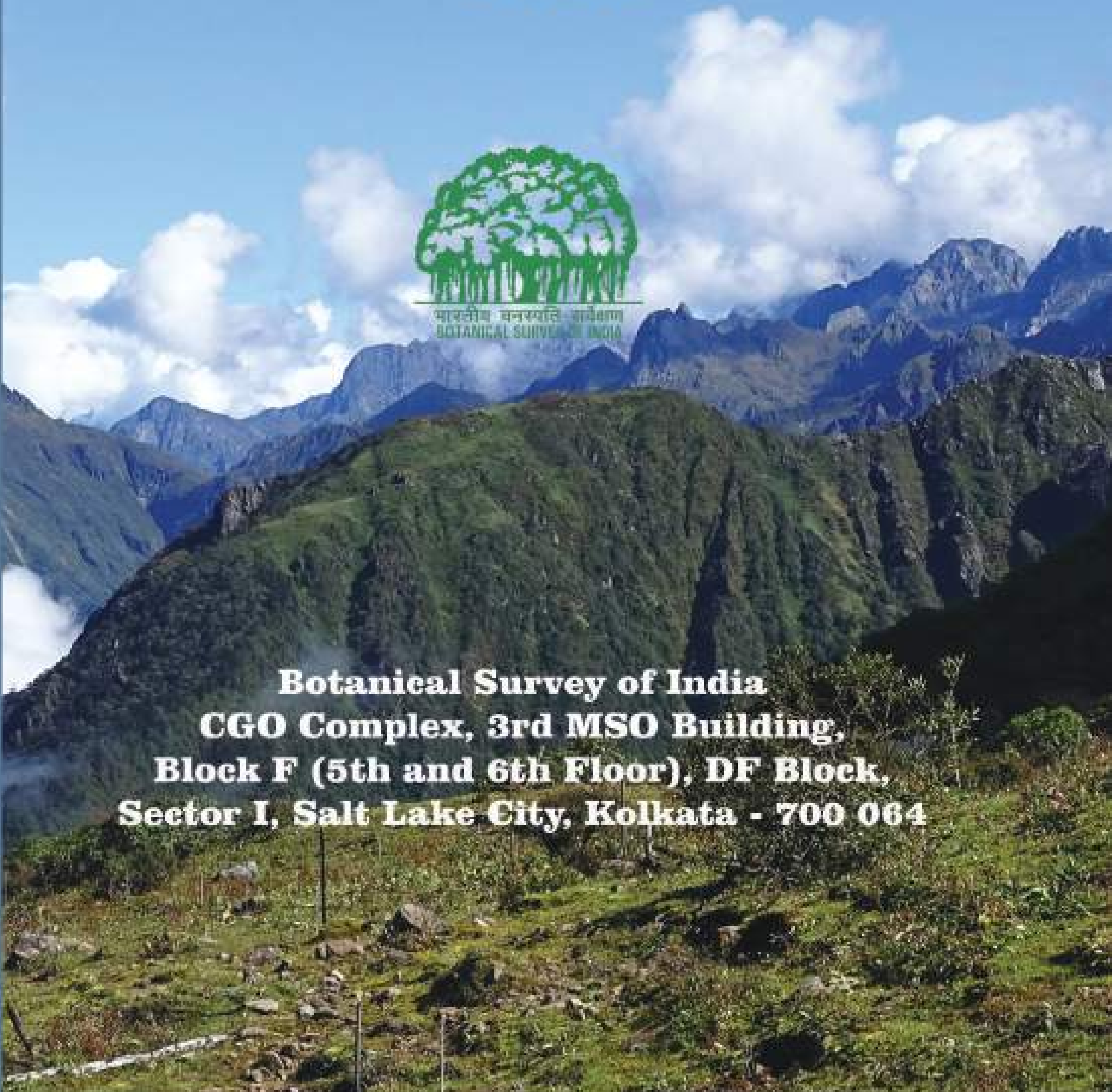

NATIONAL MISSION on HIMALAYAN STUDIES (NMHS)
FINAL TECHNICAL REPORT

CONSERVATION OF THREATENED PLANTS IN INDIAN HIMALAYAN REGION: RECOVERY AND CAPACITY BUILDING

Botanical Survey of India
CGO Complex, 3rd MSO Building,
Block F (5th and 6th Floor), DF Block,
Sector I, Salt Lake City, Kolkata - 700 064

NMHS

<u>Template/Pro forma for Submission</u>

NMHS-Himalayan Institutional Project Grant

NMHS-FINAL TECHNICAL REPORT (FTR)

Demand-Driven Action Research and Demonstrations

NMHS Grant Ref. No.:	NMHS2017-18/LG10/03

Date of Submission:	0	3	0	5	2	0	2	3
	d	**d**	**m**	**m**	**y**	**y**	**y**	**y**

PROJECT TITLE

CONSERVATION OF THREATENED PLANTS IN INDIAN HIMALAYAN REGION: RECOVERY AND CAPACITY BUILDING

Project Duration: *from* (**<u>25.09.2018</u>**) *to* (**<u>31.12.2021</u>**).

