tree prefers moist evergreen forests. In drier places, tree has stunted growth. Flowering and fruiting March-August. Drupes are velvety, white, ellipsoid to rounded, single seeded, with persistent calyx. The germination of seeds takes place during rainy season. Seeds are hard rugose pointed stones. Initial moisture content was 22.31 ± 0.7 % with $65 \pm$

0.9 % germination percentage. Seedlings given to medicinal garden for field enrichment.

- d. *Humboldtia vahliana* Wight: Is an endemic tree of Western Ghats usually found along streams or in swamps around low elevation evergreen forests generally up to 700 m. Fruits of *H. vahliana* are long light brown villous flat thin pod, 15-20 x 3.7-6 cm, elliptic and compressed. Sutures thick valves prominently veined and tomentose having 17.5 ± 0.9 cm length, 4.9 ± 1.2 cm breadth, and 33.93 ± 2.1 gm wight. Seeds 4-6, ovoid-elliptical, smooth, glabrous, surface with small striations having 23.52 ± 0.5 mm length, 19.13 ± 1.3 mm breadth, 9.65 ± 0.6 mm thickness and 9.67 gm weight. Fresh seeds with $58.2 \pm 1.9\%$ moisture content registered $90 \pm 0.8\%$ germination that started after 7 days of sowing and completed within 16 days, so there is no dormancy in this species even though the germination is slightly sporadic. When seeds are subjected to slow desiccation, moisture content reduced to $54.8 \pm 1.5\%$ with $83 \pm 1\%$ germination within 2 days and germination percentage was further reduced to 65 ± 2 on 5 days of desiccation. Within 15 days viability was completely lost ($30 \pm 0.2\%$) with $39 \pm 1.1\%$ moisture content. During fast desiccation, loss of viability is more rapid, and moisture content reduced to 50.5 ± 0.4 within one hour and corresponding germination percentage became 65 ± 0.5 . Within one day germination percentage reduced to 30 ± 1.3 with 40.2 ± 2.15 moisture content. The seeds were found to be desiccation sensitive, and that 10% reduction of moisture content decreased seed viability considerably. During fast desiccation seeds lost their viability within one day and therefore seeds are found to be recalcitrant. When both fresh and desiccated seeds were stored hermetically for one week at various temperatures (30, 20, 10, -10, and -20°C) to test the effect of moisture content and temperature on germination, after one week maximum germination was observed in fresh seeds which are stored in 30°C, followed by seeds stored in 20°C. Desiccated seeds up to $51.5 \pm 1.8\%$ moisture content retained only $50.5 \pm 0.6\%$ viability in 30°C. Both fresh and desiccated seeds lost their viability in low temperatures. Seeds start to decay in low temperatures after one week. Seeds were found to be chilling sensitive and this further confirmed the recalcitrant nature of seeds.

For extending the viability of seeds fresh surface dried seeds were hermetically stored in polycarbonate bottles and were kept in laboratory conditions ($28 \pm 2^\circ\text{C}/70\% \text{RH}$). When germination percentage was tested, three months stored seeds retained $65 \pm 0.9\%$ viability. Here, the seed viability retained up to $53 \pm 1.6\%$ for four months,

while in open laboratory conditions ($28 \pm 2^{\circ}\text{C}/70\% \text{ RH}$) seeds lost viability within 15 days ($30 \pm 02\%$).

Along with above studies seed germination study of the endemic and endangered species *Diospyros foliosa* (Rich. ex A. Gray) Bakh. (Ebenaceae), *Madhuca diplostemon* (C. B. Clarke) P. Royen (Sapotaceae), *Madhuca neriifolia* (Moon) H. J. Lam. (Sapotaceae) and *Memecylon gracile* Bedd. (Melastomataceae) were also documented.

Seedling studies in South Indian *Rauvolfia* species: Seedling morphology, especially the cotyledonary and eopyll features of five *Rauvolfia* species viz., *Rauvolfia hookeri* Srinivas. et Chithra, *Rauvolfia micrantha* Hook.f., *Rauvolfia serpentina* (L.) Benth. ex Kurz, *Rauvolfia tetraphylla* L. and *Rauvolfia verticillata* (Lour) Baill., were documented. Based on the documented seedling characters, especially, shape, size, and venation of cotyledons and mesophylls a key for the identification of seedlings of *Rauvolfia* was proposed. Observations revealed that all species showed differences with most of the characters apart from some commonness which would help in their ex-situ and in situ conservation.

Regulation mechanism of seed germination in selected species of the genus *Myristica* Gronov. (Myristicaceae) in Kerala: The effect of plant growth regulators was studied through pre-soaking of the seeds in six different concentration of plant growth regulators viz. IBA, ABA, and GA_3 . The effectiveness of Panchagavya on seed germination is also be studied. Seeds pre-soaked in distilled water were taken as control treatment. The seeds were kept in seed germinator without light ($30 \pm 2^{\circ}\text{C}$, 80 % RH). The results showed that pre-soaking of seeds with IBA at concentration of 20 ppm is very effective in inducing seed germination in *Myristica malabarica*, *M. fragrans* and *M. magnifica*. But the effective concentration of IBA for *M. beddomei* was 50 ppm. The seeds soaked in GA_3 and Panchagavya showed maximum germinability at concentration of 200 ppm, and 8% respectively in *Myristica malabarica*, *M. fragrans* and *M. magnifica*. The corresponding seed germination inducing concentration of these growth regulators in the case of *M. beddomei* was recorded as 500ppm and 10%. The Mean Germination Value (MGV) was also highest in this concentration (Czabator, 1962). Soaking with ABA has shown delayed and very poor rate of germination at lower concentration (2 ppm) and total loss of viability at medium and higher concentration. All experiments were statistically analysed by one way ANOVA and the values are expressed as mean \pm standard error [LSD ($P < 0.05$)]. Hence, pre-soaking of seeds with IBA/ GA_3 / Panchagavya at concentration of 20 ppm, 200 ppm, and 8%

respectively could be suggested as an effective method for improving the seed germinability and MGV of *Myristica malabarica*, *M. fragrans* and *M. magnifica*. It is 500 ppm and 10% respectively in the case of *M. beddomei*.

Optimisation of seed storage conditions of *Myristica malabarica*: Fresh seeds of *M. malabarica* were stored in three treatments (T) with different temperatures and relative humidity (RH) such as T1 (10±2 °C and 25 % RH), T2 (18±2 °C and 50 % RH) and T3 (10±2 °C and 80 % RH). The viability of the seed was lost after 15 days of storage (DAS) in T1 and T3 conditions, while T2 treatment was effective to extends the seed viability to 60 more days. Seed viability was tested by various parameters like seed germination, electrolyte conductivity, Total Dissolved Solutes (TDS), Dehydrogenase activity (DHA) and the levels of phenolic compounds and proline amino acid in the embryonal axis. All experiments were statistically analysed by one way ANOVA and the values expressed as mean ± standard error [LSD (P < 0.05)]. From the results, it is concluded that the seed viability period of *M. malabarica* can be extended to 60 more days under the optimal storage conditions of 18±2 °C temperature and 50 % RH.

Conservation strategies and screening of bioactive molecules in *Connarus wightii* Hook.f. (Connaraceae), an endemic species of Western Ghats: The species *Connarus wightii* belonging to the family Connaraceae is endemic to Western Ghats. Morphological and phenological parameters were evaluated. They are large climbing shrubs. Leaflets 15 cm, elliptic-oblong, abruptly acuminate, rounded at base; nerves 5 or 6 pairs, reticulate; petiole 6 mm long, transversally rugose. Panicle 18 cm, axillary on old branches. Flowers sub sessile, few-together; sepals 2.5 mm long, hispid; petals 4.5 mm, oblanceolate, puberulous outside; filaments unequal; fertile one 2 mm long; ovary densely hairy. Ovary 5,4 imperfect. Seed germination studies going on. Seed is viable but survival rate is very low. Aril part of the fruit is edible so people in the vicinity of this plant eat this fruit. For phytochemical investigation both leaf and bark extract were used whereas only leaves are used to find out the antioxidant, antibacterial and hepato-protective activities. The anti-inflammatory and anti-cancerous properties of the ethanolic extracts were evaluated. Preliminary phytochemical analysis revealed the presence of different groups of bioactive compounds such as alkaloids, flavonoids, phenol, tannin cardiac glycosides, fat and oil, steroids saponin, coumarins, phlobatannin, proteins, carbohydrates triterpenes in the leaf and bark extracts using different solvents. Among them methanolic extract yielded most phyto-constituents. Nutritional

analysis revealed the fruits of *Connraus wightii* are rich source of various nutrients such as vitamin C, protein, carbohydrate, Vitamin B1. The mineral analysis identified the presence of various macro and micro elements including magnesium, sodium, calcium, phosphorous, Iron. The characteristic colour of the fruits is due to the presence of carotenoids and lycopene in the fruits.

Seed Physiological studies of *Bentinckia condapanna* Berry ex Roxb., a rare endemic tree palm of Southern Western Ghats: *Bentinckia condapanna* Berry ex Roxb. (Arecaceae), commonly known as ‘Bentinckia palm’, or ‘Kantha Kamung’, is narrow endemic with limited distribution in the evergreen forests of southern Western Ghats at an altitude of 1,000- 1,800 MSL. The ecologically significant palm grows up to 15-20m height in the slopes of inaccessible steep rocky cliffs. The sparse crown of arching pinnate leaves bears unisexual flowers. The female flowers develop into red coloured one seeded fruit. This niche specific palm has been categorised vulnerable by the IUCN Red List Database. With immense ecological service and cultural role in the Kani tribe, the conservation and restoration of the species is of prime significance. Seed being the sole mode of propagation, the first step towards restoration is understanding its seed biology. The palm seeds, which are exposed to adverse temperature shifts during its development in the natural habitat, might be a distinct candidate in the palm seed category. Seeds are characterised by low germination rate and prolonged dormancy. Flowering and fruiting phenology and ecology of the palm species are also being investigated along with the seed biology events like desiccation, germination and priming of mature seed samples. The antioxidant study, the biochemical analysis and germination study conducted in the developing seed stages indicate the peculiar seed behaviour. The pattern of antioxidant enzyme activity points to the active oxygen species generated by dry matter accumulation during the seed maturation. Desiccation biochemical information is a vital base for the elucidation of seed physiology and metabolism. However, no data regarding biochemical profile of Kantha Kamug seed desiccation has been reported so far. The sugar, metabolome, and fatty acid composition of the palm seeds during desiccation stage was investigated against the matured seed sample. Remarkable changes in the sugar, metabolome and fatty acid composition of the desiccated stage indicated that the seeds were tolerant to desiccation mechanism.

Seed physiology of *Gymnacranthera canarica* (King) Warb., a rare endemic tree species of southern Western Ghats: *G. canarica* is a rare and threatened vulnerable tree species distributed in the swampy forests of Kerala and Karnataka and habitat destruction is considered as the major threat for this species. The present study covers the phenology and seed development study, identifying the seed storage behaviour by seed desiccation and seed storage, seed dormancy, biochemical characterization of seeds from development to germination and restoration of seedlings. Seed storage behaviour based on dehydration study evidenced that *G. canarica* is truly a recalcitrant seeded species. Normally, *G. canarica* seeds took 45 -55 days for germination indicating some kind of seed dormancy and seed dormancy in recalcitrant seeds are rare. The hydro priming treatments and manual scarification of seeds shows *G. canarica* do not shows any physical dormancy. The chemical pretreatment of seeds with Osmo priming and halo priming could not break seed dormancy but higher concentration of K_2HPO_4 (3% for 24 hours) treatment increased the germination from 34.55% (control) to 92.33%. The seeds treated with phytohormone gibberellic acid 100 ppm for 24 hrs gave 100% germination with mean germination time of 25.71 days. Increased concentration of GA_3 (500 ppm) had an inhibitory effect on seed germination and GP (26.33%) were lower than those of control seeds. The effect of warm stratification on the phenology of *G. canarica* shows the embryo growth and the E:S ratio of freshly harvested seeds was 0.19 increased to a maximum of 0.32 after five days of warm stratification (25-28°C). Thus, *G. canarica* seeds show physiological dormancy and embryo immaturity at the time of shedding from mother plant and for successive germination, seeds required warm stratification for 5 days and the moisture content become 19%. The phytohormonal content of *G. canarica* seeds (fresh and desiccated to 19% mc) were analysed through LC-MS/MS analysis and found 6 hormones -Indole-3-acetic acid, Gibberellic acid, Cytokinin, Salicylic acid, Abscisic acid and Jasmonic acid. The retention time of IAA, GA_3 , CK, SA, ABA and JA in the samples are 4.95, 3.05, 1.71, 2.44, 2.48 and 2.78 respectively. The quantification of phytohormones showed that maximal endogenous levels of analysed compounds in desiccated and non-desiccated *G. canarica* seeds shows ABA is the most abundant phytohormone in non-desiccated seeds 1172.09 ± 24.36 ng/g and the gibberellic acid content was 116.32 ± 1.35 ng/g. The dehydration through open desiccation decreased the ABA content to 519.18 ng/g and increased the GA_3 content 832.45 ng/g. The *G. canarica* seed desiccation decreased all the phytohormone endogenous levels except the gibberellic acid. Metabolite profiling of *G. canarica* seeds during desiccation revealed changes in the content of flavonoids, sugar alcohols, fatty acids, organic acids and amino acids. The most prominent

compound in both non desiccated and desiccated *G. canarica* seeds is Genistein, a polyphenolic isoflavone that belongs to the flavonoid group. Desiccation period was associated with a major switch in seed metabolism. Desiccation causes an increase in level of most metabolites, amino acids, sugars (except raffinose), organic acids (except for TCA intermediates) and slight increase in fatty acids.

Seed Bank activities:

Seed accessions (both active and reference collection) stored in the seed bank are alphabetically arranged for their easy retrieval for future use. Now 2700 accessions are maintained with 298 genera, 418 species in 101 families. During the period 324 accessions were collected and added to the active collection. They include 200 species, 164 genera, which include 8 new, 18 endemic and 12 endangered. A total of 115 properly labelled bottles were maintained and displayed in the seed bank for educational and exhibition purpose. Seed collection trips were conducted to different sites including Ponmudi, Chemungi, and Bonaccord, collected 33 species. Seeds were displayed in newly added seed display bottles for exhibition purpose.

During the period, following 10 species from 8 families were stored in the seed bank as base collection: *Elaeocarpus serratus* L. (Elaeocarpaceae), *Caesalpinia sappan* L. (Fabaceae), *Mimusops elengi* L. (Sapotaceae), *Aegle marmelos* ((L.) Correa (Rutaceae), *Caesalpinia pulcherrima* (L.) Swartz. (Fabaceae), *Clitoria ternatea* L. (Fabaceae), *Aristolochia indica* L. (Aristolochiaceae), *Terminalia elliptica* Willd. (Combretaceae), *Caryota urens* L. (Arecaceae), *Adenantha pavonina* L. (Fabaceae), *Calamus brandisii* Becc. ex Becc. & Gook. f. (Arecaceae) and *Thespesia lampas* (Cav.) Dalz & Gibs. (Malvaceae). Also, the seeds of following species received from J. S. Ayurveda Mahavidyalaya Gujarat were kept as reference collections: *Carthamus tinctorius* L. (Asteraceae), *Cassia senna* L. (Caesalpinaceae), *Cichorium intybus* L. (Asteraceae), *Convolvulus pluricaulis* Forssk. (Convolvulaceae), *Ocimum basilicum* L. (Lamiaceae), *Saraca indica* L. (Caesalpinaceae), *Sesbania grandiflora* (L.) Poirr. var. *jayanthi* (Fabaceae), *Sida rhombifolia* L. (Malvaceae) and *Uraria picta* (Jacq.) DC (Papilionaceae).

Extension activities: Seeds of 10 species (*Abelmoschus moschatus* Medik. (Malvaceae), *Anisomeles malabarica* (L.) R. Br. ex Sims. (Lamiaceae), *Ensete superbum* (Roxb.) Cheesman. (Musaceae), *Holostemma ada-kodien* Schult. (Asclepiaceae), *Mallotus philippensis* (Lam.) Muell-Arg. (Euphorbiaceae), *Mesua ferrea* L. (Calophyllaceae), *Sida cordifolia* L. (Malvaceae), *Solanum indicum* L. (Solanaceae), *Strychnos nux-vomica* L. (Loganiaceae) were supplied to J. S. Ayurveda Mahaviyalaya Gujarat. Seedlings produced during seed germination studies *Madhuca diplostemon*, *Memecylon macrocarpum*, *Putranjiva roxburghii*; *Saraca indica* and *Diospyros foliosa* were handed over to various Sections of the Institutes such as Systematic Garden, Medicinal Garden and Central Nursery.

Index Semina: Received 6 Index Semina from 6 centres/botanical Gardens from 3 countries, accessioned properly.

DIVISION OF PHYTOCHEMISTRY AND PHYTOPHARMACOLOGY

Areas of Research:

- Phytochemistry, new molecules, biological activities
- Essential oils, chemical profiling, biological activities
- Search for elite lines of medicinal plants.
- Chemical ecology
- Secondary metabolite-based nanoparticles, their biology

Major Accomplishments

1) Discovery of antiviral molecule from medicinal plants

As part of a DBT Programme Support project, an antiviral molecule with significant activity against Chikungunya virus was discovered from a medicinal plant. One of the derivatives of the isolated active molecule showed significant activity against Dengue virus. On testing at National Virology Institute, Pune these lead molecules showed only moderate activity against SARS-CoV-2 virus.

2) 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 anti-diabetes 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 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 anti-diabetes drug development.

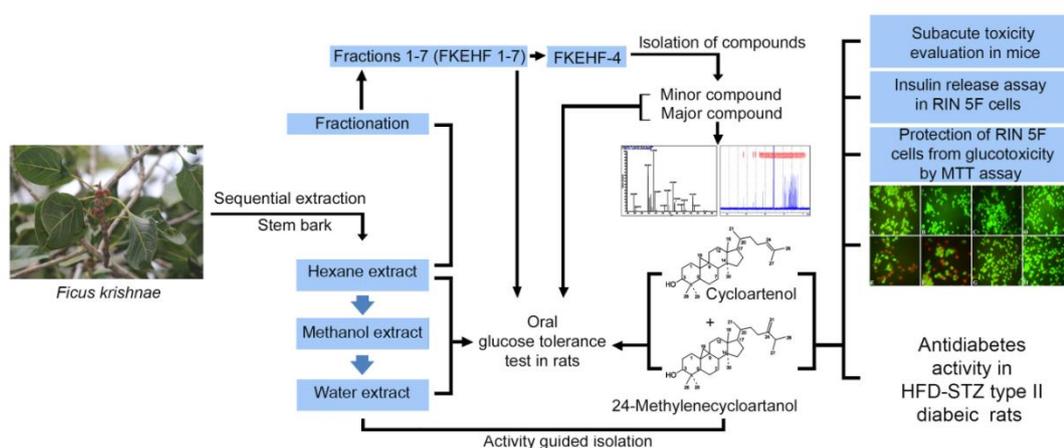


Fig. 13. Schematic diagram of activity guided (cycloartenol+24-methylenecycloartanol) from *Ficus krishnae* and their antidiabetic activity

- 3) **Development of asiaticoside nanoparticles for targeted drug delivery from *Centella asiatica*.** Asiaticoside and madecassoside, major centellosides in *C. asiatica*, have wide spectrum of neuropharmacological activity. Penetrability of drug inside the brain is limited due to the presence of defensive mechanism of brain known as Blood Brain Barrier (BBB), a major hurdle in the neuropharmacology related studies. Nano vehicles overcome these limitations by crossing the BBB to perform effective brain targeted delivery. Novel asiaticoside and madecassoside polymer nanoparticles

synthesized proved to be effective in significantly targeting the brain tumour (glioma) cells.

- 4) **Sustainable utilization of and nanoparticles synthesised from essential oils for biomaterial applications.** Volatile oils from fresh leaves of *Thottea siliquosa*, *T. ponmudiana* and *Clausena indica* were isolated by hydro distillation 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%). Nanoemulsions of volatile oils were synthesised by ionic gelation method using chitosan and alginate. DLS and Zeta potential of nanoemulsions indicated minimum sized particles with good stability. The essential 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.
- 5) **Development of controlled release formulations of eco-friendly pesticides in stored pest management.** The biopesticidal activity of basil, eucalyptus, orange and citronella essential oils are being evaluated against the two stored grain pests *viz.*, Pulse beetle (*Callosobruchus* sp.) (Coleoptera: Bruchidae) and Red flour beetle (*Tribolium castaneum*) (Coleoptera: Tenebrionidae).
- 6) **Discovery of elite lines of high value medicinal plants, *Centella asiatica* and *Bacopa monnieri*.** As part of a DBT Programme Support project, elite lines of *C. asiatica* and *B. monnieri* were discovered by screening over 250 accessions of these plants collected from their wild locations in Kerala, Tamil Nadu, and Karnataka. The agro-techniques of these elite lines were developed.
- 7) **Phytochemical and phytopharmacological investigation of *Garcinia wightii*.** Two new caged xanthenes, wightiic acid 16-methoxy wightiic acid, along with eight known compounds, gaudichaudic acid E, isogaudichaudic acid E, ursolic acid stigmasterol, lupeol, glutinol, lupenone and stigmasteryllinoleate. The structures of the compounds were elucidated by spectroscopic means.

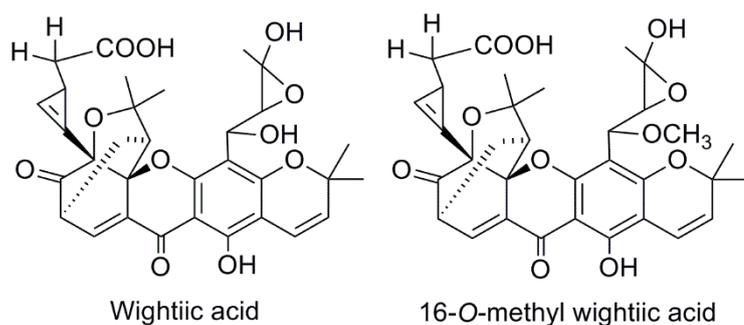


Fig. 14. Two new caged xanthenes, wightiic acid 16-methoxy wightiic acid *Garcinia wightii*

- 8) Chemical profile of leaf, fruit pericarp essential oils of *Syzygium palodense* and their cytotoxic activity against DLA and C6 glioma cells.** *Syzygium palodense* is an unexplored species endemic to the southern Western Ghats in India. Here we report the chemical profiles of essential oils of the leaves and fruit pericarps of *S. palodense* analysed by gas chromatographic techniques. Thirty-six (99.92%) constituents were identified from *S. palodense* fruit pericarp essential oil, with (E)- β -ocimene (63.20%), myrcene (15.79%) and (Z)- β -ocimene (9.70%) as its major constituents. Sixty-nine (99.40%) constituents were identified in the leaf essential oil, and the major ones were (E)- β -ocimene (30.58%), (E)-caryophyllene (14.23%), δ -selinene (13.89%), γ -himachalene (7.59%), myrcene (8.38%) and (Z)- β -ocimene (5.68%). Both leaf and fruit pericarp oils showed significant cytotoxicity in C6 glioma and Dalton's Lymphoma Ascites (DLA) cells with very low CD₅₀ values of 1.8, 1.2 μ g/ml and 4.8, 1.1 μ g/ml, respectively. 3-[4,5-Dimethylthiazol-2-yl]-2,5-diphenyl tetrazolium bromide (MTT), phase contrast/fluorescent microscopic and flow cytometric assays revealed the cytotoxic mechanism of these essential oils in C6 glioma and DLA cells as induction of apoptosis. This is the first report of the chemical profiles and biological activities of essential oils of *S. palodense*. Similar studies in hitherto uninvestigated *Syzygium* species could lead to new biologically active essential oils.
- 9) Centellosides in *Centella asiatica*: Bioconversion (ratios), elite lines, biomarkers.** Centellosides *viz.* asiatic acid (ASA), madecassic acid (MDA), asiaticoside (ASI), madecassoside (MAD), are the major bioactive molecules in *Centella asiatica* (CA). In this study MDA: ASA, MAD: ASI (C6-hydroxylation *versus* non-hydroxylation) and ASI: ASA, MAD:MDA (C28-glycoside *versus* aglycone) ratios in 50 CA accessions originally collected from wild locations in south India and grown under

identical ecological conditions for six generations were determined using validated HPTLC-densitometry protocol(s). ASA, MDA, ASI and MAD ranged from 0.01-0.29% (average $0.06 \pm 0.08\%$, $n = 22$; 28 accessions recorded ASA content as zero), 0.02-0.72% ($0.12 \pm 0.13\%$), 0.04-2.41% ($0.44 \pm 0.52\%$) and 0.15%-5.27% ($1.59 \pm 1.26\%$, $n = 50$), respectively. Distinctly, C6-hydroxylated (MDA: ASA 4.00, MAD: ASI 3.61) and C28-glycosylated (ASI: ASA 7.33, MAD:MDA 13.25) centellosides dominated over the respective non-derivatized entities. Our results infer that both C6-hydroxylations by P450-dependent monooxygenases and C28-glycosylation by UDP-Glc glucosyltransferases (UGTs) are dominant biosynthetic steps in CA. This study also discovered six elite clones of CA from south India with their (ASI+MAD) contents above the industrial benchmark ($\geq 4\%$). Two elite clones with ASI contents $\geq 2\%$ were also identified. These elite lines can be multiplied and utilized for the industrial applications of CA. Besides, this study emphasizes the need for standardizing all four centellosides as biomarkers in CA raw drugs, pharmaceutical and cosmetic products.

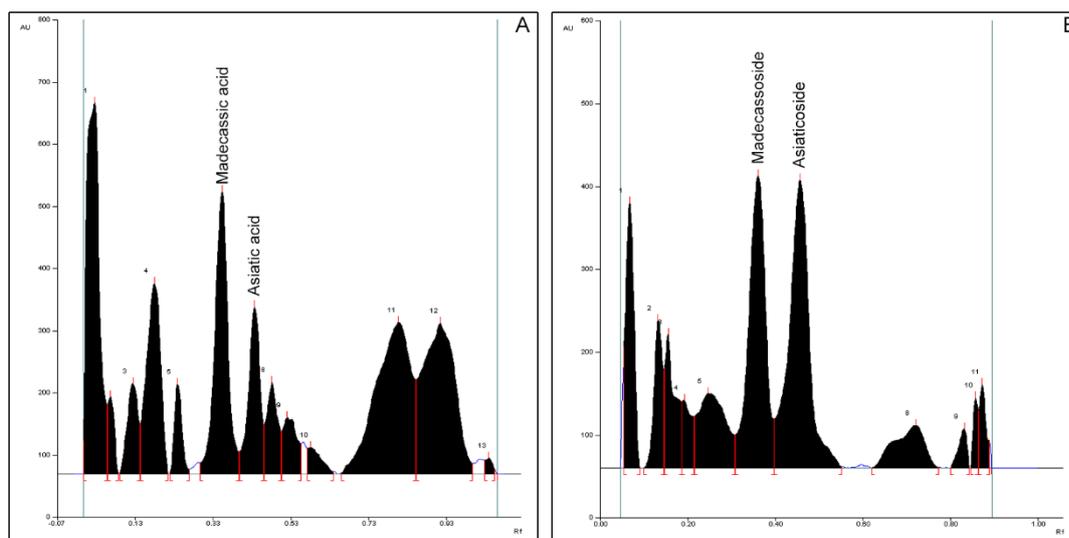


Fig. 15. Representative HPTLC chromatograms of methanol extracts of *C. asiatica* accessions, (A) Ca-56 (ASA, MDA) and (B) Ca-52 (ASI, MAD); data scanning, documentation, and analysis by CAMAG TLC Scanner 3, Reprostar 3 and WinCATS software 4.03 respectively.

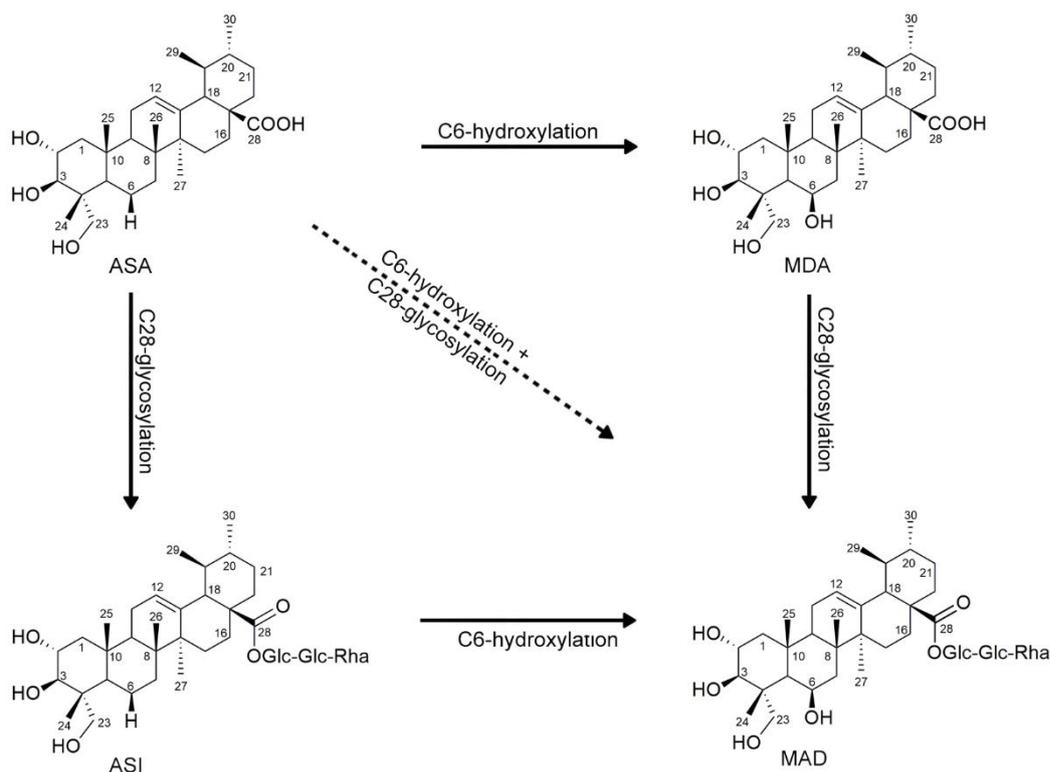


Fig. 16. Four major centellosides in *C. asiatica*, asiatic acid (ASA), madecassic acid (MDA), asiaticoside (ASI) and madecassoside (MAD), and their bioconversions through C6-hydroxylation and C28-glycosylation reactions.

Important Highlights of Major Programmes:

[1] DBT Programme Support Project: Identification of elite lines of *Centella asiatica* and *Bacopa monnieri* for commercially significant constituents for standardization of their extracts: *C. asiatica* and *B. monnieri* are two high value medicinal plants. As part of this five-year (2015-20) 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-seven *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. Voucher specimens were preserved at JNTBGRI herbarium. Whole plant specimens of 106 *C. asiatica* and 103 *B. monnieri* accessions collected from the wild were systematically analysed for the contents of their bioactive principles (*C. asiatica*: asiaticoside, madecassoside; *B. monnieri*: bacoside A, bacopaside D). 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 the huge variations (most very low & very few high contents) 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 and eight ‘elite lines’ of *C. asiatica* and *B. monnieri*, respectively.

These elite lines of *C. asiatica* and *B. monnieri* were subjected to multilocation trials at four agroclimatic locations in Kerala (Munnar, Campus sites of Malabar Botanic Garden, Puthenthope Extension Centre of JNTBGRI and JNTBGRI). We found the best biomass yield and bioactive contents for *C. asiatica* and *B. monnieri* elites at one of these four locations. Agricultural parameters (N-P-K, 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.

[2] DBT Programme Support Project: Antivirals from medicinal plants of Western Ghats selected based on traditional knowledge (TK)/ethnomedical information: As part of the DBT programme support project on “Antivirals from medicinal plants of Western ghats selected based on traditional knowledge TK/ ethnomedical information”²³ medicinal plants were selected for scientifically validating the antiviral potential based on ethno-medical information/ prescribed Ayurveda texts/ traditional knowledge. In the first phase, the antiviral activity of hydro-alcoholic extracts of these plants was screened against Chikungunya virus by preliminary CPE reduction assays, plaque reduction assays. And six extracts (JNTBGVR03, JNTBGVR06, JNTBGVR07, JNTBGVR08,

JNTBGVR13 & JNTBGVR14) showed significant (> 60%) levels of activity. All these extracts showed significantly more activity than the positive control Ribavirin which had ~40% activity. A lead molecule (A1B1) was isolated from JNTBGVR14 (*Sauropus androgynus*) by activity guided fractionation and characterized using spectroscopic techniques. A1B1 showed significant activity against CHIKV virus at very low concentrations in multiple models. A1B6, a synthetic derivative of A1B1, showed significant anti-dengue activity (>70%), but no anti-CHIKV activity, in CPE-reduction assays.

Important Collaborations established:

- **DBT Programme Support Projects Coordination:** In October 2013 JNTBGRI submitted a proposal for Programme Support to Department of Biotechnology under four suggested thrust areas, (i) conservation and maintenance of bioresources of Western Ghats, (ii) generation of knowledge base on bioresources of Western Ghats, (iii) sustainable utilization and commercialization of bioresources of Western Ghats: identification of elite species, their multiplication and value addition and (iv) bioprospecting of gene(s)/ molecule(s) for new and novel applications. This proposal also included development of conservatories and a new central instrumentation facility. Onto this proposal, two brainstorming sessions, first at DBT on December 26, 2013, and second at JNTBGRI on June 12-13, 2014, were conducted. Over 40 academicians, industrial experts and DBT officials participated in the brainstorming sessions held at JNTBGRI. Following the brainstorming meetings, JNTBGRI submitted a revised Programme Support proposal with several projects/ infrastructure components, which was evaluated by the Expert Committee on September 29, 2014, at DBT.

DBT sanctioned 6.71 crores for eight research programmes under Programme Support in May 2015. 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 are aimed at the (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. After a satisfactory first phase of Programme Support, DBT has sanctioned Rs. 3.54 crores in the Extension Phase (till May 2020) of the Programme. These Programme Support projects (completed in May 2020) had collaborations of the host institute JNTBGRI with several national Institutes.

Details of Financial assistance received during the period.