***Submitted to*:**
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Scientist 'G' and Nodal Officer, NMHS-PMU
National Mission on Himalayan Studies, GBP NIHE HQs
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***Submitted by*:**
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GENERAL INSTRUCTIONS:

1. The Final Technical Report (FTR) has to commence from the start date of the Project (as mentioned in the Sanction Order issued by NMHS-PMU) till completion of the project duration. Each detail has to comply with the NMHS Sanction Order.
2. The FTR should be neatly typed (in Arial with font size 11 with 1.5 spacing between the lines) with all details as per the enclosed format for direct reproduction by photo-offset printing. Colored Photographs (high resolution photographs), tables and graphs should be accommodated within the report or annexed with captions. Sketches and diagrammatic illustrations may also be given detailing about the step-by-step methodology adopted for technology development/ transfer and/ or dissemination. Any correction or rewriting should be avoided. Please provide all information under each head in serial order.
3. Any supporting materials like Training/ Capacity Building Manuals (with detailed contents about training programme, technical details and techniques involved) or any such display material related to project activities along with slides, charts, photographs should be brought at the venue of the Annual Monitoring & Evaluation (M&E) Workshop and submitted to the NMHS-PMU, GBP NIHE HQs, Kosi-Katarmal, Almora 263643, Uttarakhand. In all Knowledge Products, the Grant/ Fund support of the NMHS should be duly acknowledged.
4. The FTR Format is in sync with many other essential requirements and norms desired by the Govt. of India time-to-time, so each section of the NMHS-FTR needs to be duly filled by the proponent and verified by the Head of the Lead Implementing Organization/ Institution/ University.
5. Five (5) hard-bound copies of the Project Final Technical Report (FTR) and a soft copy of the same should be submitted to the **Nodal Officer, NMHS-PMU, GBP NIHE HQs, Kosi-Katarmal, Almora, Uttarakhand**.

The FTR is to be submitted into following two (02) parts:

Part A – Project Summary Report

Part B –Detailed Project Report

In addition, the Financial and other necessary documents/certificates need to be submitted along with the Final Technical Report (FTR) as follows:

Annexure I	**Consolidated and Audited Utilization Certificate (UC) & Statement of Expenditure (SE)**, including the interest earned for the last Fiscal year and the duly filled GFR-19A (with year-wise break-up).
Annexure II	**Consolidated Interest Earned Certificate**
Annexure III	**Consolidated Assets Certificate** showing the cost of the equipment in Foreign/ Indian currency, Date of Purchase, etc. (with break-up as per the NMHS Sanction Order and year wise).
Annexure IV	**List of all the equipment, assets and peripherals** purchased through the NMHS grant with current status of use, including location of deployment.
Annexure V	**Transfer of Equipment** through Letter of Head of Institution/Department confirming the final status of equipment purchased under the Project.
Annexure VI	**Details, Declaration and Refund of any Unspent Balance transferred through Real-Time Gross System (RTGS)/ PFMS in favor of NMHS GIA General**

DSL: Date of Sanction Letter							
2	6	0	2	**2**	**0**	**1**	**8**
d	d	m	m	y	y	y	y

DPC: Date of Project Completion							
3	1	1	2	**2**	**0**	**2**	**1**
d	d	m	m	y	y	y	y

Part A: Project Summary Report

1. Project Description

i.	Project Grant Ref. No.:	NMHS2017-18/LG10/03
ii.	Project Category:	Small Grant ☐ Medium Grant ☐ Large Grant √
iii.	Project Title:	**Conservation Of Threatened Plants in Indian Himalayan Region: Recovery and Capacity Building**
iv.	Project Sites (IHR States/ UTs covered) (*Location Maps attached*):	Arunachal Pradesh, Sikkim, Darjeeling District of West Bengal, Meghalaya, Uttarakhand, Himachal Pradesh, Jammu Kashmir & Ladakh, Manipur
v.	Scale of Project Operation:	Local ☐ Regional √ Pan-Himalayan ☐
vi.	Total Budget:	Approved Grant of the Project- Rs. 6,85,28,172/- (**Six crore eighty-five lakhs twenty-eight thousand one hundred seventy-two**)
vii.	Lead Agency:	Botanical Survey of India
	Lead PI/ Proponent:	**Dr. A.A. Mao**, Scientist-G & Director Head Quarters, Botanical Survey of India, Kolkata, West Bengal
	Co-PI/ Proponent:	**Dr. S. S. Dash**, Scientist-E, In Charge Technical Section Head Quarters, Botanical Survey of India, Kolkata, West Bengal Mob: 8910696033; E mail: ssdash2002@gmail.com **Dr. Late B.K. Sinha**, Former Scientist-F Head Quarters, Botanical Survey of India, Kolkata, West Bengal **Dr N. Odyuo**, Scientist-E Eastern Regional Centre, Botanical Survey of India, Shillong **Dr. Sandeep K. Chauhan**, Scientist-E Botanic Garden of Indian Republic, Noida **Dr. Giriraj Singh Panwar**, Scientist-E Northern Regional Centre, Botanical Survey of India, Dehradun **Dr. Puneet Kumar**, Scientist-D Northern Regional Centre, Botanical Survey of India, Dehradun
viii.	Implementing Partners:	State Forest Department, State Biodiversity Board, Gram Panchayat
	Key Persons (Contact Details, Ph. No., E-mail):	**Dr S.S. Dash**, Scientist-E, In Charge Technical Section Botanical Survey of India, Kolkata; Mob: 8910696033 E mail: ssdash2002@gmail.com

2. Project Outcomes

2.1. Abstract/ Summary

Background**:** Recent studies are indicating that the Himalayan biodiversity has been increasingly threatened due to various anthropogenic activities, unsustainable practices, waste generation and climate change. Hence an integrated scientific approach is need of the hour to understand the complexity of Himalayan diversity, development of protocol for assessment of threatened species, prioritization of areas for conservation of rare endemic, threatened, and endangered species, their conservation and management, and to link it to many ecosystems services including sustainable livelihood generation involving all stake holders. Keeping view this, the project was conceived and executed with following objectives.

Objectives/Aim: 1. Spatial assessment of populations of threatened flora, in the Indian Himalayan Region. 2. To study the demographic status, population sustainability and structure of selected threatened species among different plant groups; 3. To identify Himalayan biodiversity priority areas; 4. To multiply and propagate the target species through mass propagation were achieved with conventional method and 5. To enhance capacities of different stakeholders.

Methodology/Approach: i. Selection and prioritization of species, ii. Field Surveys and Collection of Secondary Data, iii. Propagation techniques (Macro and Micro Propagation), iv. Reintroduction of Species and Capacity Building, v. Threat assessment as per regional guidelines of IUCN and prepare habitat suitability modeling of species.

Approach: Collection Primary and secondary data, GIS Studies, mass propagation through traditional conventional method and in-vitro propagation through tissue culture. Population assessment through Niche modeling regeneration pattern, reintroduction, and rehabilitation of plants in its natural habitats; conducting awareness and capacity building programmes

Results**:**

- Ecological Niche Modelling distribution map of 9 species were *Aconitum heterophyllum*, *Arachnis senapatiana*, *Cymbidium tigrinium*, *Ephedra gerardiana*, *Gentiana kurroo*, *Jasminum parkeri*, *Lillium polyphyllum*, *Phlomoides superba* and *Pittosporum eriocarpum* were prepared, Beside this IUCN threat assessment of 16 species viz. *Aconitum ferox*, *Aconitum heterophyllum*, *Aesculus indica*, *Arenga westerhoutii*, *Arnebia benthamii*, *Bischofia javanica*, *Cinnamomum impressinervium*, *Cypripedium cordigerum*, *Galearis spathulata*, *Loxostigma griffithii*, *Magnolia doltsopa*, *Mallotus philippensis*, *Picrorhiza kurrooa*, *Taxus wallichiana*, *Sinopodophyllum hexandrum*, *Saurauia punduana*.

- Nearly 90000 seedling/saplings belonging to 70 targeted species have been successfully developed through traditional convention methods of seed showing. More than 20,000 seedlings have been distributed to 18 different stakeholders in 10 states

- 12,360 tissue-cultured plantlets of 12 selected species maintained in culture condition. A total of 1505 seedlings belonging to 5 species *Indopiptadenia oudhensis, Mahonia jaunsarensis Gentiana kurroo Phlomoides superba and Sophora mollis* have been successfully transferred from lab to land.

- Resolved the taxonomic complex of *Arundina graminifolia* and *Arundina graminifloia* var. *revoluta* using ISSR; *Schima wallichi* and *S. khasiana* complex using nuclear ITS loci. The result revealed significant genetic variation which helped us to substantiate the validity of retention of these species under present taxonomic positions. Chloroplast rbcL DNA of Diplazium nagalandicum, an endemic fern from Nagaland also sequenced.

- Quantitative analysis for Alkaloid, Tannin, Saponin, Flavonoid, Cardiac glycosides, Steroids and Triterpenoids carried out for 12 important medicinal plants were done. HPLC/LC-MS analysis of *Illigera grandiflora* leaves detected 10 important compounds including Reticuline - known to possess analgesic properties and effective in treatment of traumatic injuries.

- 41 Capacity Building workshops and more than 75 outreach programmes conducted in 10 different IHR states (Arunachal Pradesh, Sikkim, Jammu& Kashmir, Uttarakhand, Himachal Pradesh, Manipur, Nagaland & Meghalaya). A total of 2650 school & college students, farmers/ and villagers benefitted.