- Search for Potential Biologically Active Constituents from the Indian Pitcher Plant, *Nepenthes khasiana* [SERB, Government of India, Rs. 26.75 Lakhs]
- Effect of selected nano particles synthesized from plant secondary metabolites on seizures induced by kainic acid in mice [Kerala Biotechnology Commission, KSCSTE, Govt. of Kerala; Rs. 20.62 Lakhs].
- Development of controlled release formulations of eco-friendly pesticides in stored pest management. [KSCSTE- Ecology Environment Division Rs. 10.48 Lakhs].
- Deciphering the functional role and regulatory mechanism of PLGA-PEG encapsulated *Bacopa monnieri* secondary metabolite nanoparticles against kainic acid induced seizures [ICMR, Government of India, Rs. 13.70 Lakhs]
- Identification of elite lines of *Centella asiatica* and *Bacopa monnieri* for commercially significant constituents for standardization of their extracts. [Programme Support Project, Department of Biotechnology, Government of India; Rs. 94.95 Lakhs]
- Antivirals from medicinal plants of Western Ghats selected based on traditional knowledge (TK)/ethnomedical information [Programme Support Project, Department of Biotechnology, Government of India; Rs. 95.18 Lakhs]
- Bioprospecting of two coded antidiabetic medicinal plants based on ethnomedical leads with special reference to diabetic complications - molecular pharmacological approach [Programme Support Project, Department of Biotechnology, Government of India; Rs. 90.68 Lakhs]
 - State Plan fund.
 - Plan projects: 57.84 Lakhs (2020-21)

Other important accomplishments

1. Insecticidal properties of *Clausena austroindica* leaf essential oil and its major constituent, trans-anethole, against *Sitophilus oryzae* and *Tribolium castaneum*

In this study, the chemical profile of the leaf essential oil of hitherto uninvestigated shrub *Clausena austroindica* B. C. Stone & K. K. N. Nair and its insecticidal potential against two stored product pests, *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst) were investigated. Essential oils from the leaves of *C. austroindica* collected from two locations in south India were isolated by hydro distillation and analysed by gas chromatography-flame ionization detector (GC-FID) and gas chromatography-mass spectrometry (GC-MS). Six to eight compounds comprising 99.41-99.44% were characterized with trans-anethole (phenyl propanoid) as the major component (95.12-97.44%) in leaf essential oils. Trans-anethole was isolated from the leaf oil by column chromatography, characterized by Fourier Transform Infrared (FT-IR), ultraviolet-visible (UV-Vis), ¹H-, ¹³C- and distortion less enhancement by polarization transfer (DEPT 135) nuclear magnetic resonance (NMR) spectroscopy, and quantified by external standardization. Insecticidal activity of *C. austroindica* leaf oil and trans-anethole were assessed against the rice weevil (*S. oryzae*) and red flour beetle (*T. castaneum*) by contact and fumigant toxicity assays. The mammalian cell toxicity of *C. austroindica* leaf oil and trans-anethole was also tested against L929 cell lines using (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) MTT assay and quantification of reactive oxygen species (ROS). *C. austroindica* leaf oil and trans-anethole demonstrated superior contact and fumigant toxicities against adult beetles of *S. oryzae* and *T. castaneum*. *C. austroindica* leaf oil and trans-anethole showed potential fumigant toxicity against *S. oryzae* (lethal concentration 50 (LC50) 38.80 & 76.98 µL/L) and *T. castaneum* (LC50 35.65 & 29.10 µL/L). Relatively less prominent viz., *S. oryzae*: LC50 leaf oil 469.70 µL/L, trans-anethole 2543.20 µL/L; *T. castaneum*: LC50 leaf oil, 1090.70 µL/L, trans-anethole 2050.84 µL/L, but significant contact toxicities were displayed by the leaf oil and trans-anethole against the two stored product pests. Both *C. austroindica* leaf oil and trans-anethole (< 2.0 µg/mL) have not demonstrated any mammalian cell (L929 cell line) toxicity. Our study demonstrates the potential *C. austroindica* leaf essential oil as a new botanical insecticide for controlling stored product pests. Its major component, trans-anethole, also showed prominent insecticidal activity.

2. Anti-excitotoxicity and neuroprotective action of asiaticoside encapsulated polymeric nanoparticles in pilocarpine rodent seizure model:

Asiaticoside (ASI), an ursane-type triterpenoid saponin, isolated from the memory enhancing herb *Centella asiatica*, is known for its neuroprotective activities. In this study, the anti-excitotoxicity and neuro protective effects of ASI encapsulated alginate chitosan nanoparticles (ACNPs) were evaluated in pilocarpine (PC) induced seizure in mice model. ACNPs were prepared by ionic gelation-polyelectrolyte complex method and their physicochemical characterization was carried out by TEM, SEM, DLS, XRD and FT-IR. Subsequently their encapsulation efficiency (EE), *in vitro* drug release, cell viability, seizure score, DNA fragmentation and mRNA expression of regulatory stress markers were evaluated. Membrane permeability of ACNPs in brain, histopathology and biological TEM and SEM analyses were also carried out. TEM of ACNPs showed spherical morphology with a particle size of 200-400 nm. DLS of ACNPs displayed an average size of 486.2 nm with polydispersity index (PDI) of 0.567 and zeta potential of -14.1 mV. ACNPs achieved high EE (> 90%) and controlled release (10%). Biological evaluation studies revealed ACNPs as non-toxic to mouse neural stem cells (mNSCs). They displayed enhanced brain permeability and attenuated seizure. Our results confirmed ACNPs as effective in crossing the brain membrane barrier and mitigating seizure severity induced by PC.

3. Assessment of major centelloside ratios in *Centella asiatica* accessions grown under identical ecological conditions, bioconversion clues and identification of elite lines

Centellosides *viz.*, asiatic acid, madecassic acid, asiaticoside, madecassoside, are the major bioactive molecules in *Centella asiatica*. In this study madecassicacid:asiatic acid, madecassoside:asiaticoside (C6-hydroxylation *versus* non-hydroxylation) and asiaticoside:asiatic acid, madecassoside:madecassic acid (C28-glycoside *versus* aglycone) ratios in 50 *C. asiatica* accessions originally collected from their natural habitats in south India and grown under identical ecological conditions for six generations were determined using validated HPTLC-densitometry protocols. Asiatic acid, madecassic acid, asiaticoside and madecassoside contents ranged from 0.00-0.29% (average $0.03 \pm 0.06\%$; 28 accessions recorded asiatic acid content as zero), 0.02-0.72% ($0.12 \pm 0.13\%$), 0.04-2.41% ($0.44 \pm 0.52\%$) and 0.15-5.27% ($1.59 \pm 1.26\%$), respectively. Distinctly, C6-hydroxylated (madecassicacid:asiatic acid 4.00, madecassoside:asiaticoside 3.61) and C28-glycosylated (asiaticoside:asiatic acid 14.67, madecassoside: madecassic acid 13.25) centellosides dominated over the respective non-derivatized entities. Our results infer that both C6-hydroxylation by CYP450-dependent monooxygenases and C28-glycosylation by UDP-Glc glucosyltransferases are dominant bioconversion steps in *C. asiatica*. Besides, this study discovered six elite lines of *C. asiatica*, with their (asiaticoside+madecassoside) contents above the industrial benchmark ($\geq 4\%$) from south India. Two elite clones with asiaticoside contents $\geq 2\%$ were also identified. Standardization of the agrotechniques of these elite lines could lead to their industrial applications. Besides, this study emphasizes the need for standardizing all four centellosides as biomarkers in *C. asiatica* raw drugs, pharmaceutical and cosmetic products.

4. *Bacopa monnieri* (Brahmi): phytochemistry, use in traditional Ayurvedic formulations (Review article)

Bacopa monnieri (Brahmi) is described as a 'brain tonic' in ancient medical literature, and its formulations such as *Brahmi ghrita*, *Brahmi rasayana*, *Brahmi vati* and *Saraswataghrita* are widely used in Ayurvedic medicine. This review describes the comprehensive phytochemistry of *B. monnieri* and the role of its molecular entities in Ayurvedic formulations. Last eight decades phytochemical studies resulted in the isolation of 98 secondary metabolites from *B. monnieri*, *viz.*, dammarane type triterpenoid saponins (34), pentacyclic triterpenes (6), phenylethyl glycosides (12),

phenylpropanoid glycosides (2), cucurbitacins (7), steroids (8), flavonoids (6), alkaloids (3) and other miscellaneous compounds (20). Bacosides are the major bioactive constituents contributing to the cognitive effects of *B. monnieri*. But most *Brahmi*-based Ayurvedic formulations are not defining the chemical entities responsible for their biological activities; instead, their effects are attributed to synergism of their herbal ingredients. Chemical fingerprinting and other quality control measures are critically important in rationalizing the biological effects of Ayurvedic drugs. Similarly, bioavailability and toxicity of Ayurvedic formulations are to be assessed. Genomic, metabolomic approaches and human trials with valid models on Ayurvedic drugs are so far limited, and these efforts are to be further augmented.

5. Antiproliferative activity of leaf, fruit pericarp essential oils of *Syzygium palodense*

Chemical profiles of essential oils (EOs) of the leaves and fruit pericarps of *S. palodense* and their antiproliferative activities against C6 glioma and Dalton's Lymphoma Ascites (DLA) cells were elucidated. *S. palodense* leaves and fruit pericarps EOs were isolated by hydro distillation and characterized by gas chromatographic (GC/FID, GC/MS) techniques. Antiproliferative activities EOs were elucidated by MTT, phase contrast/fluorescent microscopic and flow cytometric assays. Thirty-six (99.92%) constituents were identified from *S. palodense* fruit pericarp EO, with (E)- β -ocimene (63.20%), myrcene (15.79%) and (Z)- β -ocimene (9.70%) as its major constituents. Sixty-nine (99.40%) constituents were identified in the leaf EO, and the major ones were (E)- β -ocimene (30.58%), (E)-caryophyllene (14.23%), δ -selinene (13.89%), γ -himachalene (7.59%), myrcene (8.38%) and (Z)- β -ocimene (5.68%). Both leaf and fruit pericarp EOs showed significant cytotoxicity in C6 glioma and Dalton's Lymphoma Ascites (DLA) cells with very low CD₅₀ values of 1.8, 1.2 μ g/ml and 4.8, 1.1 μ g/ml, respectively. MTT, phase contrast/fluorescent microscopic and flow cytometric assays revealed the cytotoxic mechanism of these EOs in C6 glioma and DLA cells as induction of apoptosis. This is the first report of the chemical profiles and biological activities of EOs of *S. palodense*. Both leaf and fruit pericarp EOs displayed strong antiproliferative activity (very low CD₅₀ values) against C6 glioma and DLA cells.

6. Biocompatible madecassoside encapsulated alginate chitosan nanoparticles, their anti-proliferative activity on C6 glioma cells.

Madecassoside (MAD), an ursane type pentacyclic triterpenoid saponin, isolated from *Centella asiatica* (CA) possesses various pharmacological activities. The aim of this study was to evaluate therapeutic potential of MAD encapsulated alginate chitosan nanoparticles (MACNPs) on C6 glioma cells. Synthesized nanoparticles were characterized by Thermogravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) and Fourier transform infrared spectroscopy (FTIR). Cell viability and compatibility of both MAD and MACNP were observed on primary astrocytes. Cytotoxicity and anti-proliferative effect of MACNPs were studied on C6 glioma cells by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetraazolium bromide tetrazolium (MTT) and 5'-ethynyl-2'-deoxyuridine (Edu) assays. MACNPs showed 90% cytotoxicity and depicted anti-proliferative activity against C6 cells. Annexin V-Alexa flour-488/propidium iodide (PI) staining followed by flow cytometry revealed that MACNPs induced necrosis in C6 glioma cells. Cell death was also observed using acridine orange/ethidium bromide (AO/EtBr) and Hoechst staining. 2', 7'-dichlorodihydrofluorescein diacetate (DCFDA) assay by flow cytometry showed an increase in reactive oxygen species (ROS) production in MACNP treated C6 glioma cells. MACNPs showed a greater uptake and distribution in C6 glioma cells and inhibited the proliferation of C6 cells *via* increased intracellular ROS production. Our findings suggest MACNP as a promising drug delivery carrier for the management of glioma and shed new insights to brain malaises.

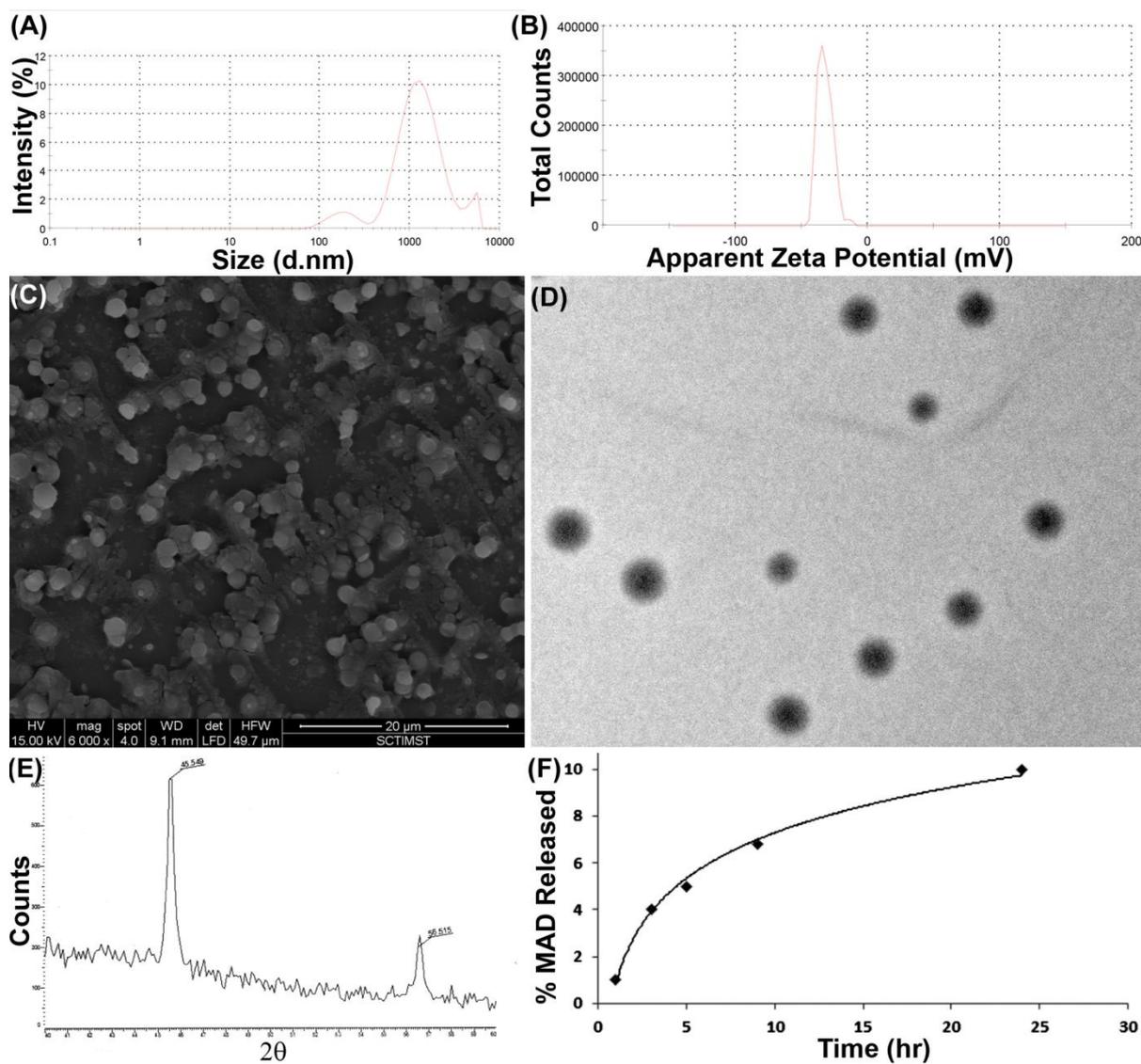


Fig. 17. Physico-chemical characterization of MACNP. (A) DLS spectrum, (B) Zeta potential, (C) SEM image, (D) TEM image, (E) XRD pattern, (F) *In vitro* release profile, of MACNP.

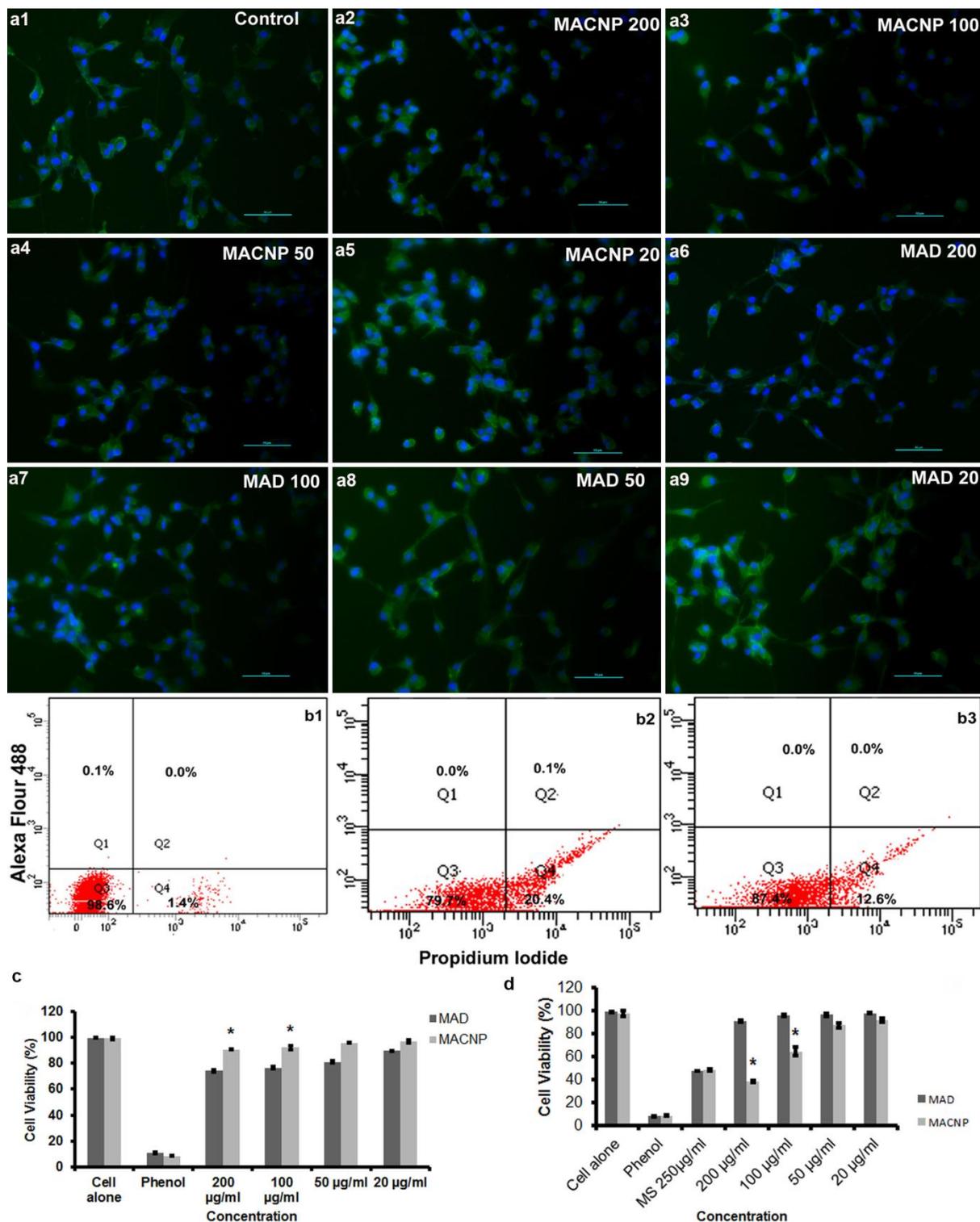


Fig. 18. Cytocompatibility and cytotoxicity evaluation of synthesized madecassoside encapsulated alginate chitosan nanoparticles (MACNP): (a1) Control mBAs (untreated); mBAs incubated with MACNP at (a2) 200 $\mu\text{g/ml}$ (a3) 100 $\mu\text{g/ml}$ (a4) 50 $\mu\text{g/ml}$ and (a5) 20 $\mu\text{g/ml}$ and mBAs incubated with MAD at (a6) 200 $\mu\text{g/ml}$ (a7) 100 $\mu\text{g/ml}$ (a8) 50 $\mu\text{g/ml}$ (a9) 20 $\mu\text{g/ml}$ and (b) Assessment of cyto- compatibility of MAD and MACNP on mBA by Live/Dead assay (b1) Control mBAs (b2) mBAs treated with MAD (200 $\mu\text{g/ml}$) (b3) mBAs treated with MACNP (200 $\mu\text{g/ml}$). (c) Relative cell viability as assessed by MTT assay for mBAs exposed to MACNP and MAD at the indicated concentrations for 24 h. (d) MTT

assay of C6 glioma cells treated with different concentrations of MACNP and MAD for 24 h. Data are expressed relative to that of untreated control cells to MACNP treated cells and phenol treated cells.

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

Glioma being the common type of malignant primary brain tumors originating from glial cells and its prognosis is poor. It is highly aggressive, treatment resistant tumor and grows rapidly in brain so there is a chance of prone to recurrence. Asiaticoside, a pentacyclic triterpenoid saponin isolated from *Centella asiatica* (L.) Urb. (Apiaceae) possesses numerous biological activities. The platform dealing with combination of natural product and nanoparticle is an emerging area of interest for effective glioma treatment. Therefore, the present study aims to develop and characterize asiaticoside encapsulated alginate chitosan nanoparticles (ACNPs) and evaluate their antiproliferative potential on C6 glioma cells. ASI encapsulated alginate chitosan nanoparticles (ACNPs) were prepared by the ionic gelation polyelectrolyte complexation technique and characterized by Dynamic Light Scattering (DLS), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), and various other techniques. Antiproliferative action of ACNPs was determined using MTT, EdU and cell cycle assays. ACNP showed encapsulation efficiency (EE) greater than 90% with 10% drug release in 24 hr. Cytotoxicity and antiproliferative effect of ACNP was studied on C6 glioma cell line using MTT and Edu-assays. Annexin V staining followed by flow cytometry analysis revealed that ACNP induced necrosis/apoptosis in C6 glioma cells. Necrotic cells were also detected using Acridine orange/Ethidium bromide (AO/EtBr) staining method. DCFDA assay by flow cytometry analysis showed an increase in reactive oxygen species (ROS) production in ACNP treated C6 glioma cells. They showed cell cycle arrest at the G1 phase and displayed chromatin condensation in C6 glioma cells. The results suggest that ACNP as an antiproliferative agent against C6 glioma cells mediated by increased intracellular ROS promoting apoptosis/necrosis pathway. This study sheds new insights into the management of brain maladies.

8. Study on pesticidal and mammalian toxicity vis-a-vis anti-cancer effect of *Clausena austroindica*

This study involved the chemical profile of the leaf essential oil of *Clausena austroindica* B. C. Stone & K. K. N. Nair and its insecticidal potential

against two stored product pests, *Sitophilus oryzae* L. and *Tribolium castaneum* Herbst. Mammalian cell toxicity of *C. austroindica* leaf oil and trans-anethole was also tested against L929 cell lines using (3-(4, 5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) MTT assay and quantification of reactive oxygen species (ROS). Another study focussed on the anti-proliferative potential of the leaf essential oil of *C. austroindica* and trans-anethole on SKBr3 breast cancer cells. MTT, live/dead using Annexin V/PI and DCFDA for reactive oxygen species generation assays were done to assess the anti-proliferative and cytotoxicity activity of essential oil from *C. austroindica* and trans-anethole. Cellular assimilation study on SKBr3 cells was also carried out by flow cytometry. These assays disclosed the anti-proliferative effect of *C. austroindica* essential oil on SKBr3 cells. Interestingly, *C. austroindica* leaf oil showed no cytotoxicity towards RAW 264.7 macrophages normal cells (EC₅₀ 6.25± 2.90) whereas trans-anethole showed cytotoxicity (EC₅₀ 0.96± 0.09). CC₅₀ value of *C. austroindica* essential oil and trans-anethole were 0.5 ± 0.03 and 12.88 ± 1.19, respectively, on SKBr3 cells. *C. austroindica* leaf oil induced significant ROS production on SKBr3 cells which ultimately leads to nuclear condensation, to culminate the cell death. Moreover, flow cytometric analysis of *C. austroindica* leaf oil treated SKBr3 cells revealed the anti-proliferative mechanism through ROS induced apoptosis. Our study for the first time delineated the anti-proliferative potential of *C. austroindica* on breast cancer cell line.

Important Highlights of Major Programmes

A) Antiproliferative secondary metabolites from *Humboldtia unijuga*

Humboldtia unijuga Bedd., a tree species endemic to southern region of Western Ghats in India, is least explored for its chemical constituents and biological activities. Phytochemical analysis of *H. unijuga* roots and stems resulted in the isolation of twenty-nine secondary metabolites with four new molecules, viz., acetoxy olean-12-en-28-oate 3-*O*-β-myristate, 3-*O*-(3'-hydroxyheptadecanoyl) lupeol, oleanol 28-aldehyde 3-*O*-β-myristate, acetoxy olean-12-en-28-oate 3-*O*-β-laurate. Antiproliferative (cytotoxicity) activity of the twenty-nine isolated compounds was evaluated by MTT assay in five cancer cell lines, viz., C6, Hepa 1-6, RIN-5F, DLA and PC-12. These *in vitro* screening assays revealed promising anticancer activity of oleanolic acid-3-acetate and (2*S*)-1-*O*-palmitoyl-2-*O*-(9*Z*-octadecenoyl)-3-*O*-(6'-sulfo-α-*D*-quinovopyranosyl) glycerol. The mechanism of anticancer activity of these

two molecules was elucidated by phase contrast and fluorescent microscopy, caspase 3 activity assay and flow cytometric cell cycle/apoptotic analyses. Briefly, this study discovered four new secondary metabolites from *H. unijuga*; and this endemic species emerged as a reservoir of unique anticancer secondary metabolites.

B) Edible oil from the seeds of *Garcinia gummi-gutta*

Oils and fats are important components in food, medicine, fuel and cosmetic sectors, and the indigenous oil production is not enough to meet the demand in our country. *Garcinia gummi-gutta* is a widely cultivated fruit crop in the Central part of Kerala, for its fruit rind, while the seeds are treated as waste products. The research at JNTBGRI revealed that the seeds of *Garcinia gummi-gutta* are good source of edible oils (yield of 35 to 40%). The oil contains stearic acid and oleic acid as the major fatty acid components. The oral and dermal toxicity studies showed the oil as safe in food as well as in cosmetic sectors.

C) New molecule discovered:

3,23-Cycloglutin-5(10)-ene (*Euphorbia vajravelui*)

[A] Scientific Social Responsibility Programme

As part of Science and Engineering Research Board (SERB) funded project ‘Search for Potential Biologically Active Constituents from the Indian Pitcher Plant, *Nepenthes khasiana*’, Phytochemistry and Phytopharmacology Division of KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute organized a two-day orientation programme on ‘Chemistry and Biology of Plant Carnivory’ for science (B. Sc. & M. Sc.) students on March 03 & 04, 2022. Twenty-nine students from various colleges in Kerala and Tamil Nadu participated in this orientation programme.

The programme was organized in line with the Scientific Social Responsibility Policy (SSRP) of SERB, Department of Science and Technology, Govt. of India. This SSR Programme was aimed to introduce to new frontiers in natural product research and plant carnivory to students. Carnivorous plants are unique life forms on Earth. They grow in nutrient-deficient soils and obtain their nutrients by capturing insects and other arthropods through their leaf-evolved prey traps. More than 800 carnivorous plants *viz.*, *Nepenthes*, *Sarracenia*, *Dionaea*, *Pinguicula*, *Darlingtonia*, *Drosera*, *Utricularia*, are known; they differ in their traps and trapping mechanisms. In this SSR Programme, carnivorous plants, their distribution, chemistry and prey capturing mechanisms were demonstrated through lectures by experts (Dr. B. Sabulal & Dr. M. Salim). An invited lecture on ‘The price of night life: Foraging

ecology of nocturnal bees' by Prof. Hema Somanathan, IISER, Thiruvananthapuram disseminated a glimpse of plant-animal interactions to the students. Visit to various conservatories and laboratory demonstrations provided live experience of various plant systems and lab facilities to the participants. This orientation programme provided an excellent opportunity for students to understand, interact and be inspired into the field of advanced research. The entire programme was conducted free of cost to the participants.



Fig. 19. *Garcinia Gummi-gutta* seeds as source of edible oil.



Technical Session
The orientation programme comprises of invited lectures on natural product research, theme-based lectures on carnivorous plants, a rare opportunity to see various carnivorous plants in the conservatory, other conservatories (garden sites), visits to research laboratories and demonstrations of sophisticated instruments such as HPTLC-densitometry, GC-FID, GC-MS, RT-PCR.

Patron
Dr. R. Prakashkumar
Director, KSCSTE-JNTBGRl

Convener
Dr. B. Sabulal
Senior Principal Scientist & Head, Phytochemistry and Phytopharmacology Division
KSCSTE-JNTBGRl

Joint Convener
Dr. V. Gayathri
Senior Scientist
KSCSTE-JNTBGRl

Co-convenors
Dr. Anil John J.
Dr. Ajikumar Nair S.
Dr. Rajani Kurup S.R.
Mr. Gokul B.S.
KSCSTE-JNTBGRl

Venue & Date
Venue: KSCSTE-JNTBGRl, Palode, Thiruvananthapuram
Date: 3-4 March 2022.

Registration
B.Sc., M.Sc., M.Pharm and M. Tech. students can apply
Last date for registration: 17 January 2022
The number of participants will be limited to 30 (on first-come-first-served basis).

Registration is free
For registration please visit www.jntbgrl.res.in

How to Reach
KSCSTE-JNTBGRl is located near Palode (PIN 695562), 40 km away from Thiruvananthapuram City in the Thiruvananthapuram-Thenkasi route. JNTBGRl is also reachable from Nilametil, Kilimanoor and Kulathupuzha.

- Transportation will be arranged from Thiruvananthapuram to KSCSTE-JNTBGRl and back on request.
- Accommodation will be arranged on payment basis on prior request.

Address for correspondence:
Dr. B Sabulal
Mobile: 9495832391
Email: jntbgrlresrp2022@gmail.com

SCIENTIFIC SOCIAL RESPONSIBILITY PROGRAMME
Two-day Orientation Programme on
Chemistry and Biology of Plant Carnivory
3-4 March 2022

Organized by

Phytochemistry and Phytopharmacology Division
KSCSTE-JNTBGRl, Palode, Thiruvananthapuram-695562

Supported by

Science and Engineering Research Board (SERB)
Department of Science and Technology
Government of India


Kerala State Council for Science Technology and Environment (KSCSTE)
Government of Kerala



Fig. 20. Scientific Social Responsibility Policy (SSRP) Programme - Brochure



About KSCSTE-JNTBGRl
KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute (KSCSTE-JNTBGRl) was founded in 1979 with the objective of establishing a Conservatory Botanic Garden of tropical plant resources. The Institute also undertakes research programmes on sustainable utilization of the plant resources. KSCSTE-JNTBGRl is the only organization in India, which maintains a 300-acre conservatory garden for the wild tropical plant genetic resources of the country, besides an integrated multidisciplinary R & D system dealing with conservation, management and sustainable utilization of tropical plant resources. During the past 40 years, it has flourished into one of the premier R & D organizations in Asia, devoted to conservation and sustainable utilization of tropical plant diversity. The Institute is recognized as a 'National Centre of Excellence in ex-situ conservation and sustainable utilization of tropical plants diversity' by the Ministry of Environment and Forests, Government of India. JNTBGRl enjoys the membership of Botanic Gardens Conservation International (BGCI). The Institute is a recognized centre of research for postgraduate and doctoral research of several universities.



Phytochemistry and Phytopharmacology Division
Phytochemistry and Phytopharmacology Division of KSCSTE-JNTBGRl was established in 1992. The main objective of the Division is to carry out chemical and pharmacological research on plant systems leading to their sustainable utilization. The Division has discovered new secondary metabolites, biologically active molecules, antiviral-antidiabetic-anticancer lead molecules, new essential oil sources, elite lines of medicinal plants and secondary metabolite based nanoparticles. Division also has significant findings on prey capture mechanisms of carnivorous plants.

Our Division has publications in Scientific Reports, Plos One, Current Neuropharmacology, Industrial Crops and Products, Phytomedicine, Phytochemistry, European Journal of Ethnopharmacology, Plant Biology, European Journal of Pharmacology, Flavour and Fragrance Journal and several other journals. Our findings were also covered by international media such as the BBC Nature, National Geographic, Smithsonian Magazine, The Guinness Book, scientific books and review articles. Twenty five Ph.Ds were produced by the Division and several Ph.D, Masters training programmes are in progress.

Orientation Programme
Science and Engineering Research Board (SERB), being a premier organization for funding basic research in the country, has devised its Scientific Social Responsibility (SSR) Policy aiming to spread the benefits beyond the direct beneficiaries, especially to the less-endowed researchers. The approach is to integrate and align the social responsibility activities within the SERB grantees committed research activities.

This two-day orientation programme will introduce students to new frontiers in natural product research and mechanisms of plant carnivory. These programmes will help building a knowledge-based society and expose students to new innovations in research.



Fig. 21. Scientific Social Responsibility Policy (SSRP) Programme - Brochure



Fig. 22. Student interaction - Prof. Hema Somanathan



Fig. 23. Visit to Conservatory – Carnivorous Plants



Fig. 24. Garden Visit



Fig. 25. Scientific Social Responsibility Policy (SSRP) Programme group

DIVISION OF PLANT SYSTEMATICS AND EVOLUTIONARY SCIENCE

The research activities of Plant Systematics and Evolutionary Science Division mainly focuses on themes such as (i) Taxonomic studies, herbarium management and development, ecosystem assessment, rescue, and restoration of RET species. The Division is also devoted to the plant systematics in the broadest sense, encompassing phylogenetic, evolutionary, and biogeographical studies at the family, population, specific and higher taxonomic levels. Exploration trips were carried out for the documentation of the plant resources of the state which include species of economically important genus *Cinnamomum*, *Sonerila*, *Ceropegia* ornamentally potential climbers and species of the family Annonaceae. Attention was also paid to enumerate the floristic richness of laterites with emphasis on endemics and threat category species. A study on the floristics of Myristica swamps also have been undertaken during the period revealing its importance in protecting water regime and ecology of the area. Established a field gene bank of 126 local mango varieties in the campus ensuring its conservation and base resource for further breeding programmes. The herbarium TBGT is the inevitable part of the division which holds 41752 specimens, 3808 species under 1429 genera. During the period, 5 new species had been published.