2.2. Objective-wise Major Achievements

S No.	Objectives	Major achievements (*in bullets points*)
1.	Spatial assessment of population of threatened flora in the Indian Himalayan region and developing geo-referenced database and mapping them by using Ecological Niche Modeling.	• Ecological Niche Modelling study was conducted for the *Gentiana kurroo, Aconitum heterophyllum, Jasminum parkeri, Phlomoides superba, Pittosporum eriocarpum, Ephedra gerardiana, Lillium polyphyllum, Arachnis senapatiana, Cymbidium tigrinium*. **(Appendix 1)** • Population status of 17 tree species from Kyongnosla Alpine Sanctuary were assessed in Sikkim Himalaya and *Veratrilla burkilliana* (Rare medicinal herb) was categorized as critically endangered in Indian perspective (According to IUCN 2017). Population status of *Ormosia fordiana and Didymocarpus bhutanicus* were also been assessed. **(Appendix 1)**
2.	To study the demographic status, population sustainability, recruitment, and regeneration status of selected threatened species.	• The population (demographic data), growth, regeneration potential and threat assessment of the selected species (List enclosed) was recorded in the field as per IUCN guidelines to designate the threat status of the species. During the surveys other potential habitats were also explored for the occurrence and extended distribution of these species. **(Appendix 1)** • Regeneration potential of 17 tree species viz. *Abies densa*, *Acer caudatum*, *Betula utilis*, *Juniperus recurva*, *Rhododendron arboreum*, *R. campylocarpum*, *R. cinnabarinum*, *R. fulgens*, *R. glaucophyllum*, *R. grande*, *R. hodgsonii*, *R. lanatum*, *R. thomsonii*, *Sorbus microphylla*, *Lyonia ovalifolia*, *Prunus cornuta*, *Viburnum erubescens* from Kyongnosla Alpine Sanctuary were assessed. **(Appendix 1)** • Reported new locality of *Aconitum heterophyllum* from Tuan and Parmar, Chamba, *Gentiana kurroo* from Suwakholi (Uttarakhand), Sangrah (HP), and from Neelkanth valley, Badrinath Uttarakhand. **(Appendix 1)** • An exhaustive list of Orchids, Balsam, Musa, and Trees of eastern Himalaya prepared. Nuclear ITS and ISSR markers were utilized to study species complex in *Arundina graminifolia*, *A. graminifolia* var. *revoluta*, *Schima wallichi* and *S. khasiana*. DNA barcoding of *Diplazium nagalandicum* an endemic fern of Nagaland using rbcL gene. **(Appendix 1 & 3)** • Quantitative analysis 12 medicinal plants done. HPLC/LC-MS analysis of *Illigera grandiflora* leaves detected 32 important compounds including Reticuline - known to possess analgesic properties and effective in treatment of traumatic injuries. **(Appendix 1)**
3.	To identify Himalayan biodiversity priority areas and to develop a set of long-term protocols for development of germplasm banks, mass multiplications,	• For identification of priority areas for germ plasm conservation we have taken into consideration of Koloriang to Sarli region of Kurung Kumey, Arunachal Pradesh and Luing forest of East Sikkim has been chosen. To find out the populations, the occurrence points of targeted species were identified based on the field surveys.

	propagation (macro or micro) and species recovery mechanism for targeted species.	• Regeneration statuses of different tree species were done in Kyongnosla alpine sanctuary, east Sikkim and Dzongri of West Sikkim. • Macropropagation of various selected species *viz. Prunus cerasoides*, *Oroxylum indicum*, *Amomum kingii*, *Magnolia doltsopa*, *Bischofia javanica*, *Castanopsis indica*, *Cinnamomum bejolghota*, *Clerodendrum colebrookeanum*, *Curcuma caesia*, *Oroxylum indicum*, *Saraca asoca*, *Terminalia arjuna*, *Wrightia coccinea*, *Livistona jenkinsiana*, *Stereospermum suaveolens*, *Sophora mollis*, *Gentiana kurroo*, *Aconitum heterophyllum*, *Jasminum parkeri*, *Mahonia jaunsarensis*, *Acer oblongum* var. *membranaceum*, *Phlomoides superba*, *Magnolia kisopa*, *Indopiptadenia oudhensis* and micropropagation of selected species viz. *Phlomoides superba*, *Sophora mollis*, *Gentiana kuroo* was also carried out. **(Appendix 1)** • Introduction of multiplied species in the wild under the habitat rehabilitation and species recovery programme viz. *Gentiana kurroo* Royle [2000 saplings at Khadamba peak, Chakrata & Bhadraj (Type locality of the species), Mussooriee], *Aconitum heterophyllum* Wall. ex Royle (500 saplings at Dev Van, Chakrata), *Indopiptadenia oudhensis* (Brandis) Brenan (1000 saplings at Raipur, Dehradun), *Phlomoides superba* (Royle ex Benth.) Kamelin & Makhm. (500 saplings at Mohand, Dehradun), *Sophora mollis* (Royle) Baker (500 saplings at Shastradhara, Dehradun) and Jasminum *parkeri* Dunn (500 saplings at Dev Van, Chakrata and Cloud end Mussooriee). **(Appendix 1 & 3)**
4.	To enhance capacities of different stakeholders (including Forest & Wildlife department staff, local Institutions/ colleges, local NGOs, and local communities regarding the importance of conserving available plant resources) and for monitoring and conserving threatened flora in the IHR through capacity building programs and use of modern science, technological tools and approaches for livelihood generation.	• Forest officials of all the IHR states, targeted students, NGOs, Self-help groups, and village communities were sensitized about the threatened status of the species ; MoUs have been signed with Forest Department, Uttarakhand, village communities for Manipur, Nagaland, Arunachal Pradesh, Sikkim and Uttarakhand for production of seedlings and facilitate the plantation programmes of threatened plants; to look after the planted species, effective management and conservation of these RET species. Saplings of 15 RET species were reintroduced in the wild in association with local community for the conservation of species at Sahiya, Kalsi, Halduwala villages of Uttarakhand, in Arunachal Pradesh, Sikkim. More than 20,000 seedlings were distributed in the targeted villages communities of Meghalaya, Manipur, Sikkim, Arunachal Pradesh and Uttarakhand states. **(Appendix 3)**

Note: **Further details may be summarized in DPR Part-B, Section-5. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.**

2.3. Outputs in terms of Quantifiable Deliverables*

S. No.	Quantifiable Deliverables*	Monitoring Indicators*	Quantified Output/ Outcome achieved	Deviations, if any, & Remarks thereof:
1.	Development of baseline geospatial data of 70 taxa focusing on endemic/ threatened/ plants.	Geospatial datasets generated	• Requisite base line information of the selected floristic elements was collected from all studied sites for spatial assessment of selected taxa.	**(Appendix 1)**
2.	Selection of 70 RET species for mass multiplication through micropropagation (12 spp.) and macro propagation (58 spp.)	Seedlings generated	• Nearly 90,000 seedlings generated and distributed in various stakeholder a local level	**(Appendix 1)** **&** **(Appendix 3)**
3.	Threat assessment of 16 selected species was carried out as per IUCN criteria B.	Area of occupancy and Extent of occurrence calculated	• Area of occupancy and Extent of occurrence calculated for the assessment of threat to a particular species.	**(Appendix 1)**
4.	Species recovery of 7 species was carried out	Ex situ conservation	• Seven species was successfully introduced in the garden of Botanical Survey of India.	**(Appendix 1)**
5.	72 Field tour were conducted across the selected states	Field tour for collection of seeds, RET plants etc.	• 72 Field tour for collection of seeds, RET plants were conducted in Arunachal Pradesh, Meghalaya, Uttarakhand, Sikkim and Darjeeling.	**(Appendix 1)** **&** **(Appendix 3)**
6.	Capacity building of local stake holders in 6 IHR states.	Community groups trained (Nos.) Awareness camps/ Programmes organized (Nos.) Publication of knowledge (No.)	• Forty-one capacity building training programmes were organized for local stakeholders. All the research staffs were also participated in several awareness campaigns and biodiversity camps. • Research findings were presented through 7 research presentations in various seminars, published one book, 39 research and 03 popular articles. All these finding so prepared describing the project activities and floral diversity were distributed during different awareness programmes.	**(Appendix 2)** **&** **(Appendix 3)**

***As stated in the Sanction Letter issued by the NMHS-PMU.**

2.4. Strategic Steps with respect to Outcomes (in bullets)

S. No.	Particulars	Number/ Brief Details	Remarks/ Attachment
1.	New Methodology/ Technology developed, *if any*:	*NA*	**NA**
2.	New Ground Models/ Process/ Strategy developed, *if any*:	Micropropagation protocol developed for the *Sophora mollis*, which is new to science.	**Appendix 1**
3.	New Species identified, *if any*:	A total of two new species of Angiosperms and two new records were identified.	**Appendix 2**
4.	New Database established, *if any:*	Georeferenced data were compiled for the EET species	**Appendix 1**
5.	New Patent, *if any*:	*NA*	**NA**
	I. Filed (Indian/ International)		
	II. Technology Transfer, *if any*:		
6.	Others, *if any*		

Note: **Further details may be summarized in DPR Part-B, Section-5. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.**

3. New Data Generated over the Baseline Data

S. No.	New Data Details	Status of Existing Baseline	Addition and Utilisation New data
1.	A checklist of flowering plants of 254 plant species belonging to 151 genera and 47 families Dzongri Goecha La area, West Sikkim was prepared.	Several of the studied sites were explored for vegetation data on ecological perspectives for the first time.	This baseline information will provide a base for further conservation measure of those ecosystems and for accessing the impact of climate change. **Appendix 2**
2.	A checklist of flowering plants of 411 taxa (400 species, 04 subspecies and 07 varieties) belonging to 173 genera and 54 families Kyongnosla Alpine Sanctuary, East Sikkim was prepared.	Several of the studied sites were explored for vegetation data on ecological perspectives for the first time.	This baseline information will provide a base for further conservation measure of those ecosystems and for accessing the impact of climate change. **Appendix 2**
3.	IUCN Red List for Indian plants includes 416 angiosperms, 12 gymnosperms, 2 Pteridophytes, 7 bryophytes and 1 fungal species under various threat categories were prepared.	This documentation is a significant addition to the status of the threatened plants of the country**.**	The information on threatened plants can be used by conservation policy makers. Further vegetation studies can be focused on the invasive alien plants to study their expansion and its effect on the existing ecosystem. **Appendix 2**
4.	Regeneration status of selected tree species of Kyongnosla Alpine Sanctuary, East Sikkim and Dzongri Goecha La area, West Sikkim was studied.	Such assessments were made for	The results will help in developing a systematic management plan which is required in the view of for conservation and sustainable utilization. **Appendix 1 & 2**

Note: **Further details may be summarized in DPR Part-B. Database files in the requisite formats (Excel) may be enclosed as annexure/ appendix separately to the soft copy of FTR.**

4. Demonstrative Skill Development and Capacity Building/ Manpower Trained

S. No.	Type of Activities	Details with number	Activity Intended for	Participants/Trained			
				SC	ST	Wo men	Tota l
1.	Workshops	41	Sustainable use of biodiversity and its conservation	-	-	49%	2650
2.	On-Field Trainings	41	-do-	-	-	34%	24
3.	Skill Development		Students	-	-	51%	190
4.	Academic Supports	06	05 Registered for PhD 01 completed PhD	-	-	50%	06
	Others (if any)	-	-	-	-	-	-