Other highlights

1. Ecology and Conservation of Freshwater Swamp Ecosystems of the Western Ghats – Kerala Region.
2. Eco restoration of Myristica swamp at JNTBGRI.
3. Ecology and Conservation of Fresh water Swamps of Southern Western Ghats in Climate change Scenario.
4. The effect of climate change on biodiversity, ecology, and productivity of high grass land of Western Ghats – analysis and modelling.
5. Detailed Project Report for Vamanapuram river rejuvenation.
6. Survey, Inventory, Documentation and Socio-Economic Valuation of Commercially Potential Plant Bio-resources of Kerala.

Programmes in nutshell:

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

Establishment of Custard Apple Park

Popularly known by the name Custard apple family, Annonaceae represents 130 genera and 2200 species world over. Annonaceae exhibits considerable endemism and quantifiable number of species that are threatened in their habitat. In India, the family inhabits 130 species, of which nearly 60% are endemic. In the Western Ghats there are 19 genera with 71 species including cultivated ones. In Kerala there are 18 genera and 57 species of which 42 are conserved in the custard apple park several of them falls under the IUCN category. The park was established in an acre of land inside the campus. *Miliusa sahyadrica* Rajkumar *et al.* and *Polyalthia malabarica* var. *longipedicellata* Alister *et al.* are the newly described species.

Annonaceae is of considerable economic 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* (Sour soup), *A. squamosa* (Sweet soup, Custard apple, Sugar apple, Sitaphal) *A. reticulata* (Bullock’s Heart, West Indian Custard apple) are juicy and edible. Sour soup is cultivated widely for its fruits which yield a sap used as beverage and in the preparation of jellies and the juice pulp is eaten raw. *Artabotrys odoratissimus*, and *Annona discolour* are known as ornamental plants and valued for their scented flowers. *Polyalthia longifolia* is planted as ornamental especially for its fine foliage. It is also used as a potential plant for green fencing. Flowers of *Cananga odorata* is the source of perfume Ylang- Ylang’ while *Desmos chinensis* yield Macassar oil. Above all, most of the species are potential larval food plants of the butterfly and are ideal resource for establishing butterfly gardens. During the reporting period 5 collection trips were conducted and collected 12 species from different localities. *Uavria zeylanica* and *Miliusa paithalmalayana* were newly added to the collection.

2) Laterite/ferrierites landscape of northern Kerala: Analysis of vegetational history and the role of sediment seed banks in the vegetation dynamics of its ephemeral wetlands

Lateritic/ferrierites ecosystems represent a legendary landscape of northern Kerala, which are the most imposing but extremely threatened, manifesting characteristic topographical and ecological features while serving as good watershed areas. These ecosystems are considered as an amphibious system, due to alternation of very wet and dry conditions, which creates an

unusual ecological situation that supports distinctive vegetation. Seasonal variation in microclimate (constituted by edaphic and metrological factors such as soil, rock, air temperature and humidity) strongly affects the prevalent plant communities. In monsoon, the impermeable nature of laterite surface causes water logging leading to formation of ephemeral wetlands. During dry phase, the thin layer of soil does not hold any moisture and the condition becomes arid. Thus, the microenvironment of the lateritic plateau tends to oscillate between extremes, *i.e.*, from waterlogged to xeric. Due to short life span and high reproduction rate, the prevailing plant communities (established vegetation) are well adapted to extreme environments and to certain level of disturbances. They survive the dry spell as dormant seeds in the sediment seed banks, which play a central role in vegetation dynamics of the ephemeral wetlands. Further, these persistent seed reservoirs are likely to provide resilience to the plant community against environmental stochasticity, which is particularly significant in the context of climate change. The present-day composition of the sediment seed banks provides an idea about the species which are vulnerable to local extinction and the ones which potentially can colonize a site if the hydrology is altered. Therefore, analysis of present-day seed banks and established vegetation may indicate succession stages of the community. If reliable information on the diversity of seed banks, their relationship to standing vegetation and responses to different environmental factors are gathered through systematic approaches, it will provide a useful tool for conservation and restoration of these exceptional habitats.

Ephemeral flush vegetation is characterised by high diversity of specialist and endemic species and contribute significantly to regional biodiversity. Restriction of endemic taxa to nutritionally imbalanced substratum (laterite, serpentine/ ultramafic) is a widespread phenomenon in endemic rich areas. There is much evidence to suggest that this nutritionally imbalanced substratum provides a strong selective force for the evolution of endemic plants (neo endemics). Therefore, the patterns, correlates, and causes of endemism will vary according to the size and location of the geographical area, as well as the taxonomy and phylogenetic relatedness of the floral assemblage under consideration. A comprehensive floral study conducted by the Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Thiruvananthapuram in the lateritic plateau of northern Kerala from Malappuram to Kasaragod, has resulted in the documentation of 685 native angiosperm taxa, covering 67 families. Of these, 114 species are endemics, including 26 exclusively endemic species to Kerala, manifesting an exceptional concentration of endemic taxa that are confined to a relatively small area. The harsh environmental conditions on the plateau have resulted in

providing the component species with certain traits that allow them to overcome environmental adversities. These traits, including carnivory (means to overcome the scarcity of nitrogen, phosphorus and potassium), succulence (desiccation avoidance strategy in xeric habitats), subterranean perennating organs, vegetative propagation, N-fixing ability (with predominance of leguminous herbs due to their association with N-fixing bacteria in their roots), semi-parasitism (feature to compensate for nutritional deficiency), poikilohydry (capacity to tolerate dehydration to low cell or tissue water content and to recover from it without physiological damage), C₄ mechanism (improved photosynthetic efficiency and minimized water loss in hot, dry period), and abnormal seed germination (emergence of plumule prior to radicle under stress conditions), help the plants to overcome major environmental stresses such as drought, high temperature, light intensity and nutrient deficiency.

It is increasingly becoming clear that variation in plant eco-physiological traits and their inherent adaptability (within and between individual and entire population) are vital in the establishment, composition, persistence, and distribution of plant communities in stressful landscapes. Added to this are the impacts caused by climate change, one of the greatest challenges currently faced by plant biologists, agronomists, and conservation biologists. Evidence gleaned from the past climate changes indicate that species are more likely to respond by migration rather than by adapting genetically. Therefore, tracing of vegetation history or gathering scientific evidence on long term distribution changes of plant communities in the landscape under consideration is significant. It is in this context that the present research project has been planned to focus on vegetation history of the laterite/ferrierites ecosystems of northern Kerala spread over the midland areas of Malappuram, Kozhikode, Kannur, and Kasaragod districts, together with community characteristics and functional dynamism of present-day vegetation and their sediment seed banks through palaeo-palynological, phyto-sociological and eco-physiological approaches.

Centres of endemism, or geographic regions with concentrations of species not found anywhere else, have long been of central interest to biogeographers, evolutionary biologists and ecologists. Evolutionary and ecological processes responsible for producing centres of endemism are complex and reflect interacting aspects of climatic, geological, and biogeographic history. Climate, and particularly its patterns of stability and change over evolutionary time, is a key ingredient in most interpretations of the origins and maintenance of centres of high plant and animal endemism. Climate change plays a powerful and diverse

role in ecosystems all over the world. Wet areas are becoming dry, dry areas are experiencing more rainfall, and CO_2 is increasing at an alarming rate. In a global climate change scenario, which is especially threatening special habitats like lateritic plateaus, it has become necessary to understand the key role that soil seed banks of ephemeral pools play in maintaining ecosystem dynamics to develop proper management plans pursuing the preservation of these habitats. Therefore, a deeper knowledge on their potential as a diversity reservoir and their spatial patterns is required. Endemics have restricted geographic ranges, sometimes associated with a specialized environmental niche, limited dispersal abilities, and reduced population size and adaptive capacity. Therefore, areas of high endemism are likely to be particularly vulnerable to climate change at both species- and community-levels.

Intergovernmental Panel on Climate Change (IPCC) mentioned about the importance of C_4 plants in the climate change scenario, i.e., C_4 Plants directly affected by all major global change parameters, often in a manner that is distinct from that of C_3 plants. In laterite most of the species having C_4 mechanism (e.g., Andropogonoid grasses: A successful neo endemic group), so these are very special group of plants especially in the event of climate change.

Increasing land use alteration and climate change are the major drivers of the loss of biodiversity in tropical regions of the world. Plant communities found on unusual soil types are an interesting case in point. Because plant communities associated with these habitats contribute disproportionately to global diversity, it is important to ask whether they will be especially at risk or relatively protected from the direct and indirect impact of global climate change. Little attention has been given to how endemic rich communities on isolated patches of low-nutrient soil (e.g., Laterite/ferrierites) will respond to climate change. Here we are analysing the effect of climatic components on different levels of diversity, especially endemic species of the microhabitats. A working model is prepared for the analysis of each component is shown below.

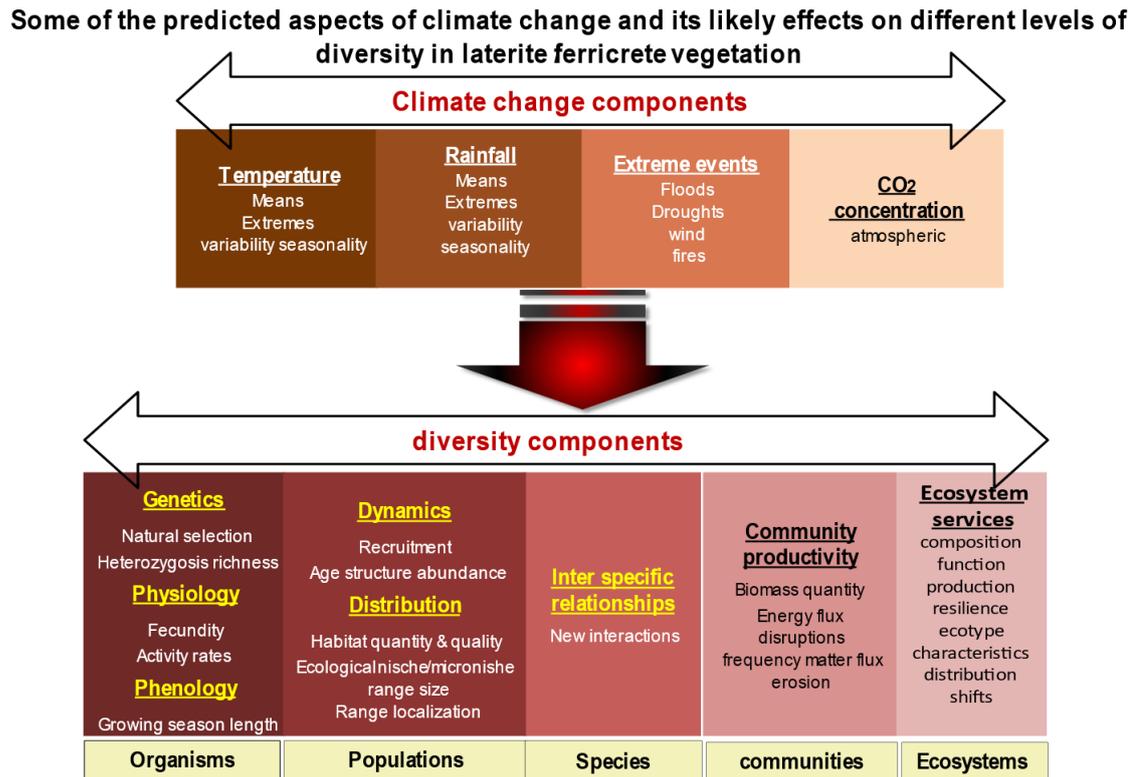


Fig. 26. Working model for analysing the effect of climatic components on different levels of diversity

During this period four exploration studies have been conducted to different lateritic areas of Kannur and Kasaragod districts, resulting the collection of 27 endemic species including two recently reported, one new record for the state, one recollection after 25 years, one regional endemic and one IUCN Red List Category species viz.,

1. *Madhuca insignis* (Radlk.) H. J. Lam. (SAPOTACEAE): IUCN Red list of Threatened species considered this species as ‘Critically Endangered’ category.
2. *Lagenandra cherupuzhica* Biju *et al.* (ARACEAE): A recently discovered species from laterite area, exclusively endemic to Kerala.
3. *Arthraxon raizadae* Jain, Hemadri & Deshp. (POACEAE): Andropogonoid grass, endemic to India, found in Maharashtra, Goa & Karnataka, is reported for the first time from the lateritic plains of Kasaragod district in northern Kerala.
4. *Ischaemum jayachandrani* Ansari *et al.* (POACEAE): A narrow, exclusive endemic species of Kerala collected after 25 years from nearby type locality.
5. *Hedyotis cyanantha* Kurz (RUBIACEAE): A rare species showing ‘Regional Endemism’ (endemic to India & Sri Lanka).

6. *Fimbristylis pokkudaniana* Sunil *et al.* (CYPERACEAE): A newly discovered species collected from the nearby localities.

Conservation of *Lepironia articulata* (Grey sedge), a lesser known, occasionally distributed fibre resource in the low-lying marshy wetlands of Alappuzha district through cultivation and sustainable utilisation with community participation:

Worldwide, the demand for natural fibres and natural-fibre-based eco-friendly products has increased substantially in recent years. Reason for this trend is not only due to an enhanced awareness of the damages caused by synthetic materials on the environment and human health but also attributed to certain advantages of natural fibres such as low-cost, lightweight, renewability, biodegradability, and high specific properties. *Lepironia articulata* (Retz.) Domin., known as Grey sedge, is one such natural fibre resource, which is discontinuously distributed from Madagascar through Indian subcontinent and Malaysia, eastwards to Australia in shallow waters (usually less than 0.8 m deep) in open marshes, swamps and along lakes and streams, often near the coast; the sedge is cultivated in Thailand, Sumatra, Borneo and China for making straws, baskets, mats and artisanal products. With the growing preference for natural fibres, the plant is attaining extensive demand for cultivation and utilisation. Occurrence of *Lepironia articulata* in Kerala was reported a decade ago (Shaji *et al.*, 2009) from an open marsh in Alappuzha district, Therefore, there is a scope for ascertaining the distribution of the species within and in the vicinity of reported location in the coastal belt of Alappuzha district, and to study in detail the mode of propagation leading to development of a package of practice for cultivation, conservation and sustainable utilisation through community participation. As the sedge was found to occur along the fringe areas of an open marsh, such an approach will offer the potential for wetland protection as well. In the above backdrop, the Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram proposes to undertake a Research project, with the following objectives.

- Exploration, relocation, habitat characterisation and mapping of the stands of *Lepironia articulata* in K. V. Jetty and its vicinity, and along the coastal lowland areas of Alappuzha in general.
- Characterisation of the fibre and collection of available information on harvest, post-harvest processing, product development and use.

The project will ultimately evolve a model scheme for cultivation and utilisation of a lesser-known, lesser-utilized plant resource of the wetland system aiding conservation and livelihood enhancement of the local people.

Contributions of vulnerable hydrogeomorphic habitats to endemic plant diversity on Lateritic Plateau:

Laterite form azonal habitat complexes which harbor diverse plant communities. Among this 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 backdrop, a comprehensive study was conducted on different ephemeral pools of laterite dominated ecosystems (special habitats/microhabitats), which 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. Endemic taxa are those restricted to a specified geographical area. The restriction of endemic plant species to nutritionally imbalanced substratum (Laterite, serpentine/ ultramafic) is a widespread phenomenon in endemic rich areas. There is much evidence to suggest that this nutritionally imbalanced substratum provides a strong selective force for the evolution of endemic plants. Therefore, the patterns, correlates, and causes of endemism will vary according to the size and location of the geographical area, as well as the taxonomy and phylogenetic relatedness of the assemblage under consideration. Therefore, endemics of laterite may be categorized according to their spatial distribution, inferred evolutionary age and affinity. categorization of endemics according to evolutionary age and affinity by Englerian dichotomy i.e., Palaeo and neo endemics and depending on the range of occurrence endemics are categorized in 4 contexts of spatial distribution, i.e., Biotope, Stenotope, Political area & Regional endemics. It focuses mainly on the evaluation of endemism patterns from a geographical perspective.

Endemism may have two quite different kinds of origin: (1) the purest form of endemism would be where a species evolves uniquely at a location and remains exclusive to that location; (2) endemism can also occur because of habitat fragmentation or destruction and a subsequent extinction from all localities except one.

Highest degree of endemism of the families is mostly represented from these vulnerable hydrogeomorphic habitats with very narrow distributional range. They may have closely

related taxa occurring in the same area, which also might have developed through speciation, and hence these vulnerable habitats of the lateritic plateau are considered as one of the active centers of speciation.



Fig. 27. *Ceropegia ariyittaparensis* P. Biju et al.; *Dimeria raizadae* V.J Nair et al.



Fig. 28. *Dimeria hohenackeri* Hochst. ex Miq. subsp. *hohenackeri*



Fig. 29. *Dimeria jainii* Sreek. et al.



Fig. 30. *Ischaemum malabaricum* Sreek. et al.



Fig. 31. *Lepturus repens* (G. Fost.) R. Br.



Fig. 32. *Mammea suriga* (Buch. -Ham. ex Roxb.) Kosterm.

Families showing high degree of stenotopic endemism from vulnerable hydrogeomorphic habitats:

Neo endemics vulnerable to local extinction

1. **Eriocaulaceae: *Eriocaulon* L.**, taxonomically considered as one of the most difficult genera of angiosperms in Peninsular India and the Western Ghats. Altogether, there are about 18 species identified from the lateritic plateaus of northern Kerala, of which 14 are endemics including 5 exclusive endemic species. This highest degree of endemism of the genus is mostly represented from these habitats with very narrow distributional range. Following are some narrow endemic species collected from vulnerable microhabitats, viz. *E. gopalakrishnanum* Rashmi. *E. madayiparense* Manju et al., *E. cheemenianum* Biju et al., *E. kannurensis* Sunil et al., *E. devendranii* San. et al., *E. heterolepis* Steud., *E. eurypeplon* Koern., *E. kolhapurense* Gaik. et al., *E. cuspidatum* Dalz., *E. lanceolatum* var. *lanceolatum* Miq. ex Koern., *E. lanceolatum* var. *pilosum* Mold., *E. odoratum* Dalz., *E. truncatum* Buch. - Ham ex Mart., *E. redactum* Ruh., *E. richardianum* (Fyson) Ansari.



Fig. 33. *Eriocaulon richardianum* (Fyson) Ansari & Balakr.

2. **Lythraceae: *Rotala* L.** an aquatic or amphibious, tropical and subtropical genus with a considerable number of phenotypic plasticity (Joseph & Sivar., 1988). Based on the nature of habitats, species of the genus *Rotala* falls under two groups, namely obligate aquatics which grow in shallow waters and semi-aquatic or terrestrials which thrive in marshy lands. In India, the genus *Rotala* is represented by 29 species, with their maximum morphological diversity in Peninsular India manifested by 26 species including 18 endemic taxa. 83% are remarkably endemics which show its evolutionary significance. Kerala is the major centre of distribution for the genus in Peninsular India with 21 species, in which 14 species are endemics, including 9 exclusive endemics. This highest degree of endemism of the genus is mostly represented from the lateritic zones of northern Kerala with very narrow distribution range. Important steno topic (narrow) endemic species from these characteristic geofomations are *R. kanayensis* Shaju & Rajendraprasad (new species collected during the study), *R. malampuzhensis* Nair ex Cook, *R. kasargodensis* Prasad & Raveedran, *R. khaleeliana* Sunil et al., *R. tulunadensis* Prasad & Raveendran, *R. malabarica* Pradeep et al.

3. **Menyanthaceae: *Nymphoides* Seguiet**, a highly ephemeral genus in lateritic plateaus shows extreme endemic diversity with narrow endemism. Out of 5 exclusive endemics species reported from Kerala, 4 species namely *N. krishnakasara* Joseph & Sivar., *N. macrosperma* Nair, *N. palyii* Biju et al., *N. balakrishnanii* Biju et al. represented from the vulnerable hydrogeomorphic microhabitats. These are considered as neo endemic in origin, in the sense that, they develop in different ecological niches or habitats through speciation and will have closely related taxa occurring in the same area. This result in a high degree of local or point endemism among the species and the region can be considered as one of the centres of active speciation of the genus.

4. **Lentibulariaceae: *Utricularia* L.**, carnivorous plants family contains bladder and butterworts (*Pinguicula*), of these bladderworts, belonging to the curious cosmopolitan genus *Utricularia* L., capable of trapping and digesting insects and animalcules. In Kerala it is represented by 12 endemics species, in which 4 endemic species identified from laterite areas. They are *U. malabarica* Janarth. & Henry, *U.*

cecilii Taylor, *U. lazuline* Taylor, *U. reticulata* Sm.- endemic to India and Sri Lanka (regional endemic).

Paleoendemic vulnerable to local extinction

Identification of 3 species of the genera *Lindernia* All., *Crinum* L., *Wiesneria* Micheli and *Euploca* Nutt. (new genus record for India, reported during the study), from vulnerable hydrogeomorphic habitats of lateritic plateaus signifies phytogeographical importance and also strengthens the theories of the Continental Drift (Alfred Wegener, 1912) and Biotic Ferry by sharing common genetic stock of plant species as a result of breaking away of the Southern Super Continent, the Gondwana into two lands mass viz Western Gondwana contains Africa and South America and Eastern Gondwana land with Antarctica, Australia and India with Madagascar (Biju & Bossuyt, 2003; Hedges, 2003). The inferred geological events and subsequent reconstruction of continents may be the possible answers to the present-day distribution.

1. *Lindernia madayiparens* Ratheesh *et al.*, (SCROPHULARIACEAE)
2. *Crinum malabaricum* Lekhak & Yadav (AMARYLLIDACEAE)
3. *Wiesneria triandra* (Dalz.) Micheli (ALISMATACEAE)
4. *Euploca baclei* Nutt. (BORAGINACEAE)

IUCN categorized endemic tree species collected from the Lateritic Riparian belt.

1. *Madhuca insignis* (Radlk.) H. J. Lam. SAPOTACEAE (IUCN: Critically Endangered)
2. *Ochreinauclea missionis* (Wight & Arn.) Ridsd. RUBIACEAE (IUCN: Vulnerable)
3. *Syzygium travancoricum* Gamble MYRTACEAE (IUCN: Critically Endangered)
4. *Chionanthus mala-elengi* (Dennst.) P. S. Green OLEACEAE (IUCN: Endangered)

Other notable observations

Plants in these special habitats often have traits associated with tolerance of drought and nutrient limitations. Following are the characteristic adaptations of the ephemeral plant species in lateritic plateaus.

1. Aquatic resurrection plants/ Poikilohydric cormophytes - Anatomical adaptations to desiccation stress

Crotalaria quinquefolia L. (Fabaceae) and *Ludwigia adscendense* L. (Onagraceae) survive intensive dehydration with a water loss of up to 80-95% of their water content at full turgor and subsequent rehydration. The drastic shrinkage is only possible by the aquatic existence of contractive tracheid. The shrinking process is accompanied by intensive wrinkling of the epidermis, which caused by the tight connection between the plasma membrane and the cell wall resulting in contraction of the whole cell during dehydration. Through this cytorrhysis plasmodesmatal connections between cells are maintained. During rehydration, water uptake may be promoted by capillary trapping of water in stem invaginations (Kluge & Brulfert, 2000)

2. Nitrogen -fixing stem nodules – a promising adaptive mechanism of a wild legume aiding tropical rice cropping system

Aeschynomene aspera (Fabaceae), a wild annual legume growing in periodically water-logged soil. This legume species is characterised by a profuse stem nodulation. Nodules are formed on the stem at the emergence of lateral root primordia, called nodulation sites. Stem nodules exhibit a high nitrogen-fixing potential. Stem modulated accumulated more nitrogen (51 g N m⁻² in 10 weeks) than root nodulated. Because of this nitrogen fixing potential and ability to grow in waterlogged conditions, this species could probably be introduced into tropical rice cropping systems.

Contributions to the IUCN Red List

In continuation to the work on the taxonomic studies of the genus *Cinnamomum* in the Western Ghats, reassessed the status of seven species and included in the IUCN Red List viz., *Cinnamomum filipedicellatum* Kosterm., *Cinnamomum goaense* Kosterm., *Cinnamomum keralaense* Kosterm., *Cinnamomum macrocarpum* Hook.f., *Cinnamomum malabattrum* (Burm. f.) J. Presl, *Cinnamomum perrottetii* Meisner and

Cinnamomum walaiwarensense Kosterm. Alongside this data on the distribution of nine species of *Garcinia* found in the Western Ghats was also submitted supporting the red listing of these species. This includes *Garcinia cowa* Roxb. ex DC., *Garcinia gummi-gutta* (L.) N. Robson, *Garcinia imberti* Bourd., *Garcinia morella* (Gaertn.) Desr. *Garcinia rubro-echinata* Kosterm., *Garcinia talbotii* Raizada ex Santapau, *Garcinia travancorica* Bedd., *Garcinia wightii* T. Anderson and *Garcinia xanthochymus* Hook. f. ex T. Anderson.

A detailed study on *Exacum courtallense* complex was done. A detailed checklist of the genus *Cinnamomum* in India was prepared. Both of this was communicated to an SCI-indexed journal.

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

The genus *Cinnamomum* Schaeffer is a well-known source of the cinnamon of commerce. The genus is represented by about 250–300 species. The species of this genus have long been acknowledged for their economic importance as the sources of camphor and other essential oils, viz., cinnamaldehyde, eugenol, safrole etc. and spices present in the bark, twigs, leaves, roots, flowers, and fruits, phytomedicines, high-quality wood, perfume, sacrificial material, for embalming etc. In India, the genus is represented by 45 species, most distributed in the Eastern Himalayas and the Western Ghats, of which 24 are endemics, with 13 exclusive endemics in the Western Ghats.

During the period under the report, as part of the 14 plant collection trips in connection with multiple projects across the forest areas of Kerala and 94 specimens were collected and processed. Fifty-three specimens of the genus from the previous collections were identified, labelled, and incorporated into the existing collection at TBGT. Based on the study, a comprehensive list of the species in this from India is prepared and published with a short description, phenology, distribution, conservation status as per IUCN Red List, notes, if any and references for full description and illustration. Critical studies were carried out on the specimens generated to understand the diversity within the *Cinnamomum malabattrum* complex.

2) Taxonomic studies of the family Gentianaceae in Southern Western Ghats

Gentianaceae, commonly known as the 'Gentian family', is of great importance as a source of medicine, dye-yielding and ornamentals. In India, the family is represented

by 16 genera and 165 species, of which 7 genera and 43 species occur in the southern Western Ghats. Due to their habitat specificity and herbaceous nature, there is a dearth in the representation of this species in herbaria, and it also lacks comprehensive taxonomic studies. Hence the study has been taken up to bring out a comprehensive account of the family in the southern Western Ghats. During the period, 51 specimens from the family Gentianaceae were collected, processed, identified, labelled, and incorporated into the existing collection. A detailed list of the species occurring in the study area was prepared along with a short description, distribution, photographs, and other relevant notes for a comprehensive account of the taxonomy and distribution of this family.

3) **Establishment of a Biorepository of the plants in the Southern Western Ghats of India with particular emphasis on endemics:**

The Global Genome Initiative (GGI) is a collaborative science-based endeavour funded by BGCI to collect the Earth's genomic biodiversity, preserve it in the world's biorepositories and make it available to researchers everywhere. During the reporting period, a seed grant from GGBN was secured to establish a genomic resource biorepository. The priority was to develop a collection of species in the Western Ghats. Initially, around 30 species endemics to the Western Ghats were identified on priority, which is currently not part of the collections available in GGBN. Nine collection trips were undertaken and collected genetic samples and voucher specimens of 35 species. The database on the collections was prepared and is ready for incorporation with the query database of GGBN.

Herbarium (TBGT)

Herbarium acts as the base for all taxonomy research. JNTBGRI Herbarium (TBGT) is a cross section of plant wealth especially of W. Ghats with 3821 species under 1431 genera and 43504 specimens. Digitalization was carried out for 2100 specimens. There were 449 visitors during the period that include students and researchers.

Conservatories: 1. Custard apple Garden, a repository of the family Annonaceae of Western Ghats with 44 species, 2. Mango germplasm, a resource hub of 126 varieties of local native mango varieties of Kerala. 3. Myristica swamp in the campus, 4. Acanthaceae consists of 40 species 5. *Strobilanthes* Garden with 14 species is maintained.



Fig. 34. The Herbarium of JNTBGRI (TBGT)

DIVISION OF ETHNOMEDICINE AND ETHNOPHARMACOLOGY

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

Important Highlights

- 1) Systematic documentation of Traditional Knowledge (TK) and Bioprospecting through Ethnopharmacological Research, which includes Ethno-medico-botanical survey and systematic documentation of Traditional Knowledge related to plants used for food and medicine.
- 2) Preparation of database on Ethnomedicine/Traditional Knowledge associated with plants used for food and medicine.
- 3) Protection of Traditional Knowledge under Sui generis system, Comparative studies of Ethno-medico-botanical data with Ayurvedic system of medicine for enriching Ayurvedic Pharmacopoeia.

- 4) Selection of plants for detailed Ethnopharmacological and Phytochemical studies pre-clinical studies based on Molecular-Ethnopharmacological approach through activity guided fractionation and Phytochemical studies.
- 5) Pharmacognostic studies of selected medicinal plants/ market samples of raw drugs.
- 6) Integrated drug development programme.
- 7) Technology transfer and commercialization.
- 8) Implementation of participatory programme on “Conservation and Sustainable utilization of Medicinal and Aromatic plants in tribal/rural areas.
- 9) “Herbs for All and Health for All” – Sustainable utilization of locally available medicinal and food plants resources for Primary Health Care.
- 10) Publication of books on various awareness programmes related to biodiversity conservation and sustainable utilization of medicinal/aromatic/wild edible plants.
- 11) Strengthening research in evaluation of quality, safety and efficacy of Ayurvedic/ herbal medicines/ nutraceuticals and Recognition of IPR through Access and Benefit Sharing.
- 12) Extension activities /outreach programme related to traditional knowledge associated with biodiversity and its protection, primary health care and empowerment of rural women.

Important Programmes

1) Implementation of Access and Benefit Sharing - Model II (Salient features of the programme on ABS between KSCSTE - JNTBGRI and Traditional healer)

KSCSTE - JNTBGRI embarked on a novel programme incorporating Science and Technology along with Traditional knowledge (TK) to find mutually beneficial outcome from development projects utilizing TK thereby protecting the traditional rights of the indigenous people. Systematically documented TK provides a platform to the research workers for developing new processes, products, patents, technology transfer, commercialization, benefit sharing etc. The present programme is the second model on Access and Benefit Sharing (ABS) carried out by KSCSTE - JNTBGRI after “JEEVANI”, an Ayurvedic drug formulated and developed including a medicinal plant based on tribal information of which the technology was transferred, commercialized and the ABS mechanism thus implemented known as “TBGRI model of Benefit sharing” won the UN Equator Initiative prize at the World summit on Sustainable development held in Johannesburg in August 2002. In this

programme, the traditional healer, Sri. T. M. Shahul Hameed Vaidya, aged 61 yrs., residing at Karunagappally, Kerala disclosed information based on a medicinal plant claimed to possess anti-diabetic, hepatoprotective and anti-fatigue properties after signing the Prior Informed Consent. A Contractual agreement for the transfer of traditional knowledge was signed on June 2nd2009 between Sri. T. M. Shahul Hameed Vaidya and Ethnomedicine & Ethnopharmacology Division of JNTBGRI for conducting the preclinical studies.

The objective of the preclinical studies was to scientifically evaluate the anti-diabetic, hepatoprotective and anti-fatigue properties as claimed by the traditional healer. The ultimate objective of the preclinical study was to develop a single drug/poly herbal formulation which possesses anti-diabetic, hepatoprotective, anti-fatigue and antioxidant effects.

The preclinical studies carried out revealed that the given coded drugs (Single and Polyherbal formulations) possess significant anti-diabetic, hepatoprotective, anti-fatigue and antioxidant properties as claimed by the traditional healer. Further studies suggested are isolation of molecules responsible for the therapeutic activity, gene expression level studies, drug development etc. followed by clinical trials according to the National/International guidelines. A monograph has also been published on this programme.

Based on the outcome of the study, a Patent application was filed with the title 'A novel polyherbal formulation with multiple therapeutic effects as anti-diabetic, hepatoprotective, anti-fatigue and antioxidant' (Application No. 2277/CHE/2011) at the Regional Patent Office, Chennai and an Indian patent has been granted for the same in 2021. Sri. Shahul Hameed Vaidya was also included as one of the inventors in the patent application. This could be the first case study on ABS where a traditional Healer was included as one of the inventors.

1) **Anti-virals from medicinal plants of Western Ghats selected based on Traditional Knowledge (TK)/ Ethnomedical information (KSCSTE JNTBGRI - DBT Programme support project - A 193 B4**

An anti-viral molecule with significant activity against Chikungunya virus was discovered from an ethno-medicinal plant, chosen based on traditional/ ethnomedical information and a provisional product patent has been filed on the discovery of this anti CHIKV molecule. It is a joint venture between Ethnomedicine &

Ethnopharmacology Division and the Phytochemistry & Phytopharmacology Division of KSCSTE- JNTBGRI as part of DBT programme support project in collaboration with RGCB, Thiruvananthapuram, Kerala, India.

2) Development of Tropical Herbal Health Mix” based on Traditional knowledge for Nutritional deficiency and livelihood enhancement of Rural Unemployed Women

In connection with Chief Minister’s 100 days programme, a project was conducted by KSCSTE_ JNTBGRI, with Dr. Binu. S, Principal Scientist as PI and Dr. Suja. S.R. Principal Scientist & Head as Co PI.

There is a critical need of creating data on traditional knowledge-related food and nutrition practices to address the health challenges. The implementation of this project has its relevance as Traditional knowledge of Kerala is a repository of natural foods which could possibly be used to promote food security, nutrition, and health for the people. We have successfully addressed the objectives, developed the above six herbal products and imparted skill development and empowerment.

Products developed are Tropical Herbal Health Mix, Tropical Vettila shampoo, Tropical ‘Naruneendi’ syrup, Tropical Lizard repellent spray Tropical room refresher Tropical Fumigation Powder. The present programme gains its importance as it highlights the development of a safe, cost effective “Herbal Health mixture” based on traditional knowledge for combating nutritional deficiency. Livelihood enhancement of unemployed women through local production of herbal Products/ homecare products to attain improved standards of living .2.