Note: **Further details may be summarized in DPR Part-B. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.**

5. Linkages with Regional & National Priorities (SDGs, INDC, etc.)/ Collaborations

S. No.	Linkages /collaborations	Detail of activities (No. of Events Held)*	No. of Beneficiaries
1.	Sustainable Development Goals (SDGs)/ Climate Change/INDC targets addressed	41 Capacity Building and Skill development program was organized.	2650 **Appendix 3**
2.	Any other:	Memorandum of understanding (MoU) was signed with the Forest Department of Uttarakhand and HUMAN INDIA- NGO	Forest Department, NGOs, Local people. **Appendix 3**

Note: **Further details may be summarized in DPR Part-B, Section-6. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.**

6. Project Stakeholders/ Beneficiaries and Impacts

S No.	Stakeholders	Support Activities	Impacts in terms of income generated/green skills built
1.	Line Agencies/ Gram Panchayats:	Awareness through workshops and training programmes	Stakeholders were intimated about the plant diversity in relation to conservation and protection. The disbursed study materials among them were palatable for nonprofessional for sustainable use of biological diversity is essential to achieving the broader goal of sustainable development and is a cross-cutting issue relevant to all biological and natural resources.
2.	Govt Departments (Agriculture/ Forest/ Water):	Awareness campaign and biodiversity camps	
3.	Villagers/ Farmers:	Awareness through workshops and training programmes	
4.	SC Community:		
5.	ST Community:		
6.	Women Group:		
	Others, *if any*:		

Note: **Further details may be summarized in DPR Part-B, Section-6. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.**

7. Financial Summary (Cumulative)

Please attach the consolidated and audited Utilization Certificate (UC) and Year-wise Statement of Expenditure (SE) separately, *ref*. **Annexure I.**

8. Major Equipment/ Peripherals Procured under the Project**

S. No.	Name of Equipment	Quantity	Cost (INR)	Utilisation of the Equipment after project
1.	Poly house	1	8,40,000.00	Being utilized for the multiplication and conservation of EET species. **[Dehradun component]**
2.	Net House	1	120750.00	
3.	Plant Growth Chamber (Remi model CHM-16+LCD)	1	2,49,882.00	
4.	Nikon Camera	1	31,950.00	Being utilized in the field tours for photography. **[Dehradun component]**
5.	pH meter Eutech pH700	1	23895.00	Being utilized in the tissue culture lab. **[Dehradun component]**
6.	GPS (*Garmin Montana 680*)	1	49500.00	Being utilized in the field tours. **[Dehradun component]**
7.	pH Electrode Eutech	1	5605.00	Being utilized in the tissue culture lab. **[Dehradun component]**
8.	Green House/ Polyhouse equipped with benches, tables in Fan & Pad System and Irrigation System	1	8,40,000.00	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
9.	Rooting Chamber with Fan and Pad System.	1	10,50,800.00	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
10.	Nanodrop analyzer (Eppendorf Biospectrometer basic and uCuvette G1.0)	1	8,37,800.00	Being utilized for the molecular study. **[Shillong component]**
11.	Field Gear (Coleman)	1	27,640.00/-	Being utilized for the field tour. **[Shillong component]**
12.	Germination Trays	1	29,700.00/-	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
13.	Camera [Nikon P-600]	1	38,700.00/-	Being utilized in the field tours for photography. **[Shillong component]**
14.	Garden Instruments [Kishan Kraft]	1	48,000.00/-	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
15.	GPS [Garmin GPS Etrex-20x 010- 801508-09]	1	16,000.00/-	Being utilized for the field tour. **[Shillong component]**
16.	pH meter, Humidity meter, Soil thermometer	1	84,524.00/-	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
17.	Laptop [Lenovo Ideapad 330]	1	72,000.00/-	Being utilized for the research work. **[Shillong component]**
18.	Desktop [Dell inspiron 3268 Desktop]	1	53,200.00/-	Being utilized for the research work. **[Shillong component]**
19.	Laptop [Model: Lenovo 8186000EIN (IP 130) Sl. No. 1WR207037]	1	34,000/-	

20.	Camera [(Model: COOLPIX P900) Sl. No.:10045780]	1	7,400/-	Being utilized for the research work. **[Kolkata component]**
21.	GPS [Garnier (Model No. GPSMAP 78S) with accessories]	1	25,960/-	
22.	GPS (Garmin, Etrex 30X)	1	1,95,166.00/-	Being utilized for the research work. **[BGIR component]**
23.	Desktop/Dell	2		
24.	UPS/Microtec	1		

Details should be provided in details **(*ref.* Annexure III &IV).

9. Quantification of Overall Project Progress

S. No.	Parameters	Total (Numeric)	Remarks/ Attachments/ Soft copies of documents
1.	IHR States/ UTs covered:	10	**Appendix 1**
2.	Project Sites/ Field Stations Developed	-	
3.	Scientific Manpower Developed (PhD/M.Sc./JRF/SRF/ RA)	24	**Appendix 1**
4.	Livelihood Options promoted	*NA*	
5.	Technical/ Training Manuals prepared	4	**Appendix 3**
6.	Processing Units established, if any	*NA*	–
7.	No. of Species Collected, if any	796	**Appendix 1**
8.	No. of New Species identified, if any	11	**Appendix 1**
9.	New Database generated (Types)	Georeferenced database	**Appendix 1**
10.	Others (if any)	–	–

***Note:* Further details may be summarized in DPR Part-B. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.**

10. Knowledge Products and Publications:

S No.	Publication/ Knowledge Products	Number		Total Impact Factor	Remarks/ Enclosures
		National	International		
1.	Journal – Research Articles/ Special Issue:	21	15	SCI- 27.551 NAAS- 149.58	
2.	Book – Chapter(s)/ Monograph/ Contributed:	1			
3.	Technical Reports:				
4.	Training Manual (Skill Development/ Capacity Building):				
5.	Papers presented in Conferences/Seminars:				
6.	Policy Drafts/Papers:				
7.	Others, if any:	3			

***Note:* Please append the list of KPs/ publications (with impact factor, DOI, and further details) with due Acknowledgement to NMHS. Supporting materials may be enclosed as annexure/ appendix separately to the FTR.**

11. **Recommendation on Utility of Project Findings, Replicability and Exit Strategy**

Particulars	Recommendations
Utility of the Project Findings	One of the pioneer project findings is the updated georeferenced database generated through existing secondary and studied primary information. This database can be useful for future ecological modelling and to prepare conservation management plans. The inventory also provides lists of economically important, threatened, and invasive alien plant species. The micropropagation protocol has been standardized for all the selected species. This vast information can directly be utilized by the inhabitants of the Himalayas for their socio-economic upliftment and sustainable development. The threat assessment data of RET taxa will be useful for future ecological studies in answering climate change issues. Local-level awareness and on-field training will empower the Himalayan stakeholders in participating in various conservation policies.
Replicability of Project/ Way Forward	The field as well as georeferenced data generated through this project are of high replicability scope. ENM findings of the present study can be used in the Species Recovery Program of threatened species in future for the reintroduction of species in the wild. New localities discovered for some threatened species offers better scope for the conservation of these species in newer localities. Micropropagation protocols developed for a few species are highly reproducible and will help in ex-situ conservation through the rehabilitation of threatened species in wild habitats and support conservation efforts. Protocols developed can be utilized for the long-term conservation of the species as well as cryopreservation of the species. These studies can also be replicated in other parts of IHR resulting in more authentic cumulative inferences.
Exit Strategy	The methodology adopted for carrying out the research work in the project was generally based on previously standardized ones, especially in ENM studies. The protocols developed in tissue culture are based on basic methodology with variations in the concentration of various chemicals, hormones, etc. The standard protocols that were developed can be used to propagate these species in future studies. In certain species where micropropagation is difficult these species can be propagated through macro propagated to speed up and facilitate the mass multiplication process. Several individuals of propagated species are available at present and can be used in future rehabilitation drives at different centres. Documents published during the study can be used as a reference for future studies in the IHR.

03/05/2023

(PROJECT PROPONENT/ COORDINATOR)

(Signed and Stamped)

निदेशक/Director
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
तृतीय एम. एस. ओ. भवन
3rd M.S.O. Building
सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक
CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

03/05

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

निदेशक/Director
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
तृतीय एम. एस. ओ. भवन
3rd M.S.O. Building
सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक
CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

Place: Kolkata
Date: 05../06../2023

Annexure-I

Consolidated and Audited
Utilization Certificate (UC) and Statement of Expenditure (SE)

For the Period: 2018-2019 to 2022-2023.

1.	Title of the project/Scheme/Programme:	Conservation of Threatened Plants in Indian Himalayan Region: Recovery and Capacity building
2.	Name of the Principle Investigator & Organization:	Dr. A. A. Mao, Director, Botanical Survey of India, Headquarters, Kolkata
3.	NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand Letter No. and Sanction Date of the Project:	NMHS2017-18/LG10/03 Dated:26.02.2018
4.	Amount received from NMHS-PMU, G.B. Pant National Institute of Himalayan Environment, Kosi-Katarmal, Almora, Uttarakhand during the project period (Please give number and dates of Sanction Letter showing the amount paid):	**1st – Rs.2,90,15,372.00/-** **2nd – Rs.9,65,440.00/-** **3rd – Rs.88,62,351.00/-** **Total– Rs.3,88,43,163.00/-**
5.	Total amount that was available for expenditure (Including commitments) incurred during the project period:	**Rs.3,88,43,163.00/-**
6.	Actual expenditure (excluding commitments) incurred during the project period:	**Rs.2,93,99,896.00/-**
7.	Unspent Balance amount refunded, if any (Please give details of Cheque no. etc.):	**Rs.1,10,06,162.77/- (Rs.51,56,310.77 at NMHS ACCOUNT KOLKATA +Rs.58,49,852/-at PAO ACCOUNT)**
8.	Balance amount available at the end of the project:	**Rs.1,10,06,162.77/-**
9.	Balance Amount:	**Rs.1,10,06,162.77/-**
10.	Accrued bank Interest(after deduction of Bank Charges):	**Rs.15,62,895.77/-**