3) Systematic documentation and Bioprospecting of ethnomedically important medicinal plants on tribal/traditional knowledge through molecular pharmacological approach” (P003)

The main objective of the project is to undertake a detailed field survey, inventorization and documentation of ethnobotanically important plant species used by the people inhabiting in the coastal and tribal areas of Kerala. The pandemic period of COVID-19 in Kerala during the financial year of April 2020 to March 2021, the pandemic restrictions and lockdown adversely affected the project work and restricted field work in the coastal and tribal areas of Kerala. On other hand, the data

analysis work of seven Gramapanchayats where field trips were undertaken during the period January to March in 2019 were completed.

As part of the research work of the project during the financial year, April 2021 to March 2022, conducted field trips to tribal areas of Kuttampuzha Gramapanchayat of Ernakulam district and Pothukallu Gramapanchayat of Malappuram district and coastal areas of Perumbadappu Gramapanchayat of Malappuram district. The data decoding and analysis of information documented during the field trips were completed. The information documented in total is 267 information were documented which includes 95 single drug information, 70 information on combinations drugs, 42 information of food plants/food preparations, 39 information on tools and artefacts and 21 other miscellaneous information from 45 knowledge providers.

As part of the scientific validation of the plants based on traditional knowledge,

- Fractionation of hydroethanolic extract of coded plant was completed with Hexane, Chloroform, Butanol and Water. The thin layer chromatographic analysis (TLC) and Column chromatography of hydro ethanolic extract of coded plant (RN) was completed with different solvent systems,
- Hydro alcoholic extract of coded plant RN root was subjected to *in-vitro* anti-inflammatory activity, through Albumin denaturation assay, proteinase inhibitory activity, membrane stabilization and anti-lipoxygenase activity. The results obtained significant level of protection in 400 µg/ml to 800 µg/ml extracts.

4) Identification of potential bioactive chemical marker compounds and biological studies of *Gloriosa superba* and their geographical variations

The project is proposed to identify elite accessions of (*Gloriosa superba*), based on active principal content (colchicine) from different states of South India and to scientifically validate its therapeutical potential in the treatment of inflammation, ulcer, wound etc. in rats. The plant was under threatened category due to its imprudent harvesting from wild as it is extensively used by medicinal industries for its colchicine content. In the current scenario, a superior verity of germplasm identification from their wild ancestor is urgently required. *G. superba* plants were collected from Kerala (KL), Tamil Nadu (TN), Karnataka (KA) and Andhra Pradesh (AP) states of Southern India. The rhizomes of accessions collected from Wayanad district in Kerala state (914.24

ng/10 µg extract) showed maximum colchicine content compared to other accessions. From the results of *in vitro/ in vivo* pharmacological studies, histopathological studies, and molecular expression studies in the present programme it is revealed that acetone fraction (Acetone fraction -GSAF) of Wayanad accessions of *Gloriosa superba* is a suitable candidate for therapeutic applications pertaining to inflammation, ulcer, and wounds. The study gains its importance due to its high pharmacological value, the presence of important alkaloid, colchicine, and the identification of elite accession. The objectives pertaining to JNTBGRI for the project is fulfilled and it is recommended that due its low germination capacity, new Biotechnological approaches may be employed in *in situ* and *ex situ* multiplication in general and micropropagation of the elite accessions in particular to conserve the plant as it is an endangered plant to meet the ever-increasing demand of farmers and the pharma industries. Awareness programmes and responsiveness should be implemented among the common people about the importance of *G. superba* in therapeutical applications to address inflammation, ulcer, and wounds etc. Chemo-taxonomical studies and long-term preservation of plant propagules in seed bank, pollen bank, DNA libraries, etc. is also warranted.

As part of the implementation of the NMPB funded project entitled “*Identification of potential bioactive chemical marker compounds and biological studies of Gloriosa superba and their geographical variations*”. The project is proposed to identify elite accessions of (*Gloriosa superba*), based on active principal content (colchicine) from different states of South India and to scientifically validate its therapeutical potential in the treatment of inflammation, ulcer, wound etc. in rats. The plant was under threatened category due to its imprudent harvesting from wild as it is extensively used by medicinal industries for its colchicine content. In the current scenario, a superiority of germplasm identification from their wild ancestor is urgently required. *G. superba* plants were collected from Kerala (KL), Tamil Nadu (TN), Karnataka (KA) and Andhra Pradesh (AP) states of Southern India. The rhizomes of accessions collected from Wayanad district in Kerala state (914.24 ng/10 µg extract) showed maximum colchicine content compared to other accessions. From the results of *in vitro/ in vivo* pharmacological studies, histopathological studies, and molecular expression studies in the present programme it is revealed that acetone fraction (Acetone fraction -GSAF) of Wayanad accessions of *Gloriosa superba* is a suitable

candidate for therapeutic applications pertaining to inflammation, ulcer, and wounds. The study gains its importance due to its high pharmacological value, the presence of important alkaloid, colchicine, and the identification of elite accession. The objectives pertaining to JNTBGRI for the project is fulfilled and it is recommended that due its low germination capacity, new Biotechnological approaches may be employed in *in situ* and *ex situ* multiplication in general and micropropagation of the elite accessions in particular to conserve the plant as it is an endangered plant to meet the ever-increasing demand of farmers and the pharma industries. Awareness programmes and responsiveness should be implemented among the common people about the importance of *G. superba* in therapeutical applications to address inflammation, ulcer, and wounds etc. Chemo-taxonomical studies and long-term preservation of plant propagules in seed bank, pollen bank, DNA libraries, etc. is also warranted.



Fig. 35. AYUSH doctors participated in the training programme with JNTBGRI.



Fig. 36. Forest exploration with the informant



Fig. 37. Awareness and training programme at Pothukallu Gramapanchayat



Fig. 38. Awareness and training programme at Perumbadappu Gramapanchayat



Fig. 39. Interaction with the Traditional Kani Tribal Healer, Sri. Pachan Kani at Amboori Gramapanchayat



Fig. 40. Interaction with Kaattunaikka tribal community of Pothukallu Gramapanchayat, Malappuram



Fig. 41. Interaction of AYUSH doctors with the Chief Guest, Dr. S. Rajasekharan during JNTBGRI Medicinal Garden visit on the first day of the training programme



Fig. 42. JNTBGRI Ethnopharmacology lab visit by AYUSH doctors

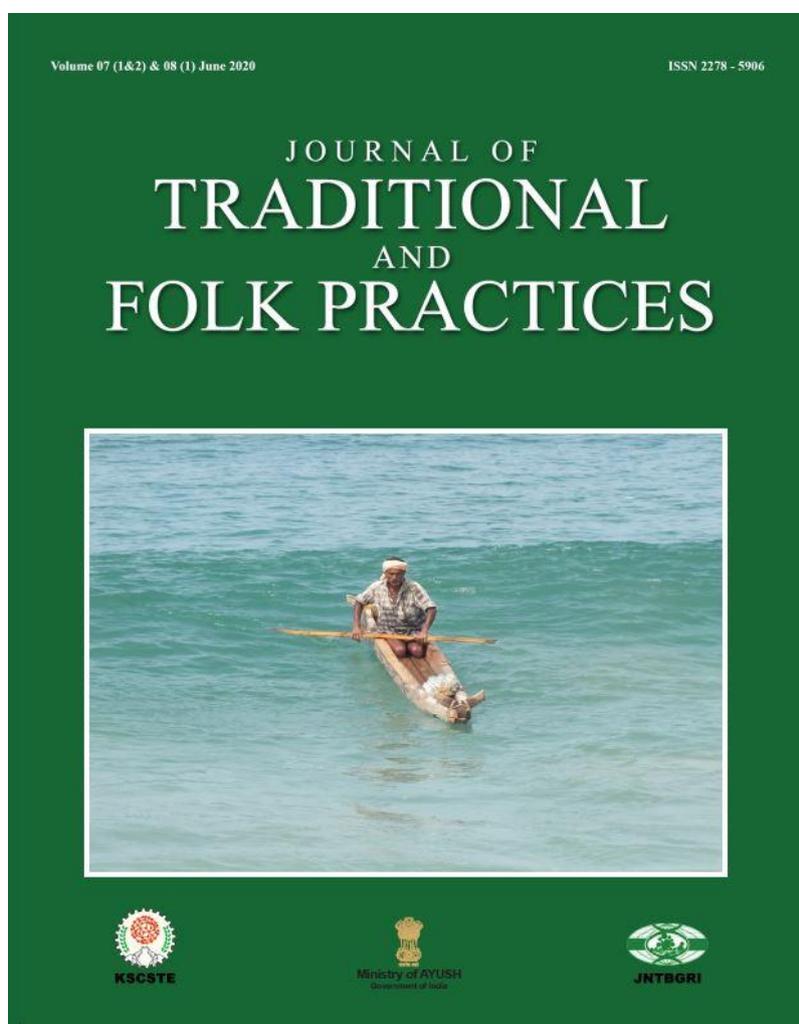


Fig. 43. Vol. 7 (1&2) and 8 (1) issue June 2020 of Journal of Traditional and Folk Practices

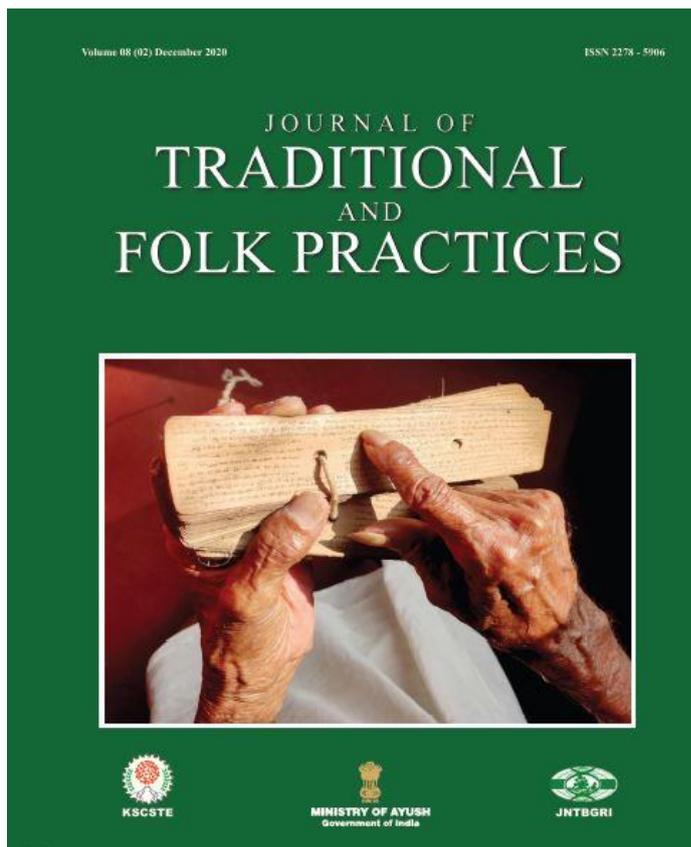


Fig. 44. Vol. 8 (2) issue December 2020 of Journal of Traditional and Folk Practices



Fig. 45. Website developed for the AYUSH Project

Fig. 46. Effect of GSAF treatment on the relative mRNA expression of TNF- α , IL-1 β , IL-6 and COX-2 in ethanol-induced ulcer in rats

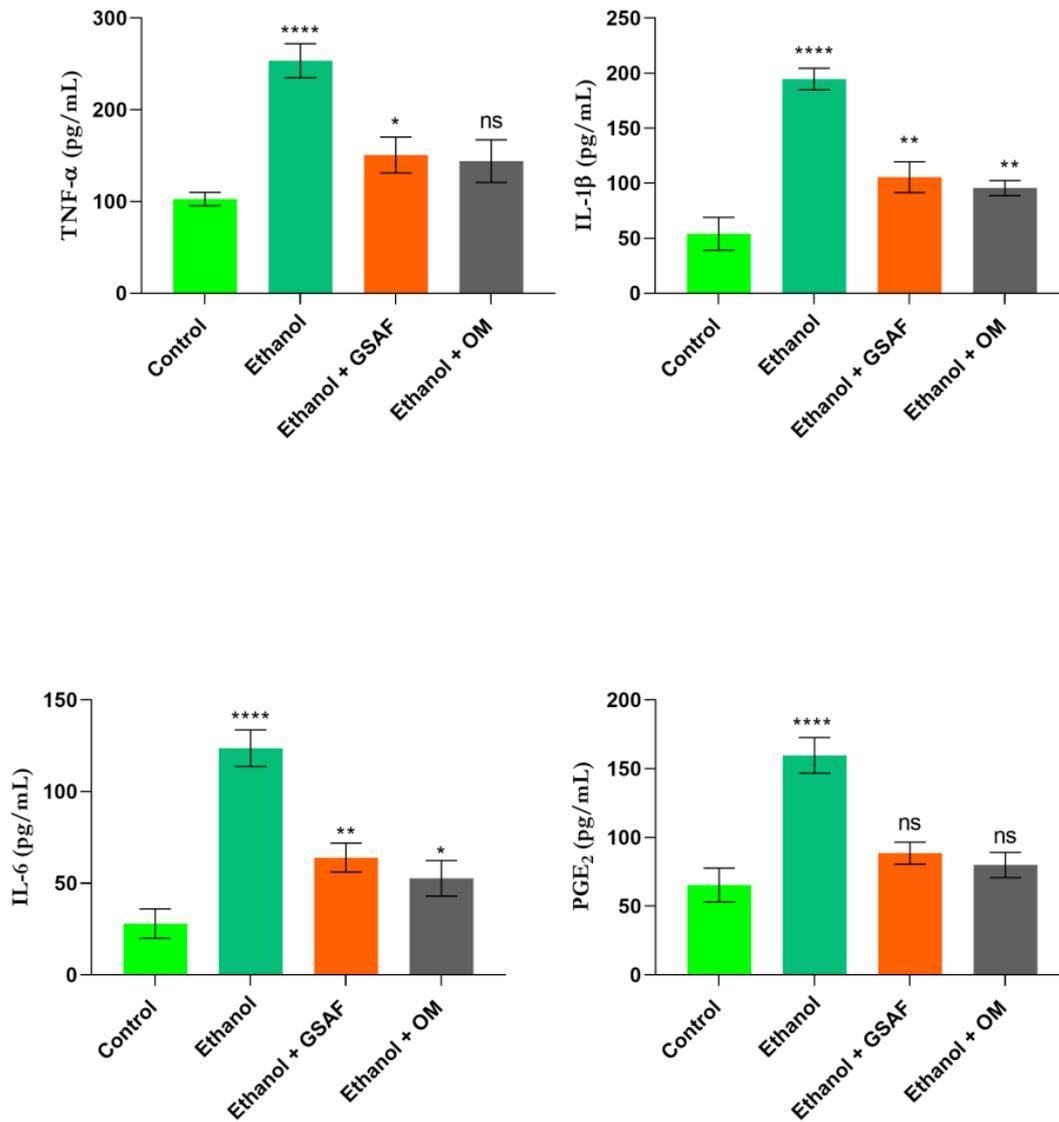


Fig. 47. Effect of GSAF treatment on the TNF- α , IL-1 β , IL-6 and PGE₂ in ethanol-induced ulcer in rats

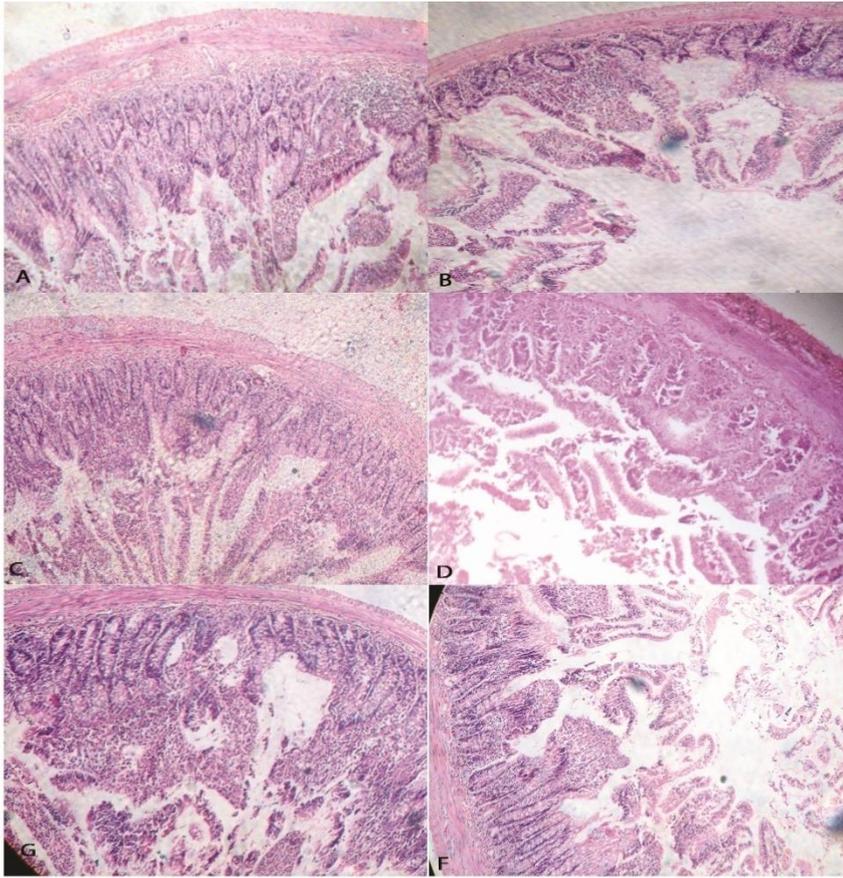


Fig. 48. Histopathology of gastric mucosa. (A) Normal group showing its normal appearance. (B) Control group treated with 1 mL of absolute alcohol showing ulcer area, mucosal edema and leucocyte infiltration (H&E staining). (C) Alcohol-induced ulcer treated with Omeprazole 20 mg/kg. (D - F) Alcohol-induced ulcer treated with the GSAF 50, 100 and 150 mg/kg respectively.

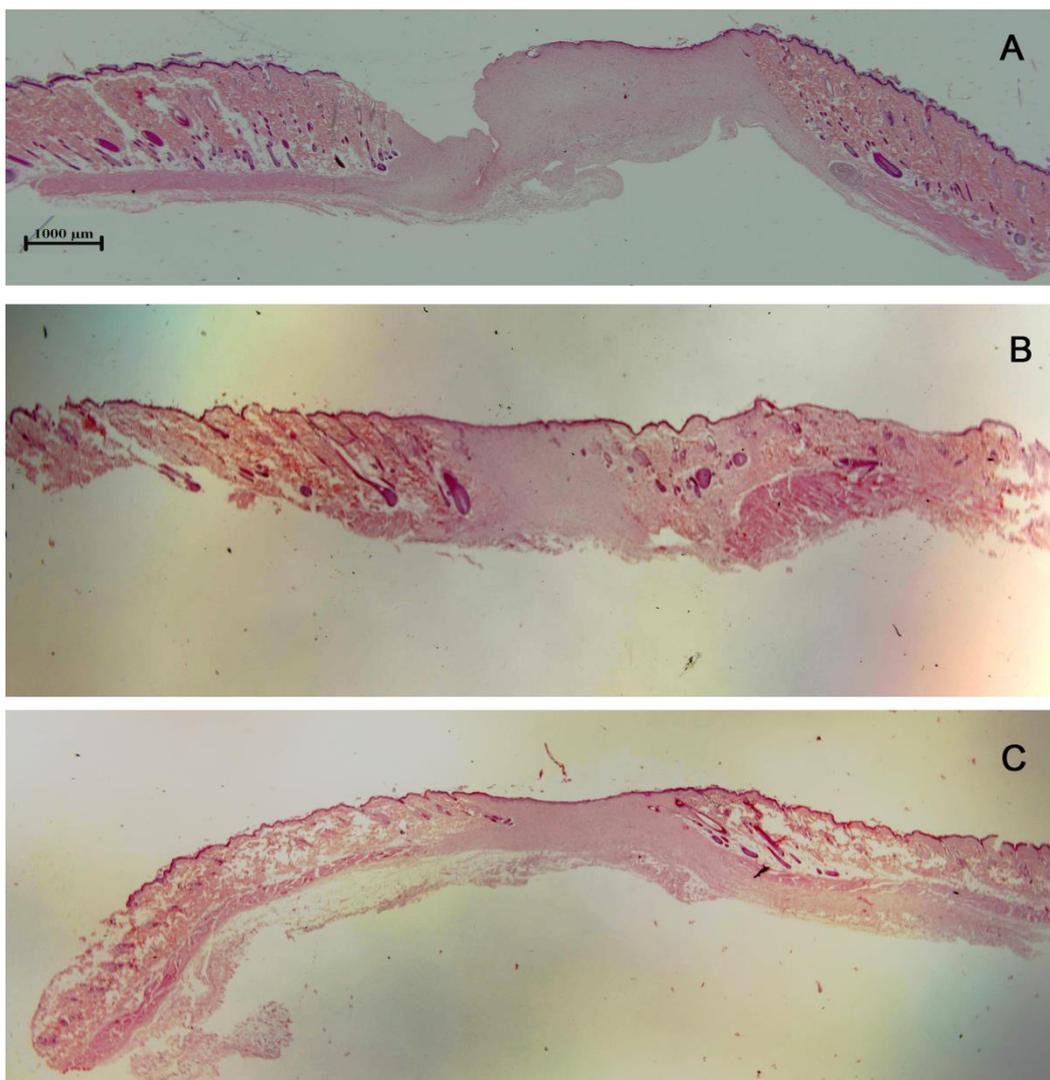


Fig. 49. Histological examination of excision model skin wounds in rats. (A) Skin of control rat showed injured epithelisation. (B) Povodine Iodine treated rat showed complete epithelialization, lack of inflammatory cells and large number of blood capillaries. (C) GSAF showed complete epithelialization on day 18.

5) **Systematic Documentation of Traditional Knowledge Related to Plants used for Food and AYUSH & Indigenous Medicine” funded by Ministry of AYUSH, Govt. of India sanctioned to Kerala State Council for Science Technology and Environment, Govt. of Kerala (A114).**

During the month of March 2021, six field trips were conducted in Kulathupuzha forest area of Kollam and Kallar, Bonaccord, Vazhvanthole, Njaraneeli and Amboori forest areas of Thiruvananthapuram districts. Interviewed 38 informants and collected 264 information from the field related to plants used for food and medicine as single drug, combination drug and food. As part of the one of deliverables of the project, published Vol. 7 (1&2) and 8 (1) issue June 2020 and Vol. 8 (2) December 2020

issues of the Journal of Traditional and Folk Practices which 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. A website for the project has been developed with the technical support from C-DIT, Government of Kerala (<https://www.webtestingonline.com/tbgri>) as part of the project and upgraded the database software developed on the first phase of the project (2009-2010) for digitization and pooling of data documented to the latest version for making the software more compatible and updated with the new search engines and for efficient functioning of the database.

6) Livelihood Enhancement of Tribal of Njaraneely Ward of Peringammala Panchayat, Thiruvananthapuram, Kerala through plant resource enrichment, buy back and Herbal products development.

A total of 13 Herbal/Home care products like Herbal tea, Herbal mix, Herbal oil, Herbal mosquito repellent agarbathies, herbal soap and other home care products were developed, and skill development training were given to the tribal women. The products are the programme will also provide livelihood enhancement - based training and capacity building to unemployed women in Thiruvananthapuram district to help them to build marketable skills to create enhanced and alternative possibilities for income generation to increase their financial abilities through the development of herbal/home care products to afford better healthcare and attain improved standards of living. Empowerment of unemployed rural women economically by providing them with skills and support for the development of Herbal/ Home care products for livelihood enhancement. Conducted five days training programme and skill development programme for the development of Herbal/ home care products for Njaraneeli tribal women at KSCSTE- JNTBGRI.

DIVISION OF MICROBIOLOGY

The Microbiology division orchestrates programmes that explore the Microbial Diversity of Kerala state. The scientific programmes are designed to explore the microbial diversity of Kerala and discover the new species of macro, micro fungi, lichens, and microbes. These new and noteworthy species will be screened for various properties of therapeutic importance. Microbial secondary metabolites will be screened for anticancer, antimicrobial and antibiofilm agents. The therapeutically viable metabolites are further explored to elucidate the mechanism of action employed in instrumenting the therapeutic action. The division also maintains a well-established Mushroom herbarium with over 19000 accessions and a microfungus and lichen herbarium.

Important achievements

- a) Various forests of Kerala were surveyed for Mushrooms and 745 samples of Mushrooms were collected and processed. Five new species of mushrooms and twelve new Indian records were discovered from Western Ghat Forests. Thirty-one gene sequences were deposited in GenBank. A mushroom Herbarium is maintained with 18767 accessions in the division. Follicolous herbarium holds 7100 samples while Lichen herbarium accommodates 3740 samples.
- b) A Book on Poisonous mushrooms describing 40 poisonous mushrooms of Kerala was published.
- c) New species of Mushrooms discovered: During the period of report, altogether six new species were discovered and described.
- d) **Discovery of a noteworthy *Agaricus***: During our on-going studies on the genus *Agaricus*, several edible and medicinally important species were collected on several occasions from JNTBGRI campus and other regions of Kerala. It includes *Agaricus gratolens*, *A. subrufescens*, *A. flocculosipes*, *A. bitorquis* and *A. bingensis*. Of these, *A. subrufescens* (“almond mushroom”) is an edible and medicinal mushroom with many pharmaceutical properties such as anti-cancer, anti-microbial and immune-modulatory properties.



Fig. 50. A) *Agaricus subrufescens*; B) *Agaricus flocculosipes*

- e) Urdamycin V treatment led to induction of programmed cell death pathway in cancer cell, p53 independent apoptosis. PARP cleavage, activation of caspases (caspase 9 and caspase 3), nuclear condensation evidenced cell death via apoptosis. Modulation of phosphorylation events in signal proteins like ERK1/2 and p38 were also observed that can be correlated to induction of programmed cell death.
- f) Urd A showed strong antimicrobial property towards the tested human pathogens *Streptococcus pyogenes*, *Staphylococcus aureus*, and *Mycobacterium smegmatis*. The most potent activity was towards *Streptococcus pyogenes* with a minimum inhibitory concentration of 5ug/mL. The compound also showed strong antibiofilm activity against biofilm formation *Streptococcus pyogenes*. The antibiofilm activity was witnessed at 1ug/mL.
- g) Described three species and one variety of foliicolous fungi new to science from various forest localities of Kerala part of Western Ghats. Recorded 15 lichens new to India and 11 new to Kerala State from different forest areas. In collaboration with National Botanical Research Institute (CSIR-NBRI), 35 secondary metabolites that are isolated from lichens were tested for biological activities and are listed along with their structure, substance class, and occurrence. Further, bioprospecting studies were also initiated.

LIBRARY AND INFORMATION CENTRE (LIC)

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

Books:6583

Theses: 178

Technical Reports: 163

Reprints: 1600

Journals: (Indian) 18; Foreign 12 (Print +Online)

Back volumes of journals: 3546

Reports:965

CDs: 34

Operations and services of Library are automated. The services of Library are accessible through campus LAN to enable member's access from their desktops.

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

During these periods 20 books were added newly. The database of books and journals is being updated on day-to-day basis with details of recently acquired materials. Facilities are provided for scientists/students/researchers for Internet browsing. To cater the information needs for scientists/researchers/ students the library provides the following services.

1. Selective dissemination of Information
2. Current awareness services
3. Indexing services
4. Bibliographic services
5. Conference alert services

6. Press clippings services.
7. Reprographic services
8. Internet browsing services.
9. Reference services
10. Document Delivery services.
11. Literature Search Services

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

The JNTBGRI Library has membership in International Association of Plant Taxonomy & Botanical Gardens Conservation International.

The library regularly compiled and updated:

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

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

Sale of JNTBGRI Publications is through the library.



Fig. 51. JNTBGRI Library

MoU AND COLLABORATIONS

- JNTBGRI signed a Memorandum of Collaboration in March 2022 with Uttarakhand Forest Department, for promoting scientific research on threatened species and their *in-situ* and *ex-situ* conservation.
- Signed a MoU between the University of Kerala and JNTBGRI for digitizing the herbarium of the University of Kerala.
- MoU with Directorate of Sports and Youth Affairs, Govt. of Kerala for the development of aesthetic landscaping and gardening at G.V. Raja Sports School, Thiruvananthapuram.
- The Biotechnology and Bioinformatics Division of JNTBGRI maintains collaboration with ICMR- NIRT for in vitro anti-tuberculosis activity screening of plant extracts and phytochemicals.
- MoU signed with Energy Management Centre, Sreekariyam in connection with consultancy project sanctioned by the EMC.
- JNTBGRI signed a MOU 30th March 2022 with Care KERALAM (P) Ltd., Thrissur for composition and process for preparing herbal Mosquito repellents and their use.

- Signed a MoU with National Centre for Disease Control (NCDC), Cherthala, Government of India.
- Signed a MoU with National Centre for Disease Control (NCDC), Mettupalayam, Government of India.
- Signed a MoU with the Division of Plant Genetic Resources, Indian Institute of Horticultural Research ICAR-IIHR, Bangalore, Government of India.
- JNTBGRI signed a MoU with Department of Semiochemicals Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad, Government of India.
- Signed a MoU with VSSC, ISRO, Trivandrum, Government of India.
- University of Kerala, Thiruvananthapuram.
- Cochin University of Science and Technology, Kerala.
- Indian Institute of Technology, Guwahati.
- Indian Institute of Technology, Bombay.
- Kerala Agricultural University, Vellayani.
- Sree Chitra Tirunal Institute of Medical Sciences and Technology, Trivandrum.
- CEP-SHRESTA-KSCSTE collaboration with University of Oklahoma Health Sciences Center, Oklahoma City, USA.
- Signed a MoU with National Chemical Laboratory, Pune in 2023 on the natural product discovery from microbes.
- Signed a MoU with National Chemical Laboratory, Pune in 2023 on the Natural product based synthetic anticancer drugs.
- Signed a MoU with Rajiv Gandhi Centre for Biotechnology, Trivandrum in 2023 on the anticancer microbial metabolite study.

Ph.D. AWARDED

1. Anju Sudhakaran, 2021. *Ex situ* conservation and Chemical characterization of *Etilingera fenzlii* (Kurz) Skronick. & M. Sabu (Zingiberaceae) - The honeybee repellent endemic plant species of the Andaman Nicobar Islands. University of Kerala.
2. Anu, S., 2021. Isolation and characterization of Starch from the Rhizomes of *Curcuma* species in South India with Special Emphasis on Validation of its Edible Value. University of Kerala.

3. Gouri Priya Renjit, 2021. Identification and profiling of miRNAs regulating triterpenoid biosynthetic pathway in *Centella asiatica* (L.) Urb. University of Kerala.
4. Govind, M. G., 2021. Chemotaxonomic Studies on the Family Myristicaceae from the Western Ghats. University of Kerala.
5. Krishnakumar, N. M., 2020. Immunomodulatory and antioxidant potential of *Morinda umbellata* L., - a traditionally important medicinal liana. University of Kerala.
6. Murugesan, K., 2021. Intraspecific Variability Studies on *Pellionia heyneana* Wedd. (Urticaceae), an Ethnomedicinally Important Plant. University of Kannur.
7. Ratheesh, S., 2021. Taxonomic Studies on *Russula* (Russulaceae) of Kerala. University of Kerala.
8. Sakthipriya M, 2021. Genetic association mapping for major quantitative traits in *Centella asiatica*. University of Kerala.

ON GOING Ph.D. PROGRAMMES

1. Ajinsha, J. S. Ethnobotanical study of Muthuvan Tribes of Idukki District of Kerala. University of Kerala.
2. Aleena Joseph. Assessment of Anti-inflammatory, Anti-arthritis, and Wound healing potential of *Malaxis versicolor* (Lindl.) Abeyw. through molecular pharmacological and green synthetic approach. University of Kerala.
3. Anooj, S. L. Ethno botanica study of Kani Tribes in the Western Ghats of Kerala. University of Kerala.
4. Arya, C. P. Taxonomic and Phylogenetic Studies on the Genus *Agaricus* (Basidiomycota) of Kerala.
5. Arya, S. Studies on Floral Variations in *Clitoria ternatea* L. and its inheritance pattern' from the University of Kerala.
6. Aswathy Anand. Utility of Semiochemicals and exploitation through *in vitro* technology of *Etlingera fenzlii*, an ethnobotanical insect repellent plant species of the Andaman Nicobar Islands in pest/insect management and its popularization as eco-friendly mosquito repellent Products. University of Kerala.
7. Aswathy, V. Nair: Insights into the Anti-Inflammatory, Wound healing and Gastroprotective potential of *Phyllocephalum rangacharii* (Gamble) Narayana, an ethnomedicinal plant used by Cholanaikkan tribe of Kerala. University of Kerala.

8. Athira, M. Systematic documentation, phytochemical analysis and comparative toxicological evaluation of *Thottea siliquosa* (Lam.) Ding Hou with tribal herbal preparations of Kerala. University of Kerala.
9. Divya, N. Murali. Documentation of Wild Relatives of Edible Cultivated Crops of Agashyamalai Biosphere Reserve in Kerala Region and Conservation strategies of Selected Taxa. University of Kerala.
10. Geetha R. Nair. Antihepatotoxic, antioxidant and Pharmacognostic studies of *Asystasia chelonoides* Nees var. *chelonoides* (Acanthaceae). University of Kerala.
11. Jisha Daniel. Systematic Studies and Phylogeographical Affinities of Family Oxalidaceae - Southern Western Ghats, India.
12. Keerthi Sugathan. *In silico* and *in vitro* evaluation of anti-Covid-19 activity in selected plant-derived nutraceuticals. University of Kerala.
13. Keerthi, V. Systematic Studies on the Genus *Pluteus* (Basidiomycota, Fungi) of Kerala State.
14. Lakshmi C. S. In-vitro studies on an endangered medicinal herb *Curculigo orchioides* Gaertn. For conservation, consistent production and metabolic profiling of a high value bioactive compound Curculigoside. University of Kerala.
15. Lekshmi S. Nath. A Molecular Pharmacological approach on the assessment of Hepatoprotective and Anti-inflammatory potential of *Lagenandra ovata* (L.) Thwaites an ethnomedicinal plant. University of Kerala.
16. Mohammed Ali Noushad. Analysis of changes in gene expression and identification of differentially expressed miRNAs in cardamom cultivated in high and low altitude areas. University of Kerala.
17. Nayana, P. K. Morpho-and molecular taxonomic studies on the genus *Candolleomyces* (Psathyrellaceae, Basidiomycota) of Kerala State.
18. Remya, R. Phytochemical profiling and pharmacological investigation in *Plectranthus vettiveroides* (K. C Jacob) N. D. Singh & B. D. Sharma.
19. Revathy, S. Development of Molecular Markers and Population Genetic Structure Analysis of *Cullenia exarillata* A. Robyns (Bombacaceae), an Endemic Species from Western Ghats. University of Kerala.

20. Rijuraj, M. P. Studies on the Lateritic flora and their Ecological adaptive Significance in Northern Kerala, India.
21. Shaina Jerald. *Ex-situ* conservation of Selected Economically Important Lesser-Known Species of the Andaman & Nicobar Islands. University of Kerala.
22. Shefin, B., Validation of the efficacy of anti-tuberculosis activity in selected nutraceutical plants through *in silico* and *in vitro* screening methods. University of Kerala.
23. Shibin Felix. *Ex situ* conservation, molecular and chemical profiling of ‘sweet flag’ (*Acorus calamus* L.) from the Western Ghats. University of Kerala.
24. Soorya, S. Development of molecular markers for sex determination in Palmyra palm. University of Kerala.
25. Soumya S. Dharan. Comparative transcriptome profiling in cardamom along an altitudinal gradient through RNA-seq analysis. University of Kerala.
26. Sreedevi S. Kumar. Scientific validation of comparative antidiabetic effect of root extract and pod extract of *Cyamopsiste tragonoloba* (L.) Taub. with special emphasis on diabetic complications. University of Kerala.
27. Sreeja Devi, P. Phytochemical profiling and biological activities of different jack fruit (*Artocarpus heterophyllus* Lam.) genotypes of Kerala. University of Kerala.
28. Sreejesh, K. M. Morphological and Molecular Taxonomy the Genus *Miliusa* Lesch. ex A. DC (Annonaceae) in India. University of Kerala.
29. Subin Mathew. *In silico* and *in vitro* screening and identification of lead compounds against hepatitis B in selected plants.
30. Suchitra G. Krishnan. Systematic Studies of Family Aristolochiaceae from the Western Ghats. University of Kerala.
31. Suresh Kumar, P. Collection, Documentation and Conservation Strategies of Selected Promising Wild Ornamental Plants of Kerala. University of Kerala.

HONOURS/ AWARDS/ RECOGNITIONS

1. Achuthan, S. has won the best paper award in the National Seminar on Fundamental and Applied Dimensions in Plant Sciences, organized by KSCSTE-JNTBGRI, Thiruvananthapuram, 24th& 25thMarch, 2022.
2. Akhilesh, S. V. Nair has won the best oral presentation award in the International Conference on Sustainable Utilization of Bioresources conducted by the Department of Botany, University of Kerala, January 2022.

3. Akhilesh, S. V. Nair has won the best paper award in the National Seminar on Fundamental and Applied Dimensions in Plant Sciences Organized by KSCSTE-JNTBGRI, Thiruvananthapuram, 24th & 25th March, 2022.
4. Aleena Joseph has bagged the best poster award, 2021 on the topic “A glance into the potential of *Azolla pinnata* R. Brown, an aquatic pteridophyte - Evaluation of its Biomass production and nutritive value” in the First International conference of NABS for Life Sciences, Contemporary approaches in Biological Sciences for Food, Health and Nutrition held during 26-28, August 2021 at the Annamalai University, Tamil Nadu.
5. Anurag Dhyani received Indian National Science Academy (INSA) Visiting Scientist Award 2021.
6. Anurag Dhyani working as Editor of the journal Plants, People, Planet, UK; Section Editor of Journal of Seed Science, Brazil, Subject Editor of Neotropical Biology and Conservation, Brazil and Associate Editor of Conservation Science & Practice, USA and Frontiers in Conservation Science, Switzerland.
7. Aparna, G. S. has won the best paper award in the international seminar on ‘Plant Chemistry, Gene Prospecting and Clinical Biology- 2022’, organized by Kerala Academy of Sciences, Thiruvananthapuram and Department of Chemistry, Mar Ivanios College, Thiruvananthapuram, on November 10th and 11th, 2022.
8. Arya, M. R. has received the best paper award, 2021 on the topic “Crossability studies in *Clitoria ternatea* L.” in the International Conference on New Horizons in Plant Science, Department of Botany, University of Kerala, Thiruvananthapuram during 4-9th January, 2021.
9. Jinu Mathew has won the best paper award in the International Seminar on ‘Plant Chemistry, Gene Prospecting and Clinical Biology- 2022’, organized by Kerala Academy of Sciences, Thiruvananthapuram and Department of Chemistry, Mar Ivanios College, Thiruvananthapuram, on November 10th and 11th, 2022.
10. Keerthi Sugathan, J. has bagged best paper presentation award, 2021 on the topic “*In-silico* evaluation of anti-SARS-CoV-2 activity in *Carica papaya* L. in the International Webinar on ‘Phytochemistry- Impacts and Applications’, Kerala Academy of Sciences. P. 49. ISBN No.: 978-81-951912-5-3.
11. Keerthi Sugathan, J. has bagged the best poster presentation award, 2021 on the topic ‘*In silico* evaluation of anti-SARS CoV 2 activity in *Aegle marmelos*’, in the 33rd Kerala Science Congress organised by KSCSTE from 25-01-2021 to 30-01-2021.

12. Pradeep, C. K. was selected as Council Member of Journal Kavaka (Official Journal of Mycological Society of India).
13. Pradeep, C. K. was selected as Section Editor (Fungi, Basidiomycota) of *Phytotaxa*, a leading international journal of Taxonomy.
14. Praseetha, S. has bagged the best paper award, 2020 on the topic “Evaluating Anti-Bio film Potential of Essential oil from *Hedychium larsenii* against *Streptococcus pyrogenes* and Toxicity assessment in *Danio rerio*” in the International Conference on Anti-microbial Resistance and Micro biome, Under Changing Climate organized by Pondicherry University during 10th to 12th October 2020.
15. Priya Rani, M. has won the best Poster Award in the Scientific Social Responsibility, Scientist category of the 34th Kerala Science Congress, organised by KSCSTE. 27-29, January 2022.
16. Radhakrishnan, K. has assisted the preparation of Ethnobotany M.Sc. syllabus for the University of Kerala.
17. Sabulal, B. has been awarded the KSCSTE-Best Scientist Award (BSA) 2022.
18. Sreedevi S. Kumar has snared the second price for the best paper/oral presentation award in the theme of Ethno/ Phyto pharmacology on the topic ‘An Ethno-medico-botanical Investigation of the Coastal Biodiversity of Thrissur District, Kerala through Systematic Documentation and Survey’ in the Two days National Seminar on Fundamental and Applied Dimensions in Plant Science held at KSCSTE-JNTBGRI during 24th - 25th of March 2022.
19. Sreekumar, S. has been appointed as a member in the AYUSH Department – Human and Animal Ethical Committee (GO (Ms) N0.35/2019/AYUSH).
20. Sreekumar, S. has been appointed as a member of the committee constituted for ‘Mapping of S & T Needs in Kerala – (KSCSTE order No.04/MS/2020, dated 19-11-2020).
21. Sreekumar, S. has been appointed as an adjudicator of the State Level National Children’s Science Congress held during 19th- 22nd January, 2021.
22. Sreekumar, S. has been appointed as an expert member for research papers evaluation (Biotechnology) in the 33rd Kerala Science Congress held during the 25-30 January 2021.
23. Sreekumar, S. has been appointed as an external examiner of M.Sc. Biotechnology for conducting practical examinations, project evaluation and viva voce in the academic year 2020-2021, 2021-2022.

24. Sreekumar, S. has been appointed as the chairman of adjudicators of the Ph.D. thesis evaluation and viva voce examination of the thesis entitled “Cultivation, characterization and mode of action of *pleurotuseous* in streptozotocin induced experimental animal of diabetes mellitus” at Bharathiyar University, Coimbatore, on 31 December 2021.
25. Sreekumar, S. has received a letter of appreciation for the evaluation of project proposals under Student Project Scheme of KSCSTE - 2021 (No. KSCSTE/1946/2021-SP, dated 01-12-2021).
26. Suja, S. R. has been invited as a resource person in the two days’ training programme for AYUSH doctors on ‘Traditional and Folk Practices’ (30 Ayurveda, Siddha and Homeopathy doctors from ISM Department and Homeopathy Department, Government of Kerala) from Thiruvananthapuram, Kollam, Pathanamthitta and Alappuzha districts on the 18th and 19th of November 2021 at KSCSTE- JNTBGRI and a delivered a talk on “Scientific Validation of Traditional Knowledge based Medicinal plants – An Experimental Ethnopharmacological approach”.
27. Suja, S. R. was awarded the “Environment Excellence Award” by International Foundation for Environment and Ecology, Kolkata, India during the 7th International Conference on Environment and Ecology held on 26-November 2021.
28. Suja, S. R. was awarded the Honorary Rosalind membership of London Journals Press, UK. November, 2020.
29. Suja, S. R. was invited as plenary speaker in the 7th International Conference on Environment & Ecology (ICEE 2021) held during 26 -28, November 2021 through Google meet and delivered the topic on “Unravelling of Ethno-medico-botanic knowledge for drug discovery- Relevance of ethnopharmacological approach.
30. Vinodkumar T. G. Nair has attended the 16th meeting of the Board of Governors of CCIM on 24.12.2020 and 29.12.2020.
31. Vinodkumar T. G. Nair has become the CCIM BOG Member (Ministry of AYUSH) and in charge of National Teachers Training Programme for first professional subjects of Ayurveda, participated in the National Teacher’s Training Programme, jointly organized by Rastriya Ayurveda Vidyapeeth, Central Council of Indian Medicine Board of Governors and All India Institute of Ayurveda, a continuing program inaugurated by the Secretary, Ministry of AYUSH, Govt. of India.
32. Vinodkumar T. G. Nair has been invited as a resource person in the two days’ training programme for AYUSH doctors on ‘Traditional and Folk Practices’ (30 Ayurveda,

Siddha and Homeopathy doctors from ISM Department and Homeopathy Department, Government of Kerala) from Thiruvananthapuram, Kollam, Pathanamthitta and Alappuzha districts during 18th - 19th November, 2021 held at KSCSTE- JNTBGRI and a delivered a talk on “Systematic documentation of medicinal plants based on traditional knowledge.”

33. Ashi Anu Mathew has bagged the best Paper Award on the topic “Riparian vegetation in Kerala’s River basins: Diversity, Ecological functions and Conservation prospects” in the National Seminar on Fundamental and Applied Dimensions in Plant Sciences organized by KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram during 24 - 25 March, 2022.

PATENTS

- A novel poly herbal formulation with multiple therapeutic effects as anti-diabetic, anti-fatigue, hepatoprotective and antioxidant (Application No. 2277/CHE/2011). Inventors: S. Rajasekharan, P. G. Latha, T. M. Shahul Hameed Vaidyar, S. R. Suja and N. M. Krishnakumar. Patent Granted on 01-02- 2021.
- A provisional patent (Composition and process for preparing herbal Mosquito repellents and their use) is applied for the product derived from the essential oil of *Etilingera fenzlii* which is currently under scrutiny (KSA Ref. No P135241 N00/2022). Inventors: Aswathy Anand, A., Radha, R. K., Kamala Jayanthi, and R. Rajendran.

FINAL TECHNICAL REPORTS

1. Prepared and submitted completion report of Heritage and aesthetic garden at Thiruvananthapuram.
2. Eco-education Projects for School Children – *Jeevanam*.
3. Vegetative and Ecological Assessment of Lateritic Zones of North Kerala.
4. Genetic Diversity Conservation and Population Study of Selected Notified Endangered Plant Species of the Western Ghats Region of Kerala.

RESEARCH PUBLICATIONS

1. Abinlal, K. C., Dhyani, A., Suresh, S., Shareef, S. M. and E. S. Santhosh Kumar, 2022. Conservation of *Garcinia gamblei*, a rare tree endemic to the southern Western Ghats, India. *Oryx* 56(4): 489–494.
2. Ahammed Nazarudeen, Gopalaprabhu Rajkumar and Raveendranpillai Prakashkumar, 2020. A new species of *Ardisia* (Primulaceae) from the Anamalai Hills of Western Ghats, India. *Annals of Plant Sciences* 9 (6): 3892-3898.
3. Ajitha, A. A., Siva Kumar, S., Viswanathan, G., Sabulal Baby and P. G. Biju, 2021. Therapeutic Properties of PDMS Nanoparticles: A Promising New Drug Delivery Vehicle Against Inflammatory Conditions. *Combinatorial Chemistry and High Throughput Screening* doi: 10.2174/1386207324666210210112843.
4. Akhilesh, S. V. N., Gangaprasad, A., Rameshkumar, K. B. and E. S. Santhosh Kumar, 2022. Taxonomy and Lectotypification of *Ophiorrhiza radicans* (Rubiaceae). *Annals Botanici Fennici* 59:61—65.
5. Akhilesh, S. V. N., Gangaprasad, A., Rameshkumar, K. B. and E. S. Santhosh Kumar, 2022. *Ophiorrhiza sasidharaniana* (Rubiaceae), a new species from Southern Western Ghats, Kerala, India. *Annals Botanici Fennici* 59: 149-152.
6. Aliyarukunju Sabeena, Haridas Biju and Sudhakaran Sujatha Dhanusha, 2021. A new species of asterinaceous fungi, *Asterina imbertiae* sp. nov. from Kerala, India. *Phytotaxa* 505(1): 114-119. <https://doi.org/10.11646/phytotaxa.505.1.9>
7. Aliyarukunju Sabeena, Haridas Biju, Sudhakaran Sujatha Dhanusha and Sugathan Shiburaj, 2020. *Asterina gordoniae* sp. nov. (Asterinaceae), a new foliar mycobiont from Kerala, India. *Phytotaxa* 441(2):211-216. <https://doi.org/10.11646/phytotaxa.441.2.8>
8. Anchana, A., Deepudas, Thomson Davis, Abdul Jabbar, M., Suharabeevi, S. and P. J. Mathew, 2020. Assessment of Genetic diversity among the three unique and potential genotypes of *Piper nigrum*- ‘PMM’, ‘PAJ’ and C. V. Karimunda using RAPD markers. *Journal of Cytology and Genetics* 21(NS): 107-114.
9. Anu, S., Mathew Dan, Rameshkumar, K. B. and S. R. Suja, 2020. Wild relative of turmeric, *Curcuma zanthorrhiza* Roxb. - A source of edible starch. *Indian Journal of Traditional Knowledge* 19(3): 519-524.

10. Anu, S., Navas, M. and M. 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.
11. Anuja, G. I., Shine, V. J., Latha, P. G., Suja, S. R., Swapna Susan Abraham, Vinodkumar, T. G. Nair and S. Rajasekharan, 2021 Evaluation of CYP2D, CYP1A2 and distribution of tetrandrine, fangchinoline in the brain, liver, and kidney of wistar rats after short-term exposure to *Cyclea peltata*. *Pharmacognosy magazine* 17 (5): 77.
12. Anurag Dhyani, Abinlal, K. C., Bindu, S., Vincy K. Wilson, Suresh, S., Santhosh Kumar, E. S. Anilkumar, C. and Megan Barstow, 2021. *Buchanania barberi*, a Tree on the Edge of Extinction, Reference Module in Earth Systems and Environmental Sciences, Elsevier, 2021, ISBN 9780124095489.
13. Arun, R. P., Riyas, C. T. and K. K. Sabu, 2020. A review on the unexplored and underutilized *Arenga* species in India. *Current Botany* 11: 226-232. <https://doi.org/10.25081/cb.2020.v11.6252>.
14. Arya C. P. and C. K. Pradeep, 2022. A new species of *Agaricus* sect. *Agaricus* (Agaricaceae) from India. *Nordic Journal of Botany* e03742. <https://doi.org/10.1111/njb.03742>.
15. Arya, C. P., Manoj Kumar, A., Pradeep, C. K., Luis A. Parra, 2022. *Agaricus brunneodiscus*, a new species of *Agaricus* section *Rarolentes* from India. *Phytotaxa* 533 (4): 181–193.
16. Arya, C. P., Ratheesh, S., and C. K. Pradeep, 2021. New record of luminescent *Mycenachlorophos* (Mycenaceae) from Western Ghats of India. *Studies in Fungi* 6(1): 507–513. <https://doi.org/10.5943/sif/6/1/40>.
17. Asok Kumar Jayasree Anand, Neenthamadathil Mohandas Krishnakumar, Somasekharan Nair Rajam Suja, Panickamparambil Gopalakrishnan Latha, Jollykutty Eapen, Stanislaus Antony Ceasar, 2022. Anti-diabetic activity of *Amrtottara Kvatha*, an Ayurvedic polyherbal drug in Wistar rats with streptozotocin-induced diabetes. *International Journal of Ayurvedic Medicine* 13 (2): 44.
18. Aswathy V. Nair, Suja, S. R. and R. Prakashkumar, 2021. Pharmacognostic and physicochemical evaluation of *Phyllocephalum rangacharii* (Gamble) Narayana: An ethnomedicinal plant. *International Journal of Botany Studies* 6 (3): 693 -699.

19. Athira, M., Shaiju, P. N. and S. R. Suja, 2021. *In vitro* anti-Inflammatory activity of the root of *Thottea siliquosa* (Lam.) Rottb., a Medicinal Under shrub in Western Ghats, India. *International Journal of Life science and Pharma Research*. doi 10.22376/ijpbs/lpr.2021.11.2. L135-142
20. Balu, G., Rasmi, A. R., Sequeira, S. and B. Haridas, 2021. Diversity and distribution of macro lichens from Kalpetta Municipality of Wayanad District, Kerala, India. *Journal of Threatened Taxa* 13 (14): 20253–20257. <https://doi.org/10.11609/jott.6706.13.14.20253-20257>.
21. Biba Vikas, Sujathan Kunjiraman, Suja Somasekharan Nair Rajam and Sukumaran Anil, 2021. The Apoptotic properties of leaf extracts of *Simarouba glauca* against Human Leukemicancer cell lines. *Asian Pacific Journal of Cancer Prevention* 22(4).
22. Biba Vikas, Sujathan, K., Suja, S. R. and S. Anil, 2022. Caspase-Dependent Apoptosis Induced by *Simarouba Glauca* on Human Non-Small-Cell Lung Cancer. *Asian Pacific Journal of Cancer Prevention* 23 (6) 1867-1872.
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BOOKS/ PROCEEDINGS PUBLISHED

- 1). Rameshkumar K. B. and Vipin Mohan Dan (Eds.), 2022. Proceeding and abstracts: National Seminar on Fundamental and Applied Dimensions in Plant Sciences 24th-25th March 2022; KSCSTE-JNTBGRI, Thiruvananthapuram, Kerala, India. ISBN No.: 978-81-955043-0-5.

CHAPTERS IN BOOK

1. Aliyarukunju, S., Haridas, B. and S. Sugathan, 2023. Current Insights into Phylloplane Fungal Species Diversity in the Western Ghats and Its Perspective. In: Aguilar, C. N., Abdulhameed, S., Rodriguez-Herrera, R. and S. Sugathan (Eds.). *Microbial Biodiversity, Biotechnology and Ecosystem Sustainability*. Springer, Singapore. https://doi.org/10.1007/978-981-19-4336-2_14.
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3. Anoosh Varghese and A. K. Sreekala, 2022. Breeding System of *Syzygium occidentale* (Bourd) Gandhi., a Vulnerable Riparian Tree species of the Western Ghats. In: Bhuyan, S. I. et al. (Eds.). Biodiversity; Exploration and Conservation, Research Culture Society and Publication (28-35) ISBN: 978-93-92504-01-3.
4. Anu, S. and M. Dan, 2021. Edible starch from *Curcuma* species: A review. In: Manju, M., Jayalakshmi, M., Menon, K. S. and S. T. Tharakan (Eds.). Emerging Trends in Plant Science, Vimala College Publications Thrissur, Kerala. ISBN 978-81-950842-8-9. pp.21-28.
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6. Gayathri Viswanathan and Sabulal Baby, 2022. Biodegradable Composites for Commodities Packaging Applications and Toxicity In: Arbind Prasad, Ashwani Kumar, Kishore Kumar Gajrani (Eds.). Biodegradable Composites for Packaging Applications, CRC Press, London, New York, pp 77-96.
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8. Jayalakshmi, M., Sreekala, A. K. and Maria Theresa, 2021. Signalling strategies and pollination syndromes exhibited by Caesalpiniodeae members, Emerging trends in plant science. In: Enflammer - the Journal Club, Department of Botany, Vimala College, Thrissur (ISBN NO-987-81-950842-8-9).
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10. Prakashkumar, R. and R. Raj Vikraman, 2023. Jawaharlal Nehru Tropical Botanic Garden and Research Institute, a Treasure House of Tropical Plant Germplasm, Blends into the Western Ghats, the Biodiversity Hotspot in Indian Region. In:

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 12. Rajkumar, G., Pandurangan, A. G. and R. Prakashkumar, 2021. Agasthyamala Biosphere Reserve: a unique natural landscape of bioresources with phytogeographical significance. In: National Webinar Series on Wildlife Sanctuaries organized by the Govt. M. S. Golwarkar College, Rewa, Madhya Pradesh in May 2021.
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19. Shefin, B., Sreekumar, S. and C. K. Biju, 2022. *In silico* evaluation of anti-SARS-CoV-2 activity of *Punica granatum* L. phytochemicals. In: Corona virus Drug Discovery: Druggable Targets and In Silico Update Vol 3, Chukwuebuka Egbuna (ed.), Elsevier Inc. pp 335-353. ISBN: 9780323851565.
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22. Suja, S. R., Aneeshkumar, A. L. and R. Prakashkumar, 2020. Bioprospecting of Ethno-Medicinal Plants for Wound Healing. In: Sukumaran, S. T., Sugathan, S. and S. Abdulhameed (Eds.). Plant Metabolites: Methods, Applications and Prospects. Springer Nature, Singapore. https://doi.org/10.1007/978-981-15-5136-9_22.
23. Suja, S. R., Krishnakumar, N. M., Bijukumar, B. S. and R. Prakashkumar, 2021. Bioactive flavonoids from Natural sources: Potential immune boosters. In:

Flavonoids as Nutraceuticals. Apple Academic Press, CRC Press, a Taylor, and Francis Group (published online).

STUDENT'S PROGRAMME

1. Akhshaya, P. T. from School of Bioscience, Mar Athanasios College for Advanced Studies, Tiruvalla has undergone training on '*In vitro* regeneration and root induction of *Rubia cordifolia*' under the guidance of Dr. R. K. Radha.
2. Alena Avarachan, Susmi Varghese and Athira, P. G., the M. Sc. Bioinformatics students from Union Christian College, Aluva has completed their internship training in NGS data analysis during 1st Nov 2020 to 31 Jan 2021 under the supervision of Dr. K. K. Sabu.
3. Amal from Indira Gandhi College of Arts and Science, Kothamangalam, Ernakulam, Mahatma Gandhi University has undergone training on the topic: Preliminary studies on *in vitro* propagation of *Bacopa monnieri* (L.) Wettst., a medicinal plant of the Western Ghats, under the guidance of Dr. R. K. Radha.
4. Amit Patil from Bhagwant University, Ajmmer, Rajasthan has undergone 3 months Training Program under the supervision of Dr. R.K. Radha.
5. Anabia Asharaf from Environment Science and Management student of Sree Sankara College, Kalady has undergone M.Sc. dissertation on the topic 'Autoecology of *Moringa oleifera* Lam, fruiting' under the guideship of Dr. C. Anilkumar and completed the programme by 03-08-2021.
6. Aneesha, S., Manodhini, R. S. and L. C. Deepthi, B. Sc. Biotechnology students from Mother Teresa Women's University, Kodaikanal has joined for internship on 20 December 2021 and completed by 3 January 2022 under the guidance of Dr. K. K. Sabu, on the topic: Tools and Techniques of Plant Molecular Biology.
7. Anjana, A. J., Ananthkrishnan, G. B., Muhammed Hakkim, N. and M. Mohamed Abdul Khader from National College, University of Kerala, Thiruvananthapuram has undergone training on the topic: Preliminary studies of *in vitro* propagation of *Bacopa monnieri* under Dr. R. K. Radha.
8. Anjana, T., Marthoma College, Thiruvalla has undergone M. Sc. dissertation on 'Phylloplane mycological associations of *Humboldtia unijuga* var. *trijuga*' under the supervision of Dr. P. S. Jothish.
9. Arathy, A. M. from Sree Narayana Guru Group of Institutions, Arts and Science College, North Paravoor (Mahatma Gandhi University) has undergone training on

the ‘Pharmacokinetics and micropropagation status of *Curcuma caesis* Roxb. under the supervision of Dr. R. K. Radha.

10. Don Jacob from St. Berchmans College, Changanassery, Kottayam, Mahatma Gandhi University has undergone one month training under the supervision of Dr. R.K. Radha.
11. Dr. Raj Vikraman, R. has coordinated the internship training for the B.Ed. students namely Mekha, M. L., Swathi, N. J., Sumayya, N., Arya R. A., Manjima M. R., Ali Noufiya N. S., Fathima Navas, S. and Parvathy, R. N. from Iqbal Training collage Peringammala for a period from 21-25 March 2022, on the topic JNTBGRI – functions, organization and contribution.
12. Dr. S. Sreekumar has provided to seven Graduate Students from A. J. College, Thonnakkal, internship training in Biotechnology during the period from 27-12-2021 to 15-01-2022 (5 days in 2021 and 15 days in 2022).
13. Dr. S. Sreekumar has provided two month’s training to P. Sam, Ph.D. scholar from the University of Kerala on the topic *in silico* screening of phytochemicals against cobra venom.
14. Dr. Surya Mudavasseril Sudheer, Post Doctoral Fellow, University of Tartu, Estonia has undergone one week training in “Basic Bioinformatics Tools” from 6th to 10th September 2021 under the supervision of Dr. S. Sreekumar.
15. Four B. Sc. Botany & Biotechnology students namely Anju, A., Nimisha Nath, Aparna B. Nair and Subuhana Khadar from K. V. V. S. College of Science & Technology, Adoor has joined for one month project work on the 10 Dec 2020 – 9 January 2021, under the supervision of K. K. Sabu, on the topic Assessment of Genetic Diversity in Asian Palmyrah Palm (*Borassus flabellifer* L.) accessions using SCOT markers.
16. Four B. Tech. (Biotechnology) students namely Rajadurai, E., Kumaresan, S., Kabish, P. and Ajith Kumar from the Tamil Nadu Agricultural University has given internship training on the topic “Plant tissue culture” from 27-12-2021 to 10-01-2022 by Dr. S. Sreekumar.
17. Gokul Mohan and Manju Manuel, M.Sc. Biotechnology students, from St. Berchman’s College (Autonomous), Changanassery, Mahatma Gandhi University

has undergone internship training on the topic ‘*In silico* screening of phytochemicals and drug discovery’ from 26-12/2021 to 03-01-2022 under Dr. S. Sreekumar.

18. Gokul, C. S., Akshara, Reghunath, K., Naufal, N. and Rahul, M. K. from National College, University of Kerala, Thiruvananthapuram has undergone training on ‘Preliminary studies of *in vitro* propagation of medicinal plants’ during the period from December 2019-January 2020 under the guidance of Dr. R. K. Radha.
19. Gopakumar, P., Indira Gandhi College of Arts and Science, Kothamangalam, Ernakulam, Mahatma Gandhi University has done B.Sc. project work on the topic: Preliminary studies on *in vitro* propagation of *Rauvolfia beddomei* (*Rauvolfia hookeri* Srinivasan and Chitra), a medicinal plant of the Western Ghats, under the supervision of Dr. R. K. Radha during December 2019 – January 2020.
20. Jithu George from St. Berchmans College, Changanassery, Kottayam, Mahatma Gandhi University has undergone one month training under the supervision of Dr. R. K. Radha.
21. Krishna Rajesh from Amritha School of Biotechnology, Kollam, Kerala has done one month training on micro-cloning and bioprospecting of medicinal plants in February 2022, under the supervision of Dr. R. K. Radha.
22. Rita Rose Chacko from St. Berchmans College, Changanassery, Kottayam, Mahatma Gandhi University, has done M.Sc. dissertation training on the shoot proliferation of *Acorus calamus* L. using liquid phase *in vitro* culture system, under the supervision of Dr. R. K. Radha, during March to June 2022.
23. Sahna, K., Pooja Radhakrishnan, and Jagath, J. D. from Central University of Tamil Nadu were given 2 months (17/06/2021-16/08/2021) internship programme under Dr A. K. Sreekala’s guideship. The topics of their study are Studies on seed biology of *Syzygium palodensis* and herbarium techniques, Pollen biology of *Brownea grandiceps* and herbarium techniques, Pollen biology of *Lagerstroemia speciosa* and herbarium techniques respectively.
24. Training on vegetative propagation and nursery management were given to 50 nos. of farmers from Vanasamrakshana samithy on 28-01-2021.
25. Vaishnavi V. Nair from School of Biotechnology, Amrita Vishwa Vidyapeetham, Clappana, Kollam has done M.Sc. dissertation studies on the ‘establishment of an efficient *in vitro* regeneration system and analysis of preliminary experiments of microrhizome induction in *Acorus calamus* L. - a potent medicinal herb, under the supervision of Dr. R. K. Radha, from November 2019 – March 2020.

OUTREACH PROGRAMMES

1. Rajendrapasad, M. became the convener, PG Interaction and Children Science Congress, 34th Kerala Science Congress.
2. Rajendrapasad, M. becomes the convenor, Finance Committee, Kerala National Children's Science Congress.
3. Rajendrapasad, M. has attended 2 meetings at Collectorate in connection with 1st anniversary of Govt of Kerala.
4. Rajendrapasad, M. has attended State Level Expert Committee meeting on Conservation of Sacred groves & Vanamithra at Forest Head Quarters.
5. Rajendrapasad, M. has attended the meeting at Pinarayi in connection with Pinarayi Beautification Programme.
6. Rajendrapasad, M. has attended workshop on Ozone Day observation invigoration of ozone layer: pros and cons, presented theme paper.
7. Rajendrapasad, M. has become the Nodal Officer, Revision of Kerala State Action Plan on climate change, Directorate of Environment, Govt. of Kerala, Thiruvananthapuram.
8. Rajendrapasad, M. has been nominated as the convener. PG Interaction and Children Science Congress, 33rd Kerala Science Congress.
9. Rajendrapasad, M. has delivered three lectures to trainees of green Skill development Programme conducted by MBG, Kozhikode.
10. Rajendrapasad, M. has done radio talk on 'Kavukal Prakruthi Samrakshanathinte Paithruka Mudrakal', Kochin FM, Ernakulam.
11. Rajendrapasad, M. has evaluated a thesis entitled 'Black Mildew Fungi in Konni Forest Division' by Gokul G. Nair.
12. Rajendrapasad, M. has evaluated and conducted Viva-Voce for two PG students, Kerala Agricultural University, Mannuthy.
13. Rajendrapasad, M. has extended service as Examiner and External expert for Dissertation and Viva Voce for M.Sc. Biodiversity Exam, Kerala university.
14. Rajendrapasad, M. has participated in a workshop on Conservation of ponds in Kannur and presented a proposal for conservation of Ponds.
15. Rajendrapasad, M. has participated in District wise monitoring meeting of National Green Corps.

16. Rajendrapasad, M. has participated in the preparation of a Float in the theme 'Biodiversity conservation to restrict pandemics' for Onam celebrations 2022 of Kerala Govt.

INVITED TALKS

1. Gopakumar, B. has delivered a talk on "Why do we have Bamboo Day?" in the webinar organized by the St. Dominic College, Kanjirappally, on 30th September.
2. Mathew Dan has delivered a talk in the National Webinar 'Botanic gardens of India - Identification, Conservation and Management' organized by M. S. Golwalkar College, Rewa, Madhya Pradesh and presented 'Conservation of Tropical Plants at JNTBGRI – a four-decade story' on 18th February 2021.
3. Mathew Dan has delivered a talk on 'A Progression from Classification, Taxonomy to Systematics' in the International Conference organized by SVM Arts and Science College, Krishnagiri, Tamil Nadu on 16th March 2021.
4. Mathew Dan has delivered a talk on 'Biodiversity richness in Western Ghats with special emphasis to Kerala' in the 'Karshikamela 2021' organized by Gandhiji Study Centre, Thodupuzha on 4th January 2021.
5. Mathew Dan has delivered a talk on 'Why Taxonomy...?' in the DBT STAR College scheme organized by Vimala College, Thrissur on 4th March 2021.
6. Mathew Dan has presented a paper on 'Scope and significance of Ethnobotanical Research' in the webinar organized by the Department of Botany, Bishop Abraham Memorial College, Thuruthicad on 19th November 2020.
7. Navas, M. has delivered an invited talk on the topic: 'Ethnobotany of Kani Tribe Leading to Access and Benefit Sharing' in connection with the Webinar on E. K. Janaki Ammal, on 05/11/2020, organised by Centre for Intangible Heritage Studies, Sree Sankaracharya University, Kaladi, Kerala.
8. Nithyamol, K. M. has done a talk on 'Ex-situ conservation of *Humboldtia species* at JNTBGRI' in the International Conference on Sustainable Utilization of Bio resources, Department of Botany, Kariavattom, Thiruvananthapuram on 15.01.2022.

9. Pradeep C. K. has delivered a guest lecture on the topic “*Mushroom Diversity and Significance*” at Bannari Amman Institute of Technology (BAIT) Sathyamangalam, Erode on 12th Sept. 2020 in virtual mode.
10. Pradeep C. K. has served as resource person and delivered a lecture in virtual mode on the topic “*Fungal Diversity & Conservation: Importance & Implications*” during the World Conservation Day celebration organized by the PG and Research Centre in Botany, Department of Botany, Sacred Heart College, Thevara, Kochi on 28th July 2020.
11. Pradeep, C. K. has delivered a lead lecture on the topic “*Mushroom Diversity & Significance*” for the students and faculties of Bannari Amman Institute of Technology, Erode, Tamil Nadu on 12-09-2020 on virtual mode.
12. Pradeep, C. K. has delivered an invited lecture on the topic “*Basics of Mushrooms*” in virtual mode organised by the Department of Botany, Balurghat College, West Bengal, on 18th May 2021.
13. Pradeep, C. K. has delivered an invited lecture on the topic “*The Fascinating World of Mushrooms*” in virtual mode organised by the Postgraduate Department of Botany and Research centre, Govt. College for Women, Thiruvananthapuram on 25th Sept. 2021.
14. Pradeep, C. K. served as a resource person and delivered a lead lecture in virtual mode on the topic “*Fungal Diversity & Conservation*” during the Biodiversity Day celebration organized by the Botany Department, University of Kerala, Karyavattom, Thiruvananthapuram on 22nd May 2021.
15. Pradeep, C. K. served as a resource person and delivered a lead lecture on the topic “*Fungal Diversity and Conservation, Importance and Implication*” in connection with World Conservation Day organized by PG & Research Centre in Botany, SH College, Thevara 28/07/2020.
16. Pradeep, C. K. served as a resource person and delivered lead talk on the topic “*The Wondrous Powers & Potential of Mushrooms*” in the One Week Virtual Faculty Development Program on Future Perspectives in Biological Sciences (FPBS), Organized by Department of Botany Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, Tamil Nadu, 8-14th Nov. 2021.
17. Radha, R. K., as an invited speaker in the 3rd International Conference on Biodiversity (7th November 2020) Singapore (Webinar of global expert meetings) has delivered a

talk on '*Ex situ Conservation of threatened medicinal plants of the Western Ghats, India*'.

18. Radhakrishnan, K. has delivered Dr. B. N. Mehrortra Medal Lecture on his contributions to ethnobotany in the National Seminar on '*Modern Trends in Ethnobotanical Research*' held at Jiwaji University, Gwalior from 5-6 March 2020.
19. Radhakrishnan, K. has presented a paper entitled '*Relevance of Ethnobotany in Pre and Post Covid-19 pandemic Era*' in the National webinar on '*Relevance of Ethnobotany in contemporary socio-economic conditions*', organised by S K Jain Institute of Ethnobiology and School of studies in Botany, Gwalior on 14 August 2020.
20. Rajkumar, G. has presented a paper '*Floristic Diversity of Peppara Wildlife Sanctuary, Kerala and its Conservation*'- in the National Webinar Series on Biosphere Reserves and National Parks organized by M. S. Golwarkar College, Rewa, Madhya Pradesh on 03 September 2021.
21. Raju Antony has delivered a talk on "*Taxonomy of Ferns and Lycophytes*" at The Govt. Women's College, Thiruvananthapuram in connection with the National Seminar on Cryptogams (24.11.2022).
22. Raju Antony has delivered a talk on the "*Diversity of Ferns in the Western Ghats*", in connection with a National Seminar on Biodiversity Challenges and Threats: Current Scenario by Postgraduate and Research Department of Botany, S.N. College, Kollam on 21.12.2022.
23. Santhosh Kumar, E. S. has delivered a talk on '*Identification of Medicinal Plants*' in connection with the workshop on "*Conservation, cultivation and sustainable utilization of medicinal plants*" organized by Dept of Botany, University of Kerala (11.10.2022).
24. Santhosh Kumar, E. S. has participated as the faculty in the Herbarium Techniques lecture series with students of Botany Department, University of Kerala (23.06.2022).
25. Santhoshkumar, E. S. has delivered a lecture on '*Sustainable harvesting of NWFP*', in connection with JNTBGRI-FRLHT programme (16.12.2020) at Kottur, Thiruvananthapuram.
26. Sreekala, A. K. has delivered a lecture on 18/12/2022 on the topic "*Importance of Botanic Garden in Conservation*" in Mar Ivanios College, Nalanchira, Thiruvananthapuram.

27. Sreekala, A. K. has delivered an invited talk on ‘How biodiversity can be conserved by understanding Reproductive Biology?’ on 13th May 2022 at Malabar Botanic Garden, Kozhikode.
28. Sreekumar, S. has delivered an invited lecture-cum-demonstration in AICTE Training and Learning (ATAL) Academy Online Elementary FDP on ‘*FDP on Molecular Modelling and In-silico Drug Designing*’ held during 23/08/2021 to 27/08/2021 at St. Joseph's College of Engineering, Chennai, Tamil Nadu.
29. Suja, S. R. in the 7th International Conference on Environment & Ecology (ICEE 2021) held on 26 -28, Nov 2021 through Google meet delivered a speech on “*Unravelling of Ethno-medico-botanic knowledge for drug discovery - Relevance of ethnopharmacological approach.*”
30. Suresh Kumar, P. has presented a paper entitled “Potential endemic wild ornamental plants from Rosemala, Ponmudi and Chemunji hills with special reference to its *ex-situ* germplasm conservation” in the International Conference on ‘Sustainable Utilization of Bio-resources’ organized by the Department of Botany, University of Kerala, Karyavattom on 10th January 2022.
31. Vinodkumar T. G. Nair has delivered a talk on ‘*Role of Ayurveda in pandemics*’ as a keynote speaker in the webinar on ‘*Role of Ayurveda in pandemics*’ organized by the Kerala University of Health Sciences on 18th September 2020.

SEMINAR/SYMPOSIA/ POSTER PRESENTATIONS

1. Abhirami Ravichandran, 2020. *Documentation of Traditional Knowledge related to Athirathram*. Webinar series - “Recent trends in plant science research at JNTBGRI” on 9th September 2020.
2. Achuthan S., Sruthy B. and K. B. Rameshkumar, 2022. *Volatile chemical profiling of Piper species by HS GC MS and GC MS analysis*. National Seminar on Fundamental and Applied Dimensions in Plant Sciences, Organized by KSCSTE-JNTBGRI, Thiruvananthapuram, 24th & 25th March, 2022.
3. Ajmi Shahul, Suja, S. R. and Vinodkumar T. G. Nair, 2022. *Ethnomedicinal importance of Rhinacanthu snasutus (L.) Kuntze, a plant used by tribal communities: Evaluation of in vitro antioxidant and anti-inflammatory potential*. National Seminar on ‘Biodiversity

challenges and Threats; Current scenario', 21st and 22nd December 2022 at S N College, Kollam.

4. Akhil Raj, A. R., 2020. *Ayurvedic rationale of Nelluvai Mukkudi - A medicated preparation*. Webinar series - "Recent trends in plant science research at JNTBGRI" on 9th September 2020.
5. Akhil, R. and A. K. Sreekala, 2021. *Variations within the varieties of the genus Humboldtia Vahl. (Fabaceae) of the Western Ghats*. International conference on New horizons in Plant Science Conducted by University of Kerala, Department of Botany, Kariavattom on 4-9th January 2021.
6. Akhilesh S. V. Nair, Gangaprasad, A. and K. B. Rameshkumar, 2022. *Diversity of the genus Ophiorrhiza L. in the Western Ghats of Kerala*. National Seminar on Fundamental and Applied Dimensions in Plant Sciences Organized by KSCSTE-JNTBGRI, Thiruvananthapuram, 24th& 25thMarch, 2022.
7. Aleena Joseph and S. R. Suja, 2022. *Phytochemical Screening and Evaluation of antioxidant potential of Malaxix versicolor (Lindl.) Abeyw. – a promising orchid of western ghats used in traditional medicine*. International seminar on m Plant chemistry, Gene prospecting and clinical Biology organised by Kerala Academy of sciences during 10 -11 November 2022 at Mar Ivanios College, Thiruvananthapuram, Kerala India.
8. Aleena Joseph, Suja, S. R., Vinodkumar T. G. Nair and R. Prakashkumar, 2021. *A glance into the potential of Azolla pinnata R. Brown, an aquatic pteridophyte - Evaluation of its Biomass production and nutritive value*. First International conference of NABS for Life Sciences, Contemporary approaches in in Biological Sciences for Food, Health, and Nutrition on 26-28, 2021, Annamalai University, Tamil Nadu.
9. Anila Rajendran, Sruthy, B. and K. B. Rameshkumar, 2022. *Leaf volatile chemical profiling of four economically important Syzygium species through essential oil and headspace studies*. National Seminar on Fundamental and Applied Dimensions in Plant Sciences, Organized by KSCSTE-JNTBGRI, Thiruvananthapuram, 24th& 25thMarch, 2022.
10. Anjana H. Nath, Anith K. N. and K. K. Sabu, 2022. *Growth Enhancement of Cardamom upon Root Colonization by Endophytic Fungus Piriformospora indica*. 34th Kerala Science Congress (held online) organized by Kerala State Council for Science, Technology & Environment, Thiruvananthapuram., 10-12 February 2022.

11. Anjana H. Nath, Sabu, K. K. and K. N. Anitha, 2021. *Co-cultivation of Elettaria cardamomum with Piriformospora indica, a phytopromotional root-colonizing endophyte*. Proceedings of International Conference on Advancements in Interdisciplinary Research (ICAIR-21) held online during 26-28 October 2021.
12. Anjusha S., Radha, R. K. and K. Satheeshkumar, 2021. *Adventitious root culture – an alternative method for the production of anthocyanin from Ipomoea batatas (L.) Lam.* 34th Kerala Science Congress, Dec 2021.
13. Anoosh Varghese and A. K. Sreekala, 2021. *Breeding system of Syzygium, occidentale (Bourd.) Gandhi: A vulnerable riparian tree species of the Western Ghats*. International conference on Biodiversity: exploration and conservation for sustainable development, Organized by the Department of Botany, Pandit Deen Dyal Upadhyaya Adarsha Maha-vidhyalaya- Behali, Assam on 26/12/2021.
14. Anto M., Anilkumar, C. and K. B. Rameshkumar, 2021. *Conservation of an endangered species Garcinia imberti Bourd.* Online Poster Presentation Competition on Endangered Species Day, organized by the Centre for Biodiversity Conservation, University of Kerala, on 21.05.2021.
15. Arya, C. P. and C. K. Pradeep, 2021. *Morphological and molecular characterization of genus Agaricus in Kerala State*. Virtual National Conference on Biodiversity and Biotechnology for fungi and 47th annual meeting of Mycological Society of India, organized by Department of Botany, Punjabi University, Patiala, Feb. 20-24.
16. Arya, M. R., Suhara Beevy, S. and M. Dan, 2021. Crossability studies in *Clitoria ternatea* L. In: International Conference on New Horizons in Plant Science, Department of Botany, University of Kerala, Thiruvananthapuram. 4-9th January 2021.
17. Ashi Anu Mathew, Shaju T. and M. Rajendraprasad, 2022. *Riparian vegetation in Kerala's River basins: Diversity, Ecological functions, and Conservation prospects*. National Seminar 'Fundamental and Applied Dimensions in Plant Sciences. KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram, 24 - 25 March, 2022.
18. Aswathy Anand A., Saravan Kumar, P., Kamala Jayanthi, P. D., Sabu, K. K., Rajendran, R. and R. K. Radha, 2022. *Behavioural, electrophysiological, and repellent effects of Etlingera fenzlii, an endemic plant species of the Andaman and Nicobar Islands in mosquito management*. International seminar on Plant Chemistry,

Gene Prospecting and Clinical Biology by Kerala Academy of Science on 10th - 11th November 2022, Mar Ivaniose College, Thiruvananthapuram, Kerala.

19. Aswathy Anand A., Saravan Kumar, P., Kamala Jayanthi, P. D., Sabu, K. K., Rajendran, R. and R. K. Radha, 2022. *Repellent effects and electrophysiological response of Elingera fenzlii against Aedes aegypti and Culex quinquefasciatus*. XXXII Annual Conference of Indian Association for Angiosperm Taxonomy and National Symposium on “The Contribution of Angiosperm Diversity to Human Wellbeing and The Risks Associated with Its Decline” on 11th - 13th November 2022 at Department of UG, PG and Research in Botany, Karnatak University’s Karnatak Science College, Dharwad, Karnataka.
20. Aswathy Anand, A. and R. K. Radha, 2022. *Utility of essential oil and semiochemicals of Etingera fenzlii, an endemic plant species of the Andaman and Nicobar Islands in mosquito management*. Prof A. Abraham Memorial Seminar, KSCSTE-JNTBGRI, Palode, Thiruvananthapuram, 28th June 2022.
21. Aswathy Anand, A., Jayanthi, P. D., Radha, R. K. and R. Rajendran, 2021. *GC/EAD analysis and mosquitocidal activity of Etingera fenzlii (Kurz) Skronick. & M. Sabu (Zingiberaceae)*. International Conference on Sustainable utilization of Bioresources, Dec 2021, Department of Botany, University of Kerala.
22. Aswathy Anand, A., Jayanthi, P. D., Rajendran, R. and R. K. Radha, 2022. *GC/EAD analysis and mosquitocidal activity of Etingera fenzlii (Kurz) Skronick. & M. Sabu*. International Conference on Sustainable Utilization of Bioresources 10-15 January 2022, University of Kerala, Thiruvananthapuram.
23. Aswathy Anand, A., Radha, R. K. and R. Rajendran, 2021. *Repellent effect of essential oil of Etingera fenzlii (Kurz) Skronick. & M. Sabu (Zingiberaceae) against Aedes aegypti*. 34th Kerala Science Congress, 2021.
24. Aswathy, L. B., Muhammad Ali Noushad and K. K. Sabu, 2021. *Differential expression of small HSPs in small cardamom under heat stress*. Proceedings of 33rd Kerala Science Congress held at Thiruvananthapuram from 25th to 30th January 2021.
25. Aswathy, S. V., Hubert Joe, I., and K. B. Rameshkumar, 2022. *Vibrational spectroscopic analysis of morelloflavone and its glycoside fukufgicide*. National Seminar on Fundamental and Applied Dimensions in Plant Sciences, Organized by KSCSTE-JNTBGRI, Thiruvananthapuram, 23 – 25 March 2022.

26. Athul Hari, S., Ajikumaran Nair, S., Anil John, J. and B. Sabulal, 2022. *Antihyperglycemic Activity of Ficus species*. 34th Kerala Science Congress, Thiruvananthapuram, 27-29 January 2022.
27. Chandni, C. L., Gokul, B. S., Anil John, J., Lizzy Mathew and B. Sabulal, 2022. *Chemical characterization of extra floral nectar in Nepenthes khasiana Hook. f.* National seminar on Advanced Functionalized Materials for Analytical, Environmental and Biomedical Applications (NSAFM-2022), Organized by Interuniversity Centre for Advanced Materials Research and Department of Chemistry, University of Kerala, 10-12 February (online mode).
28. Gokul, C. S., Vilas, T. S. and M. Rajendraprasad. *Regeneration and Recruitment of Myristica fatua (Houtt.) var. magnifica (Bedd.) Sinclar (Myristicaceae) - A Community study*. Indian Biodiversity Congress, Puduchery.
29. Govind, M. G. and M. Dan, 2022. *Studies on distribution and status of family Myristicaceae in the Western Ghats*. In: Jose S., Kumar, K. A. S. and T. M. Prajith (Eds.). Proceedings of National Seminar on Conservation of Biological Resources of Western Ghats. Govt. College Chittur. ISBN 9789356278547. pp: 25-38.
30. Govind, M. G., Dan, M. and K. B. Rameshkumar, 2021. *Chemotaxonomy of Myristicaceae in the Western Ghats using Chemical Profile of essential Oils from the leaves*. In: International Conference on New Horizons in Plant Science, Department of Botany, University of Kerala, Thiruvananthapuram. 4-9th January 2021.
31. Greeshma, B. N., Anil John, J., Ajikumaran, N. S., Chaithra, P., Nihila, L., Meenu, M. S., Sreejith, P. P., Sabulal, B. and V. Gayathri, 2022. *Wound healing and tissue regeneration activities by Thottea siliquosa leaf essential oil and its nanoparticles*. 34th Kerala Science Congress, Thiruvananthapuram, 27-29 January 2022.
32. Greeshma, B. N., Anil, J. J., Ajikumaran, N. S., Chaithra, P., Nihila, L., Meenu, M. S., Sreejith, P. P., Sabulal, B. and V. Gayathri, 2021. *Designing Thottea siliquosa essential oil nanoparticles as wound healing and regeneration interface*. Nobel Laureates S & T Seminar Series 11th India-Japan Science and Technology Seminar; Organized by Sree Chitra Thirunal Institute of Medical Sciences and Technology (SCTIMST) and Indian JSPS Alumni Association (IJAA), 6-7 December 2021.
33. Jaichand J., Sabu K. K. and V. Thankamani, 2021. *Cytotoxicity studies and antiviral activity of Sesbania grandiflora*. Proceedings of International Webinar on

- ‘Phytochemistry-Impacts and Applications’, held online on September 27th and 28th, 2021 by Kerala Academy of Sciences, Thiruvananthapuram.
34. Jisha Daniel, Santhosh Kumar, E. S., William Decruse, S. and M. Rajendraprasad, 2020. *Ethnomedicinal uses of the family Oxalidaceae: a review.* Indian Biodiversity Congress, Puduchery.
 35. Keerthi Sugathan, J., Sreekumar, S. and C. K. Biju, 2021). *In-silico evaluation of anti-SARS-CoV-2 activity in Carica papaya L.* International Webinar on ‘Phytochemistry- Impacts and Applications’. In: Rameshkumar, K. B., Priya, M and B. Sruthy (Eds.). Proceedings and Abstract Kerala Academy of Sciences. p 49. ISBN No.: 978-81-951912-5-3.
 36. Keerthi Sugathan, J., Sreekumar, S. and C. K. Biju, 2021. *In silico evaluation of anti-SARS CoV 2 activity in Aegle marmelos*. 33rd Kerala Science Congress organised by KSCSTE, 25- 30 January 2021.
 37. Keerthi Sugathan, J., Sreekumar, S. and C. K. Biju, 2021. *In silico validation of anti SARS-CoV-2 activity and identification of lead molecules in Artocarpus heterophyllus.* Biospectrum 2021: International Conference on Biotechnology & Biological Science organized by Department of Biotechnology, University of Engineering and Management, Kolkata in association with The Indian Ecological Society, Microbiologists Society and SMART, 18th - 20th November 2021.
 38. Lekshmi, R. K., Biju, C. K. and S. Sreekumar, 2021. *A potential anti-dengue lead from Ocimum sanctum L.: An in-silico study.* International Webinar on ‘Phytochemistry- Impacts and Applications’. In: Rameshkumar, K. B., Priya, M and B. Sruthy (Eds.). Proceedings and Abstract Kerala Academy of Sciences. p. 50. ISBN No.: 978-81-951912-5-3.
 39. Lekshmi, R. K., Biju, C. K. and S. Sreekumar, 2021. *A potential anti-dengue lead from Andrographis paniculata: An in-silico study.* In the 33rd Kerala Science Congress organised by KSCSTE from 25-01-2021 to 30-01-2021.P42.
 40. Lekshmi, R. K., Biju, C. K. and S. Sreekumar, 2022. *In silico Investigation of Anti-Dengue Lead from Annona reticulata L.*” Proceedings, 34th Kerala Science Congress pp. 358-359. ISBN: 978-81-953863-1-4.
 41. Mary Mathew, K., Reshma Renjanan, Swapna Sasidharan, Sabu, K. K., Nadiya, F., Muhammad Ali Noushad, Soumya S. Dharan and A. B. Remyashree, 2020. *Transcriptome analysis of small cardamom associated with capsule rot disease.*

International Symposium on Spices as Flavours, Fragrances & Functional Foods (SYMSAC X) held at ICAR-CMFRI, Kochi, Kerala during 06-09 May 2020.

42. Pradeep, C. K., 2021. *The fungal dimension of biodiversity conservation*. Virtual National Conference on Biodiversity and Biotechnology for fungi and 47th annual meeting of Mycological Society of India organized by Department of Botany, Punjab University, and Patiala, Feb.20-24.
43. Praseetha, S., Shiburaj, S., Swapna, T. S. and M. Dan, 2021. *Inhibition of Biofilm and Biofilm associated Virulence factors by underexplored Hedychium coronarium var. chryseolum Essential oil against Streptococcus pyogenes*. In: International Conference on New Horizons in Plant Science, Department of Botany, University of Kerala, Thiruvananthapuram, 4-9th January 2021.
44. Praseetha, S., Swapna, T. S., Dan, M., Pandian, S. K. and S. Shiburaj, 2020. *Evaluating Anti-Bio film Potential of Essential oil from Hedychium larsenii against Streptococcus pyogenes and Toxicity assessment in Danio rerio*. International Conference on Anti-microbial Resistance and Micro biome, Under Changing Climate organized by Pondicherry University during 10th to 12th October 2020.
45. Priya Rani M. and K. B. Rameshkumar, 2022. *Illuminating fuel oil from Garcinia gummi-gutta seeds – an R&D innovation of social relevance*. 34th Kerala Science Congress, organised by KSCSTE. 27-29, January 2022, p.477-478.
46. Raghi, R. G., 2020. *Ayurvedic Aspects of 'Pathila' – Ten Wonder Leaves of Kerala*. Webinar series - Recent Trends in Plant Science Research, at JNTBGRI" on 9th September 2020.
47. Rahul Jose, Anilkumar, C. and P. S. Jothish, 2022. *Ecological studies of Diospyros crumenata Thw. in Kerala – an endangered tree of Western Ghats*. Abstract Book of International Conference on Sustainable Utilization of Bioresources. Department of Botany, University of Kerala, Karyavattom Campus, Thiruvananthapuram from 10th to 15th January 2022. pp.67.
48. Rahul Jose, Anilkumar, C., Jothish, P. S. and P. A. Jose, 2022. *Conservation through vegetative propagation of Diospyros crumenata Thw. – An endangered tree of Western Ghats*. Proceedings of the National Seminar on Fundamental and Applied Dimensions in Plant Sciences. Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram from 24th and 25th March 2022.

49. Remya, R. P., Sreekumar, S. and C. K. Biju, 2021. *In silico evaluation of anti-diabetic activity in Plectranthus vettiveroides*. Presented poster in 33rd Kerala Science Congress organised by KSCSTE from 25-01-2021 to 30-01-2021.P41.
50. Remya, R. P., Sreekumar, S. and C. K. Biju, 2021. *In silico validation of anti-diabetic activity and identification of lead molecules in Plectranthus vettiveroides (Jacob)* N. P. Singh & B. D. Sharma. International Webinar on 'Phytochemistry- Impacts and Applications'. In: Rameshkumar, K. B., Priya, M. and B. Sruthy (Eds.). Proceedings and Abstract Kerala Academy of Sciences. P. 65. ISBN No.: 978-81-951912-5-3.
51. Remya, R. P., Sreekumar, S. and C. K. Biju, 2022. *Validation of anti-diabetic activity in Plectranthus vettiveroides and identification of lead molecules through in silico method*. In the International Conference on Advanced Biology 2022 (ICAB 2022) organized by Inter University Centre for Evolutionary and Integrative Biology, University of Kerala (iCEIB UOK) on 23-25 February 2022.
52. Reshma, R. and K. K. Sabu, 2021. *A comparative study on Genome-wide SSR markers identification using three microsatellite finding tools in Musa acuminata*. In: Proceedings of International Conference on Advancements in Interdisciplinary Research (ICAIR-21) held online during 26-28 October 2021.
53. Reshma, R. and K. K. Sabu, 2021. *Genome-wide identification of microsatellite markers in Musa acuminata subsp. malaccensis*. In: Proceedings of Online poster competition on the topic 'Genomics in Plants, Animals and Microbes' held online on 27 September 2021 at Inter-university Centre for Genomics and Gene Technology, Department of Biotechnology, University of Kerala, Thiruvananthapuram.
54. Reshmadas, M., Omar Z. Hisham and K. B. Rameshkumar, 2021. *Role of alcohol-based sanitizers in pandemics- Composition and analysis*. 33rd Kerala Science Congress, Organised by KSCSTE. 25-29, January 2021, p.46.
55. Reshmi Nair, R. J., Lakshmi, S., Suja, K. P. and K. K. Sabu, 2021. *Evaluation of cytotoxic studies and HPLC profiling of Saraca asoka ethanolic bark extract for endometriosis treatment*. In: Proceedings of International Conference on New Horizons in Plant Science, held during 4-9 January 2021 at Department of Botany, University of Kerala, Thiruvananthapuram.
56. Reshmi Nair, R. J., Lakshmi, S., Suja, K. P. and K. K. Sabu, 2021. *Impact of Glycyrrhiza glabra on endometriosis treatment*. In: Proceedings of International

- Webinar on ‘*Phytochemistry-Impacts and Applications*’, held online on September 27th and 28th, 2021 by Kerala Academy of Sciences, Thiruvananthapuram.
57. Revathy, S., Anilkumar, S. and K. K. Sabu, 2021. *Comparative assessment of genetic diversity among Cullenia exarillata from Silent Valley National Park and Kannur*. In: Proceedings of International Conference on Advancements in Interdisciplinary Research (ICAIR-21) held online during 26-28 October 2021.
 58. Revathy, S., Navami Jayan, Anilkumar, S. and K. K. Sabu, 2021. *Comparative Assessment of Genetic Diversity among Cullenia exarillata from Silent Valley National Park and Kannur*. International Conference on Advancement in Interdisciplinary Research (ICAIR-2021), Shia P.G. College, Lucknow, UP, October 26th-28th 2021.
 59. Revathy, S., Nissy Baby, Anilkumar, S. and K. K. Sabu, 2020. *Genetic variation in Cullenia exarilla populations from different locations of Wayanad, Kerala*. 6th India International Science Festival (IISF-2020) held online on 22 December 2020.
 60. Rijuraj, M. P., Rajendraprasad, M., Shaju, T. and A. G. Pandurangan, 2022. *A Study on Adaptive Traits on Lateritic Plants in Northern Kerala*. Indian Biodiversity Congress, Puduchery.
 61. Rijuraj, M. P., Shaju, T. and A. G. Pandurangan, 2022. *Socio-Economic significance of low land Grasslands in Lateritic zones of Northern Kerala, India*. Biodiversity Club, St. Thomas College, Kozhencherry, 5 December 2022.
 62. Sai Gayatri, Suja, S. R. and B. S. Bijukumar, 2022. *Role of Antioxidants in Therapeutic applications: Evaluation of in vitro antioxidant potential of Leaf Extracts of Humboldtia decurrens, Bedd. ex Oliv., an endemic tree of ethnomedicinal importance*. National seminar in recent trends in disease prevention and health management” (NS-DPHM-2022), 14-15 December 2022, CSIR-NIIST, Thiruvananthapuram.
 63. Sakthipriya, M. and K. K. Sabu, 2021. *Genetic diversity and cluster analysis in Centella asiatica (L) Urb. using microsatellite markers*. In: Proceedings of International Conference on New Horizons in Plant Science, held during 4-9 January 2021 at Department of Botany, University of Kerala, Thiruvananthapuram.
 64. Saranya Mol, S. T., 2020. *Relevance of Digitization of Traditional Knowledge*. Webinar series - Recent Trends in Plant Science Research, at JNTBGRI” on 9th September 2020.

65. Saranya, P. K., Suhara Beevy, S. and K. K. Sabu, 2021. *Seed Biochemical Studies in the Mature Seeds of Momordica charantia L.* In: Proceedings of International Conference on New Horizons in Plant Science, held during 4-9 January 2021 at Department of Botany, University of Kerala, Thiruvananthapuram.
66. Sathya Krishna, P. K., Suja, S. R, Stephan, J. and Mathew Dan, 2022. *Morphological and anatomical investigation on wild Piper betle L. from Andaman Islands in comparison with the popular cultivar from the southern western ghats aiming bioprospecting.* XXXII Annual conference of Indian association of angiosperm taxonomy and National symposium IAAT 2022 on ‘The Contribution of Angiosperm diversity to Human wellbeing and the risks associated with its decline’ on 11th to 13th November 2022 at Karnataka Science College, Dharwad, Karnataka.
67. Sayoojia, K. S, Sreekala, A. K. and P. N. Shaiju, 2021. *Gynostemium morphology of Thottea ponmudiana Sivar. An endemic species of the Western Ghats, India.* National Seminar on Biodiversity, Conservation and Ecosystem Restoration, Organized by Department of Botany, Vimala College, Thrissur on 10/12/2021.
68. Scaria, S., Jothish, P. S. and C. Anilkumar, 2021. *Population structure of a critically endangered Humboldtia unijuga var. trijuga Joseph & V. Chandras., of the southern Western Ghats.* Paper presented in XLIV All India Botanical Conference of the Indian Botanical Society and National Symposium on ‘Plant Science Research in Present Scenario: Opportunities and Challenges’ 18.10.21 to 20.10.21 organised by JNV University, Jodhpur. Pp 120-121.
69. Shalini Rajan, 2020. *Ethnobiological study on the mangroves of Vypin Island.* Webinar series - Recent Trends in Plant Science Research, at JNTBGRI” on 9th September 2020.
70. Shefin, B., Sreekumar, S. and C. K. Biju, 2021. *In silico bioprospecting of anti-tuberculosis activity in Phyllanthus emblica L. and identification of lead molecules.* Abstract, 52nd World Conference on Lung Health of the International Union Against Tuberculosis and Lung Disease (The Union), Virtual event 19–22 October 2021; The International Journal of Tuberculosis and Lung Disease 25(10) Suppl. 2, P. S452. ISSN 1027 3719.
71. Shefin, B., Sreekumar, S. and C. K. Biju, 2021. *Virtual screening of natural compounds and identification of anti-SARS CoV 2 leads.* In the 33rd Kerala Science Congress organised by KSCSTE from 25-01-2021 to 30-01-2021. P6.

72. Shefin, B., Sreekumar, S., Prabuseenivasan and S. Justin Raj, 2021. *Evaluation of anti-tuberculosis activity in Curcuma longa and identification of lead molecules*. International Webinar on ‘Phytochemistry- Impacts and Applications’. In Rameshkumar, K. B., Priya, M and B. Sruthy (Eds.). Proceedings and Abstract, Kerala Academy of Sciences. P. 75. ISBN No.: 978-81-951912-5-3.
73. Shintu Scaria, Jothish, P. S. and C. Anilkumar, 2022. *Population Status and Conservation of a Critically Endangered tree species Humboldtia unijuga Bedd. var. trijuga J. Joseph & V. Chandras., in the Western Ghats*. Proceedings and Abstracts on National seminar on Fundamental and Applied Dimensions in Plant Sciences, organized by JNTBGRI, on 24th and 25th March 2022. pp 20. ISBN 978-81-955043-0-5.
74. Shintu Scaria, Jothish, P. S. and C. Anilkumar, 2022. *Phytosociology of Humboldtia unijuga var. trijuga J. Joseph & V. Chandras., critically endangered tree species in the southern Western Ghats*. International Conference on Sustainable Utilization of Bio-resources, organised by Department of Botany, University of Kerala from January 10 to 15, 2022. pp 73.
75. Soorya, S., Sabu, K. K. and T. S. Swapna, 2021. *Lack of linkage between sex and molecular markers in dioecious Palmyra palm*. In: ‘Genomics in Plants, Animals & Microbes’, held on September 27, 2021, at Inter University Centre for Genomics & Gene Technology, Department of Biotechnology, University of Kerala, Thiruvananthapuram.
76. Soumya S. Dharan and K. K. Sabu, 2021. *Gene expression analysis in response to abiotic stress in cardamom under in-vitro conditions*. PLACROSYM XXIV. Plantations Crops Symposium. 14-16 December 2021, Kochi.
77. Soumya S. Dharan and K. K. Sabu, 2021. *Reference gene standardization and expression analysis of stress related genes in cardamom cell suspension*. In: Proceedings of International Conference on Advancements in Interdisciplinary Research (ICAIR-21) held online during 26-28 October 2021.
78. Sreedevi S. Kumar, 2020. *Insight into the richness and utilization of coastal biodiversity – An Ethnobiological survey and documentation*. Webinar series - Recent Trends in Plant Science Research, at JNTBGRI” on 9th September 2020.
79. Sreedevi S. Kumar, Vinodkumar T. G. Nair, M. Navas and S. R. Suja, 2022. *An Ethno-medico-botanical Investigation of the Coastal Biodiversity of Thrissur District, Kerala through Systematic Documentation and Survey*. National Seminar

- on Fundamental and Applied Dimensions in Plant Science held at KSCSTE-JNTBGRI on 24th and 25th March 2022.
80. Sreeja Devi, P. S., Neethu S. Kumar and K. K. Sabu, 2021. *National Conference on Sustainable ecosystems, aquaculture, fisheries and fisherfolk* (ANCOSEAFF, 2021) organized by Department of Aquatic Biology and Fisheries, University of Kerala and held at Department of Aquatic Biology and Fisheries, University of Kerala, Kariavattom, Thiruvananthapuram on the title “Diversity of Bioactive Compounds in Jackfruit Accessions Collected from Southern Districts of Kerala” held from 04 to 05 March 2021.
81. Sreeja Devi, P. S., Neethu S. Kumar, Sathees C. Raghavan and K. K. Sabu, 2022. *Comparative screening of jacalin and anticancer activity in wild and cultivar varieties of jack fruit*. 34th Kerala Science Congress (held online) organized by Kerala State Council for Science, Technology & Environment, Thiruvananthapuram.
82. Sreeja Devi, P. S., Sathees C. Raghavan, Neethu S. Kumar and K. K. Sabu, 2021. *Bioactive compounds present in Jackfruit (Artocarpus heterophyllus Lam.) and its role in human health*. In: Proceedings of International Conference on New Horizons in Plant Science, held during 4-9 January 2021 at Department of Botany, University of Kerala, Thiruvananthapuram.
83. Sreelekshmi, S. M., Biju, H., Sabeena, A. and A. K. Anilkumar, 2022. *Biodiversity Documentation of Lichens*. Proceedings National Seminar / Workshop on Ecosystem – Monitoring, Assessment and Conservation (Environment Management Training 2022), Department of Botany, Govt. College for Women, Thiruvananthapuram 9th - 11th March, 2022.
84. Sruthy, C. R., 2020. *Kalamezhuthupaattu’- A Temple ritual of Kerala*. Webinar series - Recent Trends in Plant Science Research, at JNTBGRI” on 9th September 2020.
85. Vilas, T. S., Gokul, C. S. and M. Rajendraprasad. *The Phyto - Sociological Accounts and Ecological Succession of Fragmented Myristica Swamps of the Western Ghats-Kerala*. Indian Biodiversity Congress, Puduchery.
86. Vinayak, V., Thania Sara Varghese, Rajani Kurup, S. R, Sabulal, B. and V. Gayathri. *Insecticidal and Biological Activities of Four Different Essential Oils Against Stored Grain Pests*. 34th Kerala Science Congress.

WORKSHOP/TRAINING / WEBINARS ORGANISED

1. Ecological Restoration of Degraded Ecosystems and the Role of Botanic Gardens. National Webinar Organized by KSCSTE-JNTBGRI, Palode, Thiruvananthapuram, in association with National Academy of Sciences, India (NASI), Kerala Chapter, 4.6.2021.
2. National Webinar on Restore the Earth, organized by KSCSTE-JNTBGRI, in association with National Academy of Sciences, India (NASI), Kerala Chapter, 22.4.2021.
3. Two days training programme for AYUSH doctors on 'Traditional and Folk Practices' as part of the activity of the project on 18th and 19th November 2021 at KSCSTE- JNTBGRI. As part of the external project, A114, produced two documentary films in English of two episodes of 60 minutes duration titled, 'Traditional Knowledge and Folk Practices' covering 19 selected sequences of the project, 'Systematic Documentation of Traditional Knowledge related to plants used for food, AYUSH and indigenous medicine' and another documentary film of two day training programme for AYUSH doctors titled 'Traditional and Folk Practices' held at KSCSTE – JNTBGRI on 18th and 19th November 2021.
4. Five days online bridge course on 'Oils and Fats from Plants- Future Prospects'. JNTBGRI, July 2021.
5. Three-day workshop on 'Cultivation of NTFPs/Medicinal Plants' was organized during 28th to 30th January 2020. The collaborators were FRLHT and Forest Plus 2.0, funded by USAID through MoEF. Fifty participants representing the Vanasamrakshana Samithi from Pottamavu, Thannimoodu, Njaraneeli and Narakathinkala attended the training. There were 9 resource persons who dealt classes on conservation, collection, cultivation, value addition, nursery practices, propagation, marketing, financing, and harvesting. A booklet on cultivation practices of 30 plants and 101 seedlings of 15 species were supplied to the participants. Dr. Mathew Dan, Mr. Muraleedharan Unnithan and Dr. Abdul Jabbar co-ordinated the programme and served as resource persons in different sessions.
6. Training workshop as part of the 'Quality Planting Material Producer (QPMP), on seed collection, processing, germination, dormancy-breaking treatments, viability tests and storage methods and quality seedling production has been carried out in seed bank from 23.02.2022 to 04.03.2022.

7. Two Days National Seminar on Fundamental and Applied Dimensions in Plant Sciences, organized by KSCSTE-JNTBGRI on 24th & 25th March 2022.
8. Webinar, '*Recent Trends in Plant Science Research- 'Natural Product Chemistry and its Applications'*' conducted by Phytochemistry and Ethno-pharmacology Division, JNTBGRI (09.09.2020).
9. Webinar, '*Recent Trends in Plant Science Research- 'Current Trends in Biotechnology and Bioinformatics'*', conducted by JNTBGRI (16.09.2020).
10. Webinar series - "Recent trends in plant science research at JNTBGRI" on 9th September 2020.

WORKSHOP/TRAINING / WEBINARS ATTENDED

1. Anurag Dhyani has attended Certificate of course completion Exploring Conservation- Introduction to Conservation (online 14-16 hours) organized by National Geographic Society, Washington DC, United States, 9-23 February 2021.
2. Anurag Dhyani has attended Two-months training on '*Cryopreservation Techniques*' under INSA Visiting Scientist Programme at National Bureau of Plant Genetic Resources, New Delhi, 29th October- 27th December 2021 (INSA/SP/VSP-30/2021-22 Dated 31 May 2021).
3. Anurag Dhyani has delivered a lead lecture on '*Ecosystem Restoration*' on the eve of World Environmental Day at Govt. Degree College for Women, Baramulla, Kashmir, 5th June 2021.
4. Anurag Dhyani has delivered a talk, '*Conservation Stories*' at Centre for Biodiversity Studies, Baba Ghulam Shah Badshah University, Rajouri, Jammu and Kashmir on 7th May 2021.
5. Anurag Dhyani has participated Editorial Board meeting of Journal Plants, People, Planet, New Phytologist Foundation (online) on 30th September 2021.
6. Anurag Dhyani has participated in five IUCN Seed Conservation Specialist Group leadership meetings (online) on 20 May 2020, 24 July 2020, 12 January 2021, 7 April 2021, 8 April 2021.

7. Anurag Dhyani has participated training school program '*Plant Translocation-Theory and Techniques*' (online) organized by COST Action CA 18201 Conserve Plants Rome Botanic Garden, Rome, Italy, 24-27 March 2021.
8. Biju, H. and A. Sabeena Attended Two Days National Seminar on Fundamental and Applied Dimensions in Plant Sciences, organized by KSCSTE-JNTBGRI on 24th & 25th March 2022.
9. Biju, H. and A. Sabeena has attended a Webinar on '*Mushroom Diversity and Conservation*' organized by Department of Botany, University of Kerala, Karyavattom and another Webinar jointly organized by ENVIS Hub, Kerala and Himachal Pradesh as a part of International Day for Biological Diversity, on 22nd May 2021.
10. Biju, H. and A. Sabeena has attended two days' 'International Webinar on Phytochemistry- Impacts and Applications, to commemorate the contributions of late Prof. Hisham in the field of Photochemistry, organized by Kerala Academy of Sciences on September 27th and 28th, 2021.
11. Biju, H. and A. Sabeena has participated in the Three Days Online Faculty Development Programme on "*Prospects and Challenges of IPR*" held on 18.06.2021 to 20.06.2021, organized by PG and Research Department of Microbiology, Sengamala Thayaar Educational Trust Women's College, (Autonomous), Sundarakkottai, Mannargudi.
12. Biju, H. and A. Sabeena has participated the celebration of world fungus day 2021 on 2nd October 2021 and fungal awareness week (27th September 2021- 2nd October 2021) along with Seminar on "*Role of Fungi in Marine Fisheries Enhancement*" organized by Mycological Society of India, in association with the Centre of Advanced Study in Marine Biology, Annamalai University, Chidambaram.
13. Biju, H. has attended two days' 'International Webinar on Phytochemistry- Impacts and Applications, to commemorate the contributions of Prof. Hisham, organized by Kerala Academy of Sciences on September 27th and 28th, 2021.
14. Biju, H. has participated in the Three Days Online Faculty Development Programme on "*Prospects and Challenges of IPR*" held on 18.06.2021 to 20.06.2021 organized by PG and Research Department of Microbiology, Sengamala Thayaar Educational Trust Women's College, (Autonomous), Sundarakkottai, Mannargudi.

15. Navas, M. has attended International Webinar on Phytochemistry, organized by the Kerala Academy of Sciences on 28th & 29th September 2020.
16. Navas, M. has attended the National Webinar on '*Relevance of Ethnobotany in Contemporary Socio-Economic Conditions*' on 14/08/2020, organized by S. K. Jain Institute of Ethnobiology, Jiwaji University, Gwalior.
17. Navas, M. has attended the National Webinar on '*Traditional Systems of Medicine and role of Ethnobotanicals*' on 30/08/2020, organized by Arulmigu Palaniandavar College of Arts and Science, Palani.
18. Navas, M. has attended the Webinar on '*Authentication Services in Herbal Medicine: Principles and Prospects to Prevent Fraudulence in the Herbal Market*' organized by the SRM Institute of Sciences and Technology, Kancheepuram, Tamil Nadu from 19th to 20th November 2020.
19. Navas, M., Saranya Mol, S. T. and Sreedevi S. Kumar has attended the webinar on 'Dr P. R. Pisharoty Memorial Lecture Organized by KSCSTE, on 28th January 2021.
20. Navas, M., Saranya Mol, S. T. and Sreedevi S. Kumar has attended the webinar on 'E. K. Janaki Ammal Memorial Lecture' at KSCSTE on 29th January 2021.
21. Navas, M., Sreedevi S. Kumar and Saranya Mol, S. T. has attended the National Webinar on 'Botanical evidence in Forensic Science' organized by the PG & Research Department of Botany, NSS College, Pandalam on 22.10.2020.
22. Navas, M., Sreedevi S. Kumar and Saranya Mol, S. T. has attended the Webinar on E. K. Janaki Ammal on 05/11/2020 organised by Centre for Intangible Heritage Studies, Sree Sankaracharya University, Kaladi, Kerala.
23. Pradeep, C. K. has participated the celebration of world fungus day 2021 on 2nd October 2021 and fungal awareness week (27th September 2021- 2nd October 2021) along with Seminar on "Role of Fungi in Marine Fisheries Enhancement" organized by Mycological Society of India, in association with the Centre of Advanced Study in Marine Biology, Annamalai University, Chidambaram.
24. Prasannakumari, A. A. has attended a webinar on '*Herbal remedies in managing Pandemics- Scientific evaluation*' conducted by Sanadhana Dharma College, Alappuzha, in association with Kerala Academy of Sciences (14.09.2020).
25. Prasannakumari, A. A. has attended a webinar, '*Recent Trends in Plant Science Research- Natural Product Chemistry and its Applications*' conducted by Phytochemistry and Ethno-pharmacology Division, JNTBGRI (09.09.2020).

26. Prasannakumari, A. A. has attended a webinar, '*Recent Trends in Plant Science Research- 'Current Trends in Biotechnology and Bioinformatics'*', conducted by JNTBGRI (16.09.2020).
27. Radha, R. K. has attended (online) the Fourth DBT-BIRAC Leadership Dialogue Series Lecture titled "Leadership in the Creation of a New Scientific Endeavour: Role of a Visionary and a Missionary" to be delivered by Dr. K Kasturirangan, 12th Sep 2021.
28. Radha, R. K. has attended a webinar conducted by Asian Pacific Journal of Tropical Medicine (Speaker: Bo Cui, M.D., Ph.D., Executive Editor-in-Chief, Asian Pacific Journal of Tropical Medicine, and Asian Pacific Journal of Tropical Biomedicine), China, Beijing, December 22, 2021.
29. Radhakrishnan, K. has attended the webinar on '*Folk healing within a Western context of or Magic and Medicine in modernity: Reflections from empirical findings using Ireland as a case example*' by Dr. Ronald Moore, University of Dublin, organized by Dept. of Biochemistry, St. Thomas College, Pala on 20.10.2020.
30. Raj Vikraman, R. has attended a talk on '*Status of Indigenous Ornamental plants in Indian Gardens*' as part of the National Webinar on 'Harnessing the Potential of Indigenous Ornamental Plants: Post Covid 19 Pandemic' Organized by ICAR- Directorate of Floriculture Research, Pune, Maharashtra (18.06.2020).
31. Raj Vikraman, R. has attended the inaugural talk on "*Indigenous and Exotic Species Status in Gardens of Kerala*, Webinar series (DBT-STAR SCHEME Sponsored) of Nirmalagiri College, Kannur (20.08.2020).
32. Rajendraprasad, M. has attended the National Online Training Programme on 'Conservation, Management and Utilization of Horticultural Genetic Resources for livelihood and nutritional security, ICAR, IHRD, Bangalore.
33. Rajendraprasad, M. has attended the workshop 'Vamanapuram river rejuvenation project', Thiruvananthapuram.
34. Sabu, K. K. has attended International Conference on New Horizons in Plant Science organized by Department of Botany, University of Kerala, Thiruvananthapuram during 4th to 9th January 2021.
35. Sabu, K. K. has attended the 33rd Kerala Science Congress held at Thiruvananthapuram from 25th to 30th January 2021.

36. Saranya Mol, S. T. and Sreedevi S. Kumar has attended the webinar on '*International symposium on recent approaches in plant taxonomy and ethnobotany- Women signatures in plant taxonomy and ethnobotany*' organized by the Dept. of Postgraduate and Research in Botany, S D College, Alappuzha on 4th and 5th November 2020.
37. Saranya Mol, S. T. and Sreedevi S. Kumar has attended the webinar on '*Geographical indications- Significance and Registration procedures*' organized by the Intellectual Property Rights Information Centre-Kerala, KSCSTE, on 18th December 2020.
38. Saranya Mol, S. T. and Sreedevi S. Kumar has attended the webinar on '*Overview of Intellectual Property Rights*' organized by Technology Information, Forecasting and Assessment Council & KSCSTE-IPRICK, on 18th January 2021.
39. Saranya Mol, S. T. and Sreedevi S. Kumar has attended the webinar on '*IP management in Biotechnology Industry*' organized by KSCSTE-IPRICK, on 20th - 21st January 2021.
40. Saranya Mol, S. T. and Sreedevi S. Kumar has attended the webinar on '*IP management and Technology Transfer in Agriculture and allied sector*' organized by the Intellectual Property Rights Information Centre-Kerala, KSCSTE during 24-25 February 2021.
41. Saranya Mol, S. T. has attended the National Webinar on 'Scope and Significance of Ethnobotanical Research on 19th November 2020, organized by the Dept. of Botany (SF), BAM College, Thuruthicaud, Pathanamthitta.
42. Saranya Mol, S. T. has attended the Webinar on '*Plant taxonomy and Ethnobotany in India-Future & Challenges*' from 4th to 6th November 2020.
43. Saranya Mol, S. T. has attended the webinar on '*Transgenic mice by Gene Editing Resaerch*' on 2nd February 2021, organized by BAM College, Thuruthicaud, Pathanamthitta.
44. Sreedevi S. Kumar has attended the international webinar on '*Synthetic Biology in Natural Product Drug Discovery*' on 22nd March 2021orgnaized by the Postgraduate and Research Department of Botany, St. Thomas College, Kozhencherry, Kerala.

45. Sreedevi S. Kumar has attended the Webinar on Intellectual Property Rights: An overview, organized by St. Thomas College, Kozhencherry on 25th September 2020.
46. Sreedevi S. Kumar, Saranya Mol, S. T. and Krishna Murugan has attended the webinar on '*The role of underutilized tuber crops in making world food system sustainable*' organized by the department of Botany, KKTU Govt. College on 16.10.2020.
47. Sreekala, A. K. has attended the International Conference on Photochemistry-Impacts and Applications conducted during September 27-28,2021, organized by the Kerala Academy of science.
48. Sreekala, A. K. has attended the National Seminar on Ecosystem Restoration; Aquatic Ecosystems and Water Conservations on June 5th, 2021, by Kerala Academy of science, as part of the World Environmental Day.
49. Sreekumar, S. and Keerthi Sugathan, J. has participated in the International Webinar on Phytochemistry-Impacts and Applications organized by Kerala Academy of Sciences on 27th and 28thSeptember, 2021 and published three abstracts as corresponding author and one abstract as co-author. Also bagged best paper presentation award by my Ph.D. student Keerthi Sugathan.
50. Sreekumar, S. has attended Biospectrum 2021: International Conference on Biotechnology & Biological Science organized by Department of Biotechnology, University of Engineering and Management, Kolkata in association with The Indian Ecological Society, Microbiologists Society and SMART held from 18th to 20th November 2021.
51. Sreekumar, S. has attended the 33rd Kerala Science Congress held during the 25-30 January 2021 and served as an expert member in paper evaluation and as an organizing committee member - Technical Session "Biotechnology".
52. Sreekumar, S. has attended the All-India Council for Technical Education - (AICTE) Training and Learning Academy Online Elementary FDP on "FDP on Molecular Modelling and In-silico Drug Designing." Course from 23/08/2021 to 27/08/2021 at St. Joseph's College of Engineering, Chennai.
53. Suja, S. R. has attended 5 days training course on Role of nutraceuticals in tissue generation organised by Dept of Zoology in association with Dept of Nano Science and Nano technology and CLIFF Kerala sponsored by Ministry of Human Resource development, Govt of India. 25-29, October 2022.

54. Suja, S. R. has attended the DBT Webinar series on COVID-19, the first webinar under this series "DBT's Response to COVID-19" on July 3rd 2020.
55. Suja, S. R. has attended the Two weeks hands on training programme on online Faculty Development programme on Marine Bio and Nanotechnology jointly organized by Centre for Ocean Research (COR), DBT, SIST in association with Earth Science and Technology from December 1st to 10th 2021.
56. Suja, S. R. has attended the webinar on 'A Paradigm Shift in Infectious Diseases: Lessons from a Pandemic' hosted by Merk KGaA on 1st September 2020.
57. Suja, S. R. has attended the webinar on "COVID-19 Insights: Possible research solutions to help you accelerate development of drugs, vaccines and therapies" on 29/08/2020, organized by eLearning Phenomenex.
58. Suja, S. R. has attended the webinar on "*Toxicology: Science of wellness*" on 28/08/2020, organized by Centre of Medical Knowledge Excellence (CMeKE).
59. Vipin Mohan Dan has attended a workshop on "*Introduction to Phylogenetics*" July 6th -7th 2021, conducted by RGCB, Thiruvananthapuram.

POPULAR ARTICLES

1. Bhatt, N. and A. Dhyani, 2021. Sacred groves in India- Biodiversity Conservation. Nursery Today 1(1):102-106.
2. Dhyani, A., 2021. Back from the brink: *Buchanania barberi* in India. BGjournal- Journal of Botanic Gardens Conservation International. 18(2): 8-10.
3. Dhyani, A., Abinlal, K. C., and S. Bindu, 2021. *Santalum album* at a glance. Nursery Today 8(1): 100-102.
4. Gopakumar, B. and Mathew Dan, 2021. "Bamboo –The Green Gold", Special Issue Newsletter 'Plant Bamboo', Department of Botany, University of Kerala, Karyavattom, p.3.
5. Mathew Dan, Saleem, M. and R. Prakashkumar, 2020. "*Nithya Vismayamee Irapidiyan Sasiyangal*", Aaranyam, Forestry Information Bureau Publication, Forest Department of Kerala 40 (09):12-13.
6. Radha, R. K., 2021. Concept bank in the context of Corona Epidemic- Concept Bank COVID-19 infection: the perspectives on immune responses of

traditional medicinal plants- PART 2 submitted to KSBB, Govt. of Kerala, May 2021.

7. Radha, R. K., 2020. Concept Bank (Technical Article) COVID-19 infection: the perspectives on immune responses of traditional medicinal plants) Developing concept bank in the context of the Corona Epidemic - PART 1, Kerala State Biodiversity Board, Government of Kerala (KSBB), Govt. of Kerala Dec 2020.
8. Raj Vikraman, R. and R. Prakashkumar, 2020. Botanical Gardens in Kerala and its Relevance. ENVIS KERALA (Vol.2) Issue 1 Oct – Dec 2020.
9. Santhosh Kumar, E. S., 2021. *Malampuli – vamshanasham neridunna vanavriksham (Dialium travancoricum - An Endangered Wild Tree)*. Aranyam (June):36-37.

SIGNIFICANT ASSIGNMENTS AND CONSULTATIONS

1. Anilkumar, C. has given technical guidance to the Malayinkeezhu Gramapanchay at Krishibhavan for the setting up of a seed bank under Janakeeyasuthruanam, 2021-22.
2. Anilkumar, C. has served as a resource person in the Training on Traditional and Folk Practices for Ayush Doctors and led two Technical Session with a lecture on the topic ‘*Seed Science for balancing bio resource demand and supply*’ on 18th November 2021.
3. Anilkumar, C. has supervised the research of Arun R. Pillai, Department of Botany, Karyavattom, University Kerala for the successful completion of ASPIRE internship on the proposed work “*Metabolite profiling of Arenga wightii Griff. seeds during different desiccation stages*”.
4. Anilkumar, C. has worked as a subject expert in the University of Calicut Ph. D pre-submission through online mode seminar on 29-12-2021.
5. Anurag Dhyani has become a member of the technical session and paper evaluation committee in the 33rd Kerala science congress, 25-28 January 2021.
6. Anurag Dhyani has been working in Collaboration with Dr. Uromi Manage Goodale (Associate Professor) and her Ph.D. student Namrata Pradhan (Regeneration Ecology, Seed-Bio physiology and Conservation Laboratory, Guangxi Key Forest Ecology and Conservation, College of Forestry, Guangxi University, Daxuedonglu 100, Nanning 530005, Guangxi, China) for her on-going research on orchid conservation at Guangxi University. The collaboration focuses on writing, analysis, and publications on *in situ* and

ex situ conservation of orchids.

7. Anurag Dhyani has reviewed 13 papers for Journals such as Sustainability (1), Journal for Nature Conservation (1), Genetic Resources and Crop Evolution (1), Ethiopian Journal of Science (1), Journal of Seed Science (1), Journal of Traditional and Folk Practices (2), Journal of Biological Diversity (1) and Indian Journal of Traditional Knowledge (5).
8. Jothish, P. S. became the Editorial and Publication Committee Member of the 33rd Kerala Science Congress, 25-30 January 2021.
9. Jothish, P. S. has supervised Reshma M. Das, Research Scholar, Department of Botany, University Kerala, Karyavattom for her successful completion of ASPIRE internship on the work “*Metabolite profiling of Bentinckia condapanna* Berry ex Roxb. seeds during different desiccation stages”.
10. Pradeep, C. K. became the co-chairperson in the Virtual Conference on the “*Role of Fungi in Marine fisheries enhancement*”, organized by CAS in Marine Biology, Annamalai University, Parangipettai, Tamil Nadu, on 2 October 2021.
11. Pradeep, C. K. has been appointed as an external expert in the Research Advisory Committee, for evaluation of Research progress of Sudheesh Kumar N, Research Scholar, Kannur University (2021-2023).
12. Radha, R. K. has become a Resource Person/Member of District Level Technical Support Group (TSG), Kerala State Biodiversity Board (KSBB), Govt. of Kerala.
13. Radha, R. K. has become member of the judging panel for Kerala State Biodiversity Conservation Award and Children's Biodiversity Congress of Kerala State Biodiversity Board.
14. Radha, R. K. has become one of the resource persons of the committee of Semiochemicals in pest management and its popularization as eco-friendly and environmentally safe agro practices in Kerala organized by Indian Institute of Chemical Technology, Hyderabad, Directorate of Agriculture, Kerala and State Planning Board, Government of Kerala.
15. Radha, R. K. has become the Expert Member of Environmental Conservation Committee (ECC), VSSC, ISRO, Thiruvananthapuram.
16. Raj Vikraman, R. has coordinated the joint involvement of Conservation Biology, PGR, and Garden Management Division's Quality Planting Material Producer (QPMP) Training programme (30 days programme from 23/02/2022 to 31/03/2022) under the

Green Skill Development Programme (GSDP) funded by MoEF&CC, Government of India through the KSCSTE ENVIS Hub.

17. Rajkumar, G. and A. Nazarudeen have provided expert opinion on three disputed lands in the EFL area at Nachivayal, Marayur on 21-02-2023, as per request from the Working Plan Officer, Munnar, Kerala Forest Department.
18. Sreekala, A. K. has chaired a technical session in the national seminar on biodiversity, conservation and ecosystem restoration organized by Dept. of Botany, Vimala College, Thrissur on 10/12/2021.
19. Sreekala, A. K. has inaugurated the Botany association and digital garden and served as the resource person of Mar Ivanios College, Nalanchira, Thiruvananthapuram on 18/12/2022.
20. Sreekala, A. K. has evaluated the Ph D thesis entitled “Reproductive Ecology of *Canavalia gladiata* (Jacq.) DC, *Tephrosia purpurea* (L.) Pers. and *Tephrosia villosa*(L.) Pers. Family Fabaceae; sub family Faboidea, submitted by Sunitha Rani, Andhra University, Visakhapatnam.
21. Sreekala, A. K. has reviewed 3 research papers for Jordan Journal of Natural history (The Royal Society for the Conservation of Nature, Jordan), Journal Phytologia Balcanica and Journal of Taiwan.
22. Sreekala, A. K. has served as the chairman of the Ph. D. viva voce of Sunitha Rani, on the topic “Reproductive ecology *Canavalia gladiata* (Jacq.) DC, *Tephrosia purpurea* (L.) Pers. and *Tephrosia villosa* (L.) Pers. Family Fabaceae; sub family Faboidea” on 8/10/2021, Andhra University, Visakhapatnam.
23. Sreekala, A. K. has served as the doctoral committee member of the Ph.D. students of Karuppuswamy and Anjana Surendran of Gandhi gram rural institute, Dindigul, Tamil Nadu.
24. Sreekala, A. K. has served as the examiner of pre-Ph.D. viva voce of Thilagam, M. (MS University, Tirunelveli) on the topic “*Phytomediated Synthesis of Silver Nanoparticles: Characterization and Pharmacological Actions*” on 20/01/2021.
25. Sreekumar, S has provided necessary guidelines to develop an aesthetic garden as per request from the TRIDA Chairman. A Concept Proposal for establishing greenery in the premises of Commercial Block for TRIDA, Chala, Thiruvananthapuram was prepared and given.
26. Sreekumar, S. has become the co-convenor of the Registration Committee in the 33rd Kerala Science Congress held during 25 – 30 January 2021.

27. Sreekumar, S. has been nominated as the co-convenor of the registration Committee of 33rd Kerala Science Congress held during 25-31st January 2021.
28. Sreekumar, S. has delivered an invited lecture-cum-demonstration in the AICTE Training and Learning (ATAL) Academy Online Elementary FDP on "*FDP on Molecular Modelling and In-silico Drug Designing.*" Conducted from 23/08/2021 to 27/08/2021 at St. Joseph's College of Engineering.
29. Sreekumar, S. has served as a mentor of Drug Discovery Hackathon, 2020, organised jointly by DBT, AICTE, Pharmacy Council of India and Ministry of Education Innovation Cell Govt. of India; delivered three lectures cum demonstration online classes on '*In silico screening and drug discovery*' from plant derived compounds' to the M.Tech/Ph.D. Biotechnology students of St. Joseph's College of Engineering, Chennai and Ph.D. students of JNTBGRI.
30. Sreekumar, S., Sabu K. K., Biju, C. K. and R. K. Radha becomes the advisory committee members of the M.Sc. and Ph.D. students' thesis work, as part of the existing collaboration with College of Agriculture, Kerala Agricultural University.
31. Suja, S. R. has chaired a Technical Session at International Conference on Plant Physiology and Biochemistry (IVPCB)-2022) held during 19th and 20th Jan 2022 at Fatima Mata National College. Kollam.
32. Suja, S. R. has chaired a Technical Session in the International Seminar on Recent trends in Omics, Regenerative and Precision medicine: Interface between infectious and non-infectious diseases from 22nd July 2022- 24th July 2022 organised by Department of Zoology, University of Kerala.
33. Suja, S. R. has chaired a Technical Session in the XXXII Annual Conference of Indian Association of Angiosperm Taxonomy and National Symposium IAAT 2022 on 'The Contribution of Angiosperm Diversity to Human wellbeing and the risks associated with its decline' on 11th to 13th November 2022 at Karnataka Science College, Dharwad, Karnataka.
34. Suja, S. R. has chaired a Technical Session on National Seminar in Recent Trends in Disease Prevention and Health Management (NS-DPHM-2022), 14-15 December 2022, CSIR-NIIST, Thiruvananthapuram.
35. Suja, S. R. has chaired a Technical Session on the 5th Annual Conference SAAE (1-2022) on Alternatives to Animal experiments in translational research organized by Indian Society of Alternative to Animal experiments (SAAE), Dept of Zoology, SCTIMST, Kerala Academy of Sciences at Dept. of Zoology, University of Kerala from 8-9 December 2022.

36. Suja, S. R. has served as a chairman of the Advisory Committee and Dr. Vinod Kumar T.G. Nai became a member for conducting the Google meet defence seminar of Meera, T. S., M. Sc. Integrated Biotechnology student, Agricultural College, Vellayani in June 2020.
37. Suja, S. R. has served as Chairman of Advisory committee and Dr. Vinod Kumar, member conducted Google meet Final Viva voce of Meera, T.S. M.Sc. Integrated Biotechnology student, Agricultural College on 10 Nov. 2020.
38. Dr. K. K. Sabu has chaired a session on 11.01.2022 for a talk by Dr. Girinath Pillai on "Phytochemicals as Lead molecules for Drug Discovery using Computational methods" during International Conference on Sustainable Utilisation of Bioresources held online from 10-15 January 2022.

MAJOR INFRASTRUCTURE FACILITIES CREATED

1. Establishment of Centre of Excellence in Phytochemical-Nanotechnology (CEP) at KSCSTE-JNTBGRI under the scheme State Higher Research centres of Excellence in Science & Technology Applications (SHRESTA)-KSCSTE
2. LC-MS (CIF)
3. Upgradation of HPTLC
4. HPLC
5. Timer controlled misting facility for hardening seedlings of wild ornamentals.
6. Potting shed cum store house of (12 x 5) m² plinth area.
7. Seedling hardening shed in the Arboretum nursery.
8. Store house cum seedling hardening shed of (8 x 5) m² plinth in Palmetum.
9. Chain link fencing (680 m) of 1.5 m height, surrounding the seedling stock of the Arboretum, Palmetum nurseries and wild fruit garden as a measure to protect the seedling stock from wild animals.
10. Raised frame of 4m height around Jack tree variant 'Thenvarikka' in the Fruit plant garden to do approach-grafting in large scale.
11. Transportable metallic approach-grafting stands of different heights (eight numbers).
12. Renovation of Fernery roofing with 70% transparent new roofing sheets achieving a tremendous improvement in survival rate of plants inside.
13. The abandoned poly house near guest house is renovated for rose plant propagation and hardening.
14. Hot air oven for phyto-remediation studies of water plants.

MAJOR EXHIBITS AND COLLECTIONS

Every year the public relations unit of the division coordinates arranging stalls highlighting the plant conservation and sustainable utilization activities of JNTBGRI in exhibitions arranged by Government or quasi-Government institutions. The Institute also resumed participating in exhibitions of selected, esteemed festivals by 2021 by the lifting of Covid restrictions. In the 2021-22 periods the institute took part in the usually attending fests like the 35th Kerala Science Congress organized by KSCSTE, Palode Agri/Cattle Fest, Kerala Biodiversity Congress, Vaiga Argo Expo 2022 etc.

EXTENSION WORKS

1. The landscaping work in the campus of Institute of Advanced Virology, Thonnakkal has been done by the Garden Management Division of JNTBGRI., under the direct supervision of Dr. R. Raj Vikraman and Dr. E. S. Santhosh Kumar.
2. Setting up of a fruit tree garden in the premises of the Institute of Advanced Virology (KSCSTE) Thonnakkal under the supervision of Dr. R. Raj Vikraman and Dr. E. S. Santhosh Kumar.
3. Dr. R. Raj Vikraman, R. has been a special invitee in the technical committee for initiating softscape activities with indigenous trees around the Elephant Rehabilitation Centre, Kottoor.
4. Assessment of the floristic diversity of the proposed project site of the Herbal Garden Ranni Grama Panchayat jointly with the Kerala Forest Department: Dr. E. S. Santhosh Kumar & S. M. Shareef explored the site, prepared the list, and submitted to the DCF, Ranni.
5. The Public Relations Officer V. Premkumar has carried out sculpturing of the statue of G.V. Raja and has done the landscaping and gardening activities at G. V. Raja sports school, Mylam, Vattiyoorkavu in Thiruvananthapuram (2021).
6. The activities of Bamboo Biology Unit were telecasted by Kairali Channel, “*Nammude mannine rakshikkan prakriti niyogicha green gold*” in November and in the Asianet Channel ‘Kissan Krishideepam’ on 12th and 13th December 2020.

7. The video on rare flowering of a bamboo at Bambusetum was documented and exhibited in the virtual 'Biodiversity Conclave', 23-25th December 2020, organized by the Ministry of Science & Technology, Government of India.
8. Participated in the Virtual Kerala Bamboo Fest 2020, during 16-21 December 2020, organized by the Kerala State bamboo Mission.
9. Dr. M. Saleem has provided training to Forest Development Agency (FDA) staff at Mankulam, Munnar as part of UNDP project on 7-10 September 2020.
10. Dr. B. J. Radhika have given one month training to 3 persons namely Lakshmi, P., Sajith, S. D. and Anusree, V. S. from Chenkal Grama Panchayat in the topic 'Tissue Culture of Banana and Ornamentals'.
11. As part of various programmes on riverbank protection, 10,965 bamboo saplings were supplied to various agencies/organizations such as Vamanapuram Block Panchayat, Kerala Forest Development Corporation, Kerala Forest Department and Thiruvananthapuram Corporation during 2020- 2022 financial year.
12. Organized training on 'Preparation of Bamboo Products and Crafts' was organized during 25th to 29th October 2021 at JNTBGRI. Twenty-nine participants from five Grama Panchayats (Peringammala, Nanniyode, Anadu, Vithura and Pangode) were trained in making products by two trainers approved by the State Bamboo Mission. Display and sale of bamboo products were also arranged as part of the programme.
13. Participated in the Kerala Bamboo Fest 2021 at Marine Drive Ground, Ernakulam from 19 -24 December 2021.
14. A two-day's training programme on the 'Nursery Practices of Bamboos' has been conducted at JNTBGRI during 18th & 19th March 2022 with a view to enhance 'Quality Planting Material Production'.
15. Dr. M. Saleem has given technical guidance to the field staff of the Malabar Botanic Garden and Institute for Plant Science, Kozhikode on 8 January 2020 in nurturing live collections of orchids and carnivorous plants.

16. Dr. B. Gopakumar has presented a radio talk on 12 February 2022 on the topic 'Mula Sadharanakkaranthe Thadi' through All India Radio, Thiruvananthapuram.
17. Conducted Two days training programme for AYUSH doctors on 'Traditional and Folk Practices' on 18th and 19th November 2021 at KSCSTE- JNTBGRI.

VIP VISITS

1. Dr. Raghavendra Rao and Dr. M Sabu, Research committee members, JNTBGRI.
2. Dr. Archana Godbole, Director, Applied Environmental Research Foundation, Pune.

PLAN FUNDED RESEARCH AND INFRASTRUCTURE PROGRAMMES

SN	CODE	PROJECT NAME	DIVISION
1	P-01	<i>Ex situ</i> Conservation and Sustainable Utilization of Selected Plant Genetic Resources in the Southern Western Ghats through the invention of Biotechnology and Bioinformatics	Biotechnology & Bioinformatics
2	P-02	Studies on conservation biological aspects of selected flowering plants of Kerala.	Conservation Biology
3	P-03	Systematic documentation and bioprospecting of Ethnomedicinally important medicinal plants on tribal/traditional knowledge through molecular pharmacological approach	Ethnopharmacology & Ethnomedicine
4	P-04	Development and Upkeep of Germplasm Conservatories and Landscapes and Dissemination of Botanical knowledge	Garden Management, Education, Information and Training
5	P-05	Survey, Inventory, Bioprospecting and Sustainable Utilization of	Microbiology

		Microbial and Lichen Diversity of Western Ghats.	
6	P-06	Community Agro Biotech Resource Centre (CARC)	Microbiology
7	P-07	Sustainable utilization of medicinal, aromatic and other potential economic plants of the Kerala region of Western Ghats through phytochemical and pharmacological means	Phytochemistry & Phytopharmacology
8	P-08	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	P-09	Survey, Exploration and Documentation of Floristic wealth of Kerala and Assessment of Ecosystem Services	Plant Systematics & Evolutionary Science
10	P-10	Inventory, documentation and Phylogenetic studies of mushrooms of Western Ghats and Establishment of a regional reference centre for mushrooms	Plant Systematics & Evolutionary Science
11	P-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 & Bioinformatics
12	P-12	Integrated R&D Centre of JNTBGRI	Biotechnology & Bioinformatics

		– An extension of the Screw pine Tissue culture project at Kuzhur, Kodungalloor	
13	P-13	Improvement of Existing Landscape and Field Gene Bank	JNTBGRI
14	P-14	JNTBGRI Infrastructure Programmes	JNTBGRI
15	P-15	Central Instrumentation Facility	JNTBGRI
16	P-16	Development of a comprehensive database on achievements of JNTBGRI Bioinformatics	JNTBGRI

EXTERNALLY FUNDED PROGRAMMES

No.	Project Code	Title of the project	Principal Investigator
1	A-19	Establishment of Bioinformatics Sub-Distributed Information centre at TBGRI	Dr. S. Sreekumar
2	A-113	Development of Tissue Culture Protocol for mass propagation of selected Screwpine (<i>Pandanus</i> spp.) plants leading to technology transfer and establishment of tissue culture facility at KIDS	Dr. K. Satheeshkumar
3	A-114	Systematic documentation of Traditional Knowledge Related to plants used for Food and Medicine from the Oral Tradition	Dr. Vinodkumar T. G. Nair
4	A-168	Production and Supply of Quality Seedlings of selected Medicinal Plants	Dr. Mathew Dan
5	A-176	Identification of Potential Bioactive Chemical Marker Compounds and Biological Studies of <i>Gloriosa superba</i> and their Geographical Variations	Dr. S. R. Suja
6	A-193A2	Ecology and Conservation of Fresh water Swamp Ecosystems of the Western Ghats-Kerala Region	Dr. M. Rajendra Prasad
7	A-193A3	Comparative Biogeography of Plants of the Western Ghats	Dr. N. Mohanan

8	A-193B1	Identification of the elite lines of <i>Centella asiatica</i> and <i>Bacopa monnieri</i> for commercially significant constituents for standardization of their extracts.	Dr. B. Sabulal
9	A-193B2	Bioprospecting 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
10	A-193B4	Antiviral from medicinal plants of Western Ghats selected based on Traditional Knowledge/Ethnomedical information	Dr. S. R. Suja
11	A-193B5	Characterization, recombinant expression process scale up and validation of selected hydrolases from native action-bacteria for commercial exploitation	Dr. S. Shiburaj
12	A-203	Genetic Diversity Conservation and Population Study of Selected Notified Endangered Plant Species of Western Ghats Region of Kerala	Dr. S. William Decruse
13	A-219	Establishment of a Herbal Garden at Raj Bhavan, Thiruvananthapuram	Dr. Mathew Dan
14	A-222	Development of Lakeshore Leisure Trail Landscape, JNTBGRI, to enhance the aesthetics of the Garden	Dr. R. Raj Vikraman
15	A-225	Cultivation, Conservation and Sustainable Utilization of Medicinal Plants Through the Participation of Unemployment Women Folks	Dr. S. Binu
16	A-229	Biotransformation of saponins to diosgenin for enhanced yield from <i>Dioscorea</i> sp. using indigenous fungal strains	Dr. S. R. Reji
17	A-231	Training on Familiarization and Propagation of Medicinal Plants	Dr. Mathew Dan
18	A-233	Effect of selected nanoparticles synthesized from plant secondary metabolite on seizures induced by kainic acid in mice	Dr. V. Gayathri
19	A-241	DBT Fellowship	Ms. Soumya S. Dharan

20	A-242	CSIR Fellowship	Ms. S. Nusrin
21	A-248	CSIR studentship programme	Ms. Divya S. Pillai
22	A-249	Solvent tolerant protease from <i>Exiguobacterium</i> sp. TBG-PICH01: Cost effective Bioprocess Development and Functional Characterization for Industrial Applications	Dr. S. Shiburaj
23	A-250	Exploration of Banana Biodiversity and its Biotechnological Research in Nagaland	Dr. K. K. Sabu
24	A-254	Process Optimization and Scale up of Tannase from Marina Fungi and Evaluation of its Application in the Production of Value-Added Products from Cashew Apple	Dr. S. Shiburaj
25	A-255	Green Skill Development Programme (GSDP) – Entrusting the Certificate Course on Plant Tissue Culture Techniques and its Applications	Dr. K. K. Sabu
26	A-257	Phytochemical profiling of the aromatic Cyperaceae members of South India	Dr. K. B. Rameshkumar
27	A-258	Population Structure and Genetic Variability Analysis of <i>Cullenia exarillata</i> populations in Western Ghats	Dr. Mathew Dan
28	A-259	Analysis of genetic diversity, development of sex- linked SCAR markers and marker-assisted selection of Asian Palmyra palm (<i>Borassus flabellifer</i> L., Arecaceae)	Dr. K. K. Sabu
29	A-260	Sustainable utilization of the seeds of <i>Garcinia</i> species from the Western Ghats	Dr. M. Priya Rani
30	A-261	Biological Diversity awareness through setting up of a butterfly garden in JNTBGRI	Dr. S. Anilkumar
31	A-266	ICMR Studentship programme of Reshmi Nair R. J.	Mrs. R. J. Reshmi Nair
32	A-268	ICMR Studentship programme of Vini C. Sekhar	Mrs. Vini C. Sekhar
33	A-269	Taxonomic Revision and phylogeny of the genus <i>Piper</i> L. (Piperaceae) in India with its Biogeography.	Dr. Mathew Dan

34	A-271	Conservation of Endemic and critically endangered <i>Buchanania barberi</i> in India	Dr. Anurag Dhyani
35	A-272	KSCSTE Studentship programme of Mrs. Aswathy Anand	Mrs. Aswathy Anand
36	A-274	Back to Lab Programme: Molecular phylogeny of Meliolaceous fungi of Kerala	Mrs. S. S. Dhanusha
37	A-275	Development of Database Application Tool and Digitization of Botanical Herbarium of Department of Botany, University of Kerala	Dr. S. Sreekumar
38	A-276	M.Sc. Integrated Biotechnology students	Director, JNTBGRI
39	A-278	Population Biology of <i>Humboldtia unijuga</i> var. <i>trijuga</i> , an endemic and endangered tree species of the southern Western Ghats and its conservation	Dr. P. S. Jothish
40	A-279	Travel grant to Mr. Nandu T. G., SRF for the tour conducted to Sri Lanka	Mr. T. G. Nandu
41	A-280	Population Dynamics and agroecology of <i>Trichopus zeylanicus</i> Gaertn. ssp. <i>travancoricus</i> (Bedd.) Burkill ex Narayanan 'Árogyappacha'	Dr. C. Anilkumar
42	A-281	DST INSPIRE Fellowship of Mrs. Aswathy, J.	Mrs. J. Aswathy
43	A-282	The production of 50000 seedlings of <i>Tinospora cordifolia</i> as a part of Nation-wide campaign on 'Amrita for Life'	Dr. Mathew Dan
44	A-283	Conservation vulnerable sandalwood (<i>Santalum album</i> L.) through propagation and reintroduction.	Dr. Anurag Dhyani
45	A-284	Landscaping and gardening in the G. V. Raja Sports School, Mylom.	Dr. S. Sreekumar
46	A-285	Certificate Course on Quality Planting Material Producer to KSCSTE-JNTBGRI, Palode	Dr. Mathew Dan
47	A-286	Certificate Course on Plant Tissue Culture Techniques and its Applications to KSCSTE-JNTBGRI, Palode	Dr. K. K. Sabu
48	A-287	Central Instrumentation Facility, Internship, training, workshop etc.	Dr. K. K. Sabu & Dr. K. B. Rameshkumar

49	A-288	Development of Controlled Release Formulation of Eco-friendly Pesticides in Stored Pest Management	Dr. V. Gayathri
50	A-290	Establishment of Biodiversity Park at Chirayinkeezhu Block Panchayat Premises, Thiruvananthapuram Dist.	Dr. R. Raj Vikraman
51	A-292	Conservation of Orchids – Setting up of Orchidarium and Orchid Interpretation Centre at Eravikulam National Park	Dr. Mathew Dan
52	A-293	Search for Potential Biologically Active Constituents from the Indian Pitcher Plant, <i>Nepenthes khasiana</i> .	Dr. B. Sabulal
53	A-294	Three days training for selected unemployed women on familiarization and methods of cultivation of selected economically important medicinal plants.	Dr. S. William Decruse
54	A-295	One year student project programme	Dr. S. R. Suja
55	A-296	Eco-restoration and sustainable development of Poredam Mahadevar Temple's Sacred Grove at Chadayamangalam, Kollam (Conservation of Sacred Grove at Kollam with Community Participation).	Director, JNTBGRI
56	A-297	Best paper award project	Dr. A. L. Aneesh Kumar
57	A-298	Establishment of Bamboo Craft Centre at JNTBGRI	Dr. Mathew Dan
58	A-299	Establishment of Bamboo Tissue Culture Unit and expansion of Bamboo Conservatory at JNTBGRI.	Dr. Mathew Dan
59	A-300	Establishment of Biopark in Kukkirippara, Maranalloor Panchayat, Thiruvananthapuram Dist.	Dr. R. Raj Vikraman
60	A-301	Preparation of Red Data Book and Assessment of Threatened Species of Kerala	Dr. Nazarudeen Ahammed
61	A-302	Chemical Profiling of cardamom essential oils	Dr. B. Sabulal
62	A-303	Eco Tourism at Jawaharlal Nehru Tropical Botanical Garden and research Institute, Palode, Thiruvananthapuram	Director, JNTBGRI

63	A-304	Beautification of Virology campus	Dr. R. Raj Vikraman
64	A-305	Pumba river biodiversity conservation	Dr. E. S. Santhosh Kumar
65	A-306	The livelihood enhancement of the tribal of Njaraneely Ward for Peringammala Panchayat, Thiruvananthapuram district, Kerala through plant resource enrichment, buy back and herbal products development	Dr. S. Binu
66	A-307	Ex-situ conservation of five critically endangered plants of the Western Ghats, India.	Dr. Anurag Dhyani
67	A-308	Species distribution modelling and bioprospecting of wild Germplasm of <i>Salacia oblonga</i> Wall, a high value antidiabetic plant across the Western Ghats.	Dr. R. K. Radha
68	A-309	Micropropagation and cultivation of native orchids and hybrids for on-farm conservation and income generation in Kerala through cluster formation.	Dr. R. Prakash Kumar
69	A-310	Establishment of a biorepository of the plants endemic to southern Western Ghats of India	Dr. R. Prakash Kumar
70	A-311	Erudite public lecture	Dr. R. Prakash Kumar
71	A-312	CSIR Fellowship – Ms. Arya	Ms. C.P. Arya
72	A-313	Establishing a Butterfly Garden at Aashramam Biodiversity Centre, Kollam	Dr. S. Anilkumar
73	A-314	CSIR, Fellowship Mr. Muhammed Ali	Mr. Muhammed Ali
74	A-315	Reverse the Red: Assessing the population trends and developing recovery programme for two <i>Cinnamomum</i> species endemic to the Western Ghats.	Dr. Deepu Sivadas
75	A-316	Nutritional analysis and development of nutraceuticals/ food supplements based on Arogyapacha: an ethnomedically important plant	Mrs. Angala Mathew
76	A-317	GSDP	Dr. R. Raj Vikraman
77	A-318	Development of propagation techniques and establishment of nurseries for indigenous RET plants and species notified under Biological	Dr. Nazarudeen Ahammed

		Diversity Act and promoting cultivation with the support of research organizations, Kudumbasree and MNREGS.	
78	A-319	National seminar	Dr. K. B. Rameshkumar
79	A-320	INSA Fellowship	Dr. Anurag Dhyani
80	A- 321	Habitat distribution modelling and reinforcement of two threatened trees in Kerala region of the Western Ghats for the improvement of their conservation status.	Dr. R. K. Radha
81	A-322	Inventory Systematics and conservation of <i>Ixora</i> L. (Rubiaceae) of Kerala	Dr. G. Rajkumar
82	A-323	Tri party action plan for the reintroduction of Red Plants of Kerala	Dr. C. Anilkumar
83	A-324	Open house	Dr. K. B. Rameshkumar
84	A-325	SHRESTA	Director, JNTBGRI
85	A-326	National workshop	Dr. C. K. Pradeep
86	A-327	Green Kerala Initiative	Director, JNTBGRI
87	A-328	Course fee for M.Sc. Biotechnology students	Dr. K. K. Sabu
88	A-329	Course fee for M.Sc. Biotechnology students	Dr. K. K. Sabu
89	A-330	Beautification of IAV campus	Dr. S. Sreekumar
90	A-331	Evaluation and Characterization of Antimicrobial Potential of Wild Edible Mushrooms of Kerala	Dr. C. K. Pradeep
91	A-332	New Phytologist Foundation to Support the Research and teaching	Dr. Anuraj Dhyani
92	A-333	Cardamom for rainforest conservation	Dr. K. K. Sabu
93	A-334	Identification, creation of database, propagation , conservation and value addition of wild and underutilized edible varieties of leafy vegetables, tubers, fruits, pulses, edible mushrooms etc	Dr.Nazarudeen Ahammed
94	A-335	Documentation, Database and Conservation of Edible Mushroom Recourse of Kerala	Dr. C. K. Pradeep
95	A-336	Database on anti-viral plants with emphasize on nutraceuticals <i>in silico</i> validation of photochemicals	Dr. S. Sreekumar

		and formulation of a herbal product	
96	A-337	Conservation, Eco restoration and popularization of three endemic and threatened tree species of Kerala	Dr. A. K. Sreekala
97	A-338	Survey and documentation of Folk use of plants used by the Kani tribes of Kerala part of Agasthyamala Bioreserve with emphasis on NWFP based livelihood aspects	Dr. G. Rajkumar

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 Bioscience Institute of Chemical Technology Nathalal Parekh Marg, Matunga, Mumbai-400019	Member
3	Dr. Mohammed Aslam Senior Advisor Department of Biotechnology Ministry of Science & Technology 6-8 th Floor, Block 2, CGO Complex, Lodhi Road New Delhi - 110003	Member
4	Dr. Madhmitha Biswas Director Ministry of Environment, Forest & Climate Change Indira Paryavaran Bhavan, Jorbagh Road, New Delhi - 110003	Member
5	Prof. M. Sabu Department o Botany University of Calicut	Member

	Malappuram District Calicut University P.O. Pin. 673635, Kerala	
6	Dr. N. Anil Kumar Director M.S. Swaminathan Research Foundation Community Agro Biodiversity Centre Puthoorvayal P.O. Meppadi, Wayanad Pin- 673577, Kerala	Member
7	Dr. R. Prakash Kumar Director Jawaharlal Nehru Tropical Botanic Garden & Research Institute, Palode, Thiruvananthapuram - 695562	Permanent Invitee & Member Convener

MANAGEMENT COMMITTEE

SN	NAME & DESIGNATION	POSITION
1	Dr. R. Prakash Kumar, Director	Chairman
2	Dr. Syam Viswanath, Director, KFRI	Member
3	Dr. B. Sabulal, Principal Scientist, JNTBGRI	Member
4	Mr. Madhu, Additional Secretary, Science & Technology Department	Member
5	Mr. Shyam Kumar, Registrar, JNTBGRI	Member Convener

STAFF RETIRED/ TRANSFERRED/ DEPARTED

SN	Name	Designation	Date of Retirement
1	Sri. A. P. Sukumaran Nair	Security Officer Gr. II	30-04-2020
2	Sri. G. Vijayakumaran	Gardener Gr. IV	30-04-2020
3	Mr. K. P. Pradeep Kumar	Technical Officer (Photographer, Gr. II -5)	31-05-2020
4	Sri. T. Mohanakumar	Driver Gr. IV	31-05-2020
5	Sri. M. Varghese	Gardener Gr. IV	31-05-2020
6	Sri. S. Suresh Kumar	Assistant Artist Gr. III	Expired
7	Smt. Baby Girija	Sweeper Gr. III	31-01-2021
8	Sri. S. R. Kamaleshkumar	Gardener Gr. IV	28-02-2021
9	Sri. C. Muraleedharan Unnithan	Technical Officer Gr. IV	30-04-2021
10	Smt. Meenakumary	Section Officer Gr. II	31-05-2021
11	Sri. K. Ramachandran Nair	Security Guard Gr. IV	31-05-2021
12	Sri. K. Radhakrishnan	Senior Scientist	31-07-2021
13	Dr. C. Sunil Chandran	Estate Supervisor Gr. III	31-07-2021
14	Sri. Vijayan. A	Security Guard Gr. I	31-07-2021
15	Sri. K. Suresan	Security Guard Gr. I	31-07-2021
16	Sri. V. Venugopalan Nair	Gardener	31-10-2021
17	Dr. N. S. Pradeep	Senior Scientist	Transferred

STAFF LIST

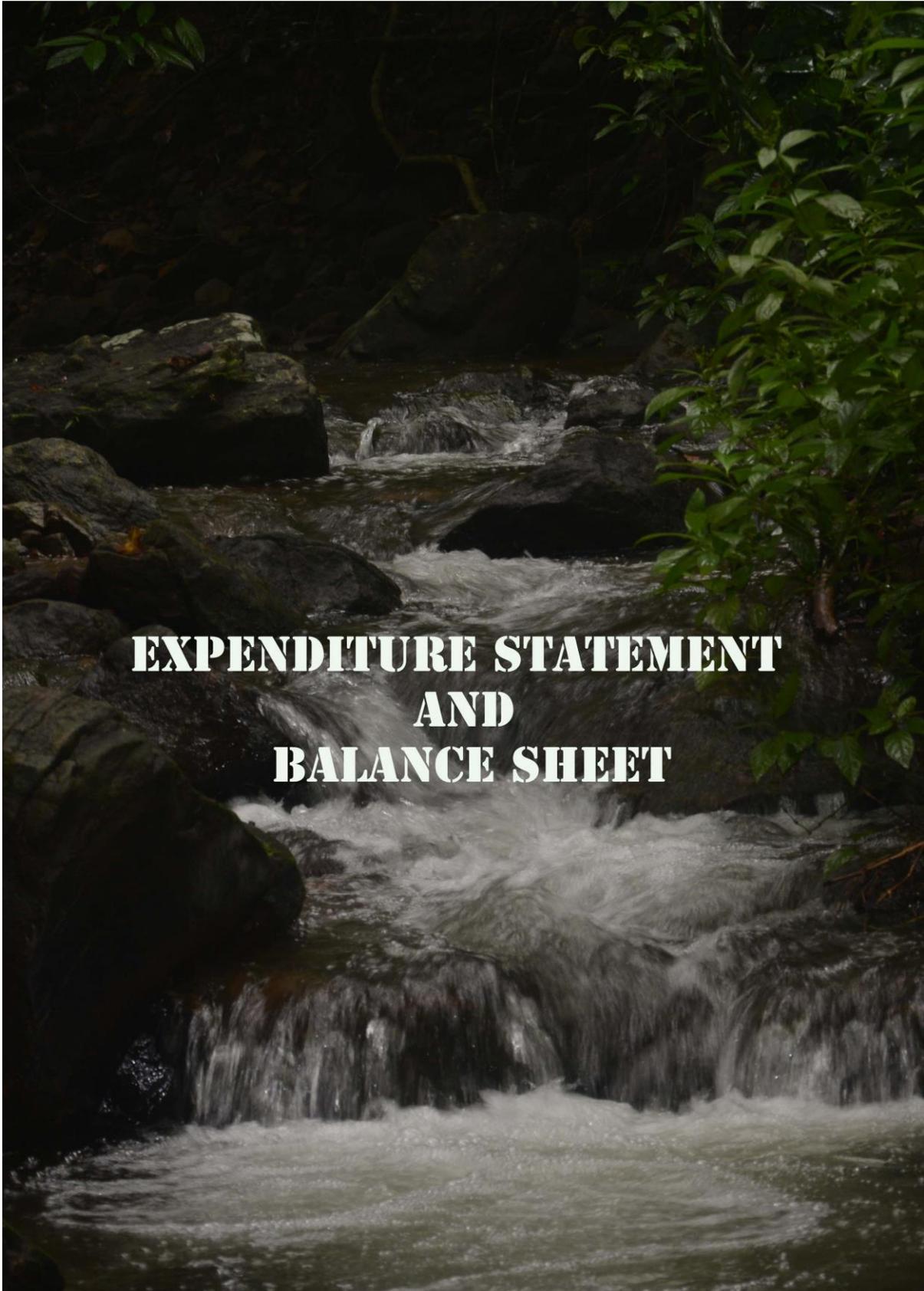
SN	NAME	DESIGNATION
1	Dr. R. Prakash Kumar	Director
Garden Management, Education, Information & training Division		
2	Dr. R. Raj Vikraman	Principal Scientist & Head
3	Dr. A. A. Prasannakumari	Scientist
4	Mr. V. Premkumar	Public Relations Officer
5	Dr. Raju Antony	Technical Officer Gr. III

6	Dr. Joemon Jacob	Technical Officer Gr. IV
7	Mr. S. Muhammed Shareef	Technical Officer Gr. IV
8	Dr. T. Sabu	Technical Officer Gr. III
9	Dr. K. J. Lathan Kumar	Technical Officer Gr. III
10	Dr. A. Hussain	Technical Officer Gr. III
11	Dr. E. S. Santhosh Kumar	Technical Officer Gr. III
12	Mr. K. S. Kalesh	Technical Officer Gr. II
13	Mr. B. Harilalkumar	Gardener Gr. IV
14	Mr. K. Vijayakumar	Gardener Gr. IV
15	Mr. K. Anilkumar	Gardener Gr. IV
16	Mr. J. Rajan	Gardener Gr. IV
17	Mr. V. Satheesan	Gardener Gr. III
18	Mr. M. Shajahan	Gardener Gr. IV
19	Mr. R. Lalan	Gardener Gr. I
20	Mr. R. Suresh Kumar	Gardener Gr. III
21	Mr. P. Babu	Gardener Gr. III
22	Mr. D. Udaya Kumar	Gardener Gr. III
23	Mr. N. Pradeep	Gardener Gr. III
24	Mr. P. S. Hanikumar	Label Writer
25	Mr. A. Ullas	Gardener Gr. I
26	Mr. S. Shafeerkhan	Photocopy Operator Gr. I
Plant Genetic Resources Division		
27	Mathew Dan	Principal Scientist & Head
28	Dr. M. Abdul Jabbar	Technical Officer Gr. III
29	Dr. M. Saleem	Technical Officer Gr. III
30	Dr. B. Gopakumar	Technical Officer Gr. IV
31	Dr. B. J. Radhika	Technical Officer Gr. IV
32	Mr. M. K. Sreekumaran	Technical Officer Gr. II
33	Mr. G. Manoharan	Gardener Gr. IV
34	Mr. S. Ajayakumar	Gardener Gr. IV
35	Mr. K. Ashok Kumar	Gardener Gr. IV
36	Mr. B. Jayalalkumar	Gardener Gr. IV

37	Mr. S. Thulaseedharan	Gardener Gr. IV
38	Mr. K. Asokachandran Nair	Gardener Gr. IV
39	Mr. G. Sudarsana Kurup	Gardener Gr. III
40	Mr. A. K. Azeem	Gardener Gr. III
41	Mrs. T. Mini Thomas	Gardener Gr. I
Biotechnology and Bioinformatics Division		
42	Dr. S. Sreekumar	Principal Scientist & Head
43	Dr. K. K. Sabu	Principal Scientist
44	Dr. C. K. Biju	Principal Scientist
45	Dr. R. K. Radha	Senior Scientist
46	Dr. M. Raveendran	Scientist
47	Dr. S. Shailaja Kumary	Technical Officer Gr. II
48	Mrs. V. S. Sindhu	Lab Attendant Gr. IV
49	Mrs. S. Syamala Kumary	Lab Attendant Gr. IV
50	Mrs. S. Kanakasundaram	Lab Attendant Gr. IV
51	Mr. B. Chandran	Gardener Gr. III
52	Mr. M. Vijayan	Gardener Gr. III
53	Mr. R. Anil Kumar	Gardener Gr. III
54	Mr. M. Shajahan	Gardener Gr. III
55	Mr. G. S. Madhusoodhanan Asary	Office Attendant Gr. III
56	Mrs. R. Sreekumari	Gardener Gr. I
Conservation Biology Division		
57	Dr. C. Anilkumar	Principal Scientist & Head
58	Dr. P. S. Jothish	Principal Scientist
59	Dr. Anurag Dhyani	Scientist
60	Mrs. A. Rasiya Beegam	Senior Scientist
61	Dr. C. R. Chitra	Technical Officer Gr. IV
62	Mr. M. Sibi	Technical Officer Gr. IV
63	Dr. S. Suresh	Technical Officer Gr. III
64	Dr. S. Bindu	Technical Officer Gr. III
65	Mr. G. Madhu	Gardener Gr. III
Ethnomedicine & Ethnopharmacology Division		

66	Dr. S. R. Suja	Principal Scientist & Head
67	Dr. Vinod Kumar T. G. Nair	Senior Scientist
68	Dr. M. Navas	Technical Officer Gr. IV
69	Mr. S. Radhakrishna Pillai	Technical Assistant
70	Mr. G. Anilkumar	Lab Attendant Gr. IV
Phytochemistry & Pharmacology Division		
71	Dr. B. Sabulal	Senior Principal Scientist & Head
72	Dr. K. B. Rameshkumar	Principal Scientist
73	Dr. V. Gayathri	Senior Scientist
74	Dr. Anil John	Technical Officer Gr. III
75	Dr. S. Ajikumaran Nair	Technical Officer Gr. III
76	Dr. S. R. Rajani Kurup	Technical Officer Gr. III
77	Mr. G. Santhoshkumar	Technical Assistant
78	Mrs. P. Sasikala	Lab Attendant Gr. IV
79	Mrs. A. Leela	Office Attendant Gr. III
Plant Systematics & Evolutionary Science Division		
80	Dr. G. Rajkumar	Principal Scientist & Head
81	Dr. M. Rajendraprasad	Principal Scientist
82	Dr. A. Nazarudeen	Senior Scientist
83	Dr. T. Shaju	Senior Scientist
84	Dr. V. S. Usha	Herbarium Asst. Gr. III
85	Dr. M. P. Geethakumary	Technical Officer Gr. IV
86	Dr. K. P. Deepthi Kumary	Technical Officer Gr. III
87	Dr. G. Thulasidas	Technical Officer Gr. III
88	Mr. R. Thulaseedharan Nair	Gardener Gr. III
Microbiology Division		
89	Dr. C. K. Pradeep	Principal Scientist & Head
90	Dr. Vipin Mohan Dan	Scientist
91	Dr. H. Biju	Technical Officer Gr. III
92	Dr. A. Sabeena	Technical Officer Gr. III
93	Mrs. S. Sheeja	Office Attendant Gr. I
CARC Programme		

94	Dr. S. Binu	Principal Scientist
Library and Information Centre		
95	Mrs. V. Leena Kumary	Office Attendant Gr. II
96	Mr. C. R. Vinu Krishnan	Office Attendant Gr. II
Administrative Staff		
97	Mr. M. Anilkumar	Sect. Officer Gr. I
98	Mrs. R. Subha Sankar	Computer Operator Grade III
99	Mrs. R. Sofia	Assistant Grade II
100	Mrs. S. Sudha	Assistant Grade I
101	Mr. Vishnu P. S.	Assistant Grade I
102	Mr. K. P. Eliyas	Store Assistant Gr. II
103	Mr. K. Mohammed Habeebulla	Typist/ Data Entry Operator Gr. III
104	Mr. B. R. Dinesh	Record Keeper Gr. II
105	Mr. G. Murukesan Nair	Driver Gr. I
106	Mr. S. Sanalkumar	Driver Gr. I
107	Mr. N. Hariprasad	Driver Gr. I
108	Mr. Balachandran	Driver Gr. I
109	Mrs. K. S. Bindu	Office Attendant Gr. II
110	Mrs. J. Anithakumari	Office Attendant Gr. I
Engineering Section		
111	Mr. S. Ajith	Assistant Work Supervisor Gr. IV
112	Mr. V. S. Sureshkumar	Technical Assistant Gr. IV
113	Mr. P. Ajithkumar	Technical Assi. (Electrical) Gr. IV
114	Mrs. M. R. Geetha	Technical Assistant
115	Mr. G. Ajayakumar	PABX Operator Gr. II
116	Mrs. K. Lalikutty	Sweeper Gr. III
Security Section		
117	Mr. S. Vikraman Nair	Security Guard Gr. I
118	Mr. C. Sureshkumaran Asari	Security Guard Gr. I
119	Mr. R. Prasannakumar	Security Guard Gr. I
120	Mr. R. Nagappan	Security Guard Gr. I
121	Mr. G. Anilkumar	Security Guard Gr. I



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 31 MARCH 2021

EXPENDITURE	SCH	Year Ended 31 March 2021	Year Ended 31 March 2020	INCOME	SCH	Year Ended 31 March 2021	Year Ended 31 March 2020
To Research & Development Expenses	9	3,42,81,323	3,71,98,904	By Grant From Govt of Kerala	13	17,85,43,007	18,66,19,311
To Employee Benefits	10	14,66,28,510	14,98,58,663	By Other Receipts	14	23,28,690	12,44,274
To Administrative Expenses	11	4,80,754	11,23,990	By Interest from Banks		5,18,890	3,17,967
To Expenses of External Project	12	2,33,24,455	3,26,32,239	By External Projects			
To Depreciation Institute	5A	86,83,159	96,53,854	Grant for External Projects	15	2,23,51,081	3,06,24,519
External Projects	5B	1,02,10,976	1,13,16,058	Other Receipts		1,07,728	9,01,304
				Interest from Banks		8,65,646	11,06,416
TOTAL		22,36,09,177	24,17,83,708	By Depreciation on Asset Acquired out of Grant			
				Written Back			
				TOTAL		22,36,09,177	24,17,83,708

The accompanying notes form an integral part of the financial statements
For JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN & RESEARCH INSTITUTE

[Signature]
 Dy. Registrar (Finance)
 Jawaharlal Nehru Tropical Botanic Garden and Research Institute
 Thiruvananthapuram - 695 562

[Signature]
 Registrar
 JAWAHARLAL NEHRU TROPICAL BOTANIC GARDEN AND RESEARCH INSTITUTE
 KARIANCOSE, PACHA, PALODE
 THIRUVANANTHAPURAM - 695 562
 KERALA, INDIA

[Signature]
 Director
 Director
 Jawaharlal Nehru Tropical Botanic Garden and Research Institute
 Kariyankode, P.O., Pacha, Palode
 Thiruvananthapuram-695 562
 KERALA, INDIA

In terms of our report attached:
For Mohan & Mohan Associates
 Chartered Accountant
 FRN:002097



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, 2022

Expenditure	Sch no.	Year Ended		Income	Sch no.	Year Ended	
		31 March 2022	31 March 2021			31 March 2022	31 March 2021
To Research & Development Expenses(Plan)	9	4,54,39,966	3,42,81,323	By Grant From Govt of Kerala Reckoned	13	25,61,91,467	17,85,43,007
To Salaries and Allowances (Non Plan)	10	21,75,93,846	14,66,28,510	By Other Receipts	14	70,84,309	23,28,690
To Administrative Expenses (Non Plan)	11	7,60,423	4,80,754	By Interest from Banks		5,18,460	5,18,890
To Expenditure to External Projects	12	1,25,03,062	2,33,24,455	By External Projects			
To Depreciation				Grant for External Projects Reckoned	15	1,12,32,537	2,23,51,081
Institute	5A	1,63,72,710	86,83,159	Other Receipts-External Projects	16	1,78,881	1,07,728
External Projects	5B	1,77,31,045	1,02,10,976	Interest from Banks-External Projects		10,91,644	8,65,646
TOTAL		31,04,01,052	22,36,09,177	By Depreciation written back		3,41,03,755	1,88,94,135
				TOTAL		31,04,01,052	22,36,09,177

The accompanying notes form an integral part of the financial statements
 For Jawaharlal Nehru Tropical Botanic Garden & Research Institute

In terms of our report attached.

For Mohan & Mohan Associates
 Chartered Accountants
 FRN 002092S

[Signature]
 Director

[Signature]
 Finance officer

[Signature]
 Registrar



Finance Officer
 Jawaharlal Nehru Tropical Botanic
 Garden and Research Institute
 Thiruvananthapuram - 695 562

Place : Thiruvananthapuram
 Dated 08-11-2022
 Director
 Jawaharlal Nehru Tropical Botanic
 Garden and Research Institute
 Palode, Thiruvananthapuram - 695 564
 Kerala

R Suresh Mohan
 Partner
 M.No.013398

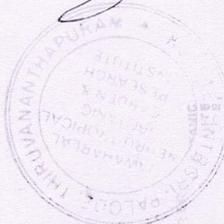
UDIN: 22013398 BDGTLUR2662

Jawaharal 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 2022

Liabilities		Sch No.	As at 31 March 2022	As at 31 March 2021	Assets	Sch No.	As at 31 March 2022	As at 31 March 2021
Capital Reserve					Property, Plant & Equipment			
Institute		1A	6,61,31,472	6,38,57,943	Institute	5A	6,61,31,473	6,37,95,234
External Projects		1B	6,51,21,353	7,07,57,107	External Projects	5B	6,51,21,354	7,07,57,107
Unspent Balance					Current Assets			
Institute		2A	(4,77,08,766)	(6,13,32,923)	Institute	6A	3,53,65,812	4,96,40,064
External Projects		2B	4,48,46,054	4,61,72,207	External Projects	6B	4,58,79,923	4,67,00,267
Corpus Fund		2C	2,40,93,729	2,19,62,811				
General Fund			4,79,03,075	4,79,03,075	Loans & Advances			
Book Publication Reserve			2,09,904	2,09,904	Institute	7A	1,39,71,758	1,37,93,781
Orchid Farming Project Reserve			3,00,000	3,00,000	External Projects	7B	3,33,339	4,75,123
Loan Funds		3	4,23,291	4,23,291	Suspense Accounts	8	9,07,757	9,07,757
Current Liabilities								
Institute		4A	2,00,17,369	4,96,43,459				
External Projects		4B	10,01,251	7,98,778				
Control Accounts								
Suspense Accounts External Projects			25,73,594	25,73,594				
STEC / CSIR / UGC			23,63,850	23,63,850				
			4,36,237	4,36,237				
Total			22,77,11,414	24,60,69,334	Total		22,77,11,414	24,60,69,334

The accompanying notes form an integral part of the financial statements
 For Jawaharal Nehru Tropical Botanic Garden & Research Institute

Director
 Finance officer
 Registrar



R Suresh Mohan
 Partner
 M No. 013398
 Chartered Accountants
 FRN/007092S

UDIN: 22013398 BDCGLU P2662

Finance Officer
 Jawaharal Nehru Tropical Botanic
 Garden and Research Institute
 Thiruvananthapuram - 695 562

Place : Thiruvananthapuram
 Dated: 08-11-2022
 KSGS
 Jawaharal Nehru Tropical Botanic
 Garden and Research Institute
 Palode, Thiruvananthapuram
 PIN: 695 562
 KERALA, INDIA



KSCSTE - JNTBGRI
Jawaharlal Nehru Tropical Botanic Garden and Research Institute
Pacha-Palode, Karimancode P.O., Thiruvananthapuram - 695 562,
Kerala, India
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