Certified that the expenditure of **Rs.2,93,99,896.00/-(Rupees Two Crore Ninety Three Lakhs Ninety Nine Thousand Eight Hundred and Ninety Six only)** mentioned against Sr. No. 6 was actually incurred on the project/scheme for the purpose it was sanctioned. Date:

03/05/2023 — (Signature of Principal Investigator)
निदेशक/Director भारतीय वनस्पति सर्वेक्षण Botanical Survey of India तृतीय एम. एस. ओ. भवन 3rd M.S.O. Building सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक CGO Complex, Salt Lake कोलकाता/Kolkata-700 064

03/05/2023 — (Signature of Registrar/ Finance Officer)
आहरण व संवितरण अधिकारी Drawing & Disbursing Officer भारतीय वनस्पति सर्वेक्षण सी.जी.ओ. कॉम्प्लेक्स, सॉल्ट लेक कोलकाता-700 064

03/05/2023 — (Signature of Head of the Institution)
निदेशक/Director भारतीय वनस्पति सर्वेक्षण Botanical Survey of India तृतीय एम. एस. ओ. भवन 3rd M.S.O. Building सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक CGO Complex, Salt Lake कोलकाता/Kolkata-700 064

OUR REF. No.

ACCEPTED AND COUNTERSIGNED
Date:
COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALAYAN STUDIES (GBP NIHE)

Statement of Consolidated Expenditure

[Institution Name BOTANICAL SURVEY OF INDIA, KOLKATA]

Statement showing the expenditure of the period from
Sanction No. and Date : GBPNI/NMHS-2017-18/LG-03/570; Dated:26.02.2018

1. Total outlay of the project : Rs. 6, 85, 28,172/-
2. Date of Start of the Project : October, 2018
3. Duration : 3 years 2 months
4. Date of Completion : 31.12.2021

a) Amount received during the project period : **Rs.3,88,43,163.00/-**

b) Total amount available for Expenditure : **Rs.3,88,43,163.00/-**

S. No.	Budget head	Amount received	Expenditure	Amount Balance/ excess expenditure
1	SALARY	10923040.00	15809831.00	-4886791.00
2	TRAVEL	3150000.00	1355463.00	1794537.00
3	EXPANDABLE	2625000.00	1825448.00	799552.00
4	CONTINGENCY	1800000.00	1741290.00	58710.00
5	ACTIVITY	10218151.00	2984949.00	7233202.00
6	EQUIPMENT	10126972.00	5682915.00	4444057.00
	TOTAL-	**38843163.00**	**29399896.00**	**9443267.00**
10	Institutional charges	0	0	0
11	Accrued bank Interest (after deduction of bank charges)	**1562895.77**	**0**	**1562895.77**
12	**Total**	**40406058.77**	**29399896.00**	**11006162.77**

Certified that the expenditure of **Rs.2,93,99,896.00/-(Rupees Two Crore Ninety Three Lakhs Ninety Nine Thousand Eight Hundred and Ninety Six only)** mentioned against Sr. No. 12 was actually incurred on the project/scheme for the purpose it was sanctioned. Date:

Date: 03/05/2023

03/05/2023
(Signature of Principal Investigator)
Principal Investigator
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
तृतीय एम. एस. ओ. भवन
3rd M.S.O. Building
सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक
CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

03/05/2023
(Signature of Registrar/ Finance Officer)
आहरण व संवितरण अधिकारी
Drawing & Disbursing Officer
भारतीय वनस्पति सर्वेक्षण
सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक
कोलकाता-700 064

03/05/2023
(Signature of Head of the Institution)
निदेशक/Director
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
तृतीय एम. एस. ओ. भवन
3rd M.S.O. Building
सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक
CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

GIA REF. No.

ACCEPTED AND COUNTERSIGNED

Date:

COMPETENT AUTHORITY
NATIONAL MISSION ON HIMALYAN STUDIES (GBP NIHE)

भारत सरकार

GOVERNMENT OF INDIA

पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय

MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE

भारतीय वनस्पति सर्वेक्षण / BOTANICAL SURVEY OF INDIA
सी.जी.ओ. कॉम्प्लेक्स / CGO COMPLEX

तृतीय एम. एस. ओ. भवन / 3RD MSO BUILDING
पांचवाँ और छठा तल/ 5TH & 6TH FLOOR
डी एफ ब्लॉक, सेक्टर I / DF BLOCK, SECTOR I

साल्टलेक, कोलकाता-६४/ SALT LAKE, KOLKATA – 700064

Tel.: (033) 2321 4050 [Tech. Section] ; E-mail: tech@bsi.gov.in

Annexure-II

Consolidated Interest Earned Certificate

This is to certify that during the project period i.e. from 2018-2019 to 2022-2023 Rs. 15, 62,895.77/- (Rupees Fifteen Lakh Sixty Two Thousand Eight Hundred and Ninety Five and Seventy Seven Paise only) earn after deduction of Bank charges.

03/05/2023

(A.A.MAO)
DIRECTOR

निदेशक/Director
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
तृतीय एम. एस. ओ. भवन
3rd M.S.O. Building
सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक
CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

Telephone: 03323344963(Director); 03323218991(Head of Office); 03323214050(Technical In-charge); 03323584240(Publication In-charge); 03323215775(Accounts); 03323213891(Administration); 03323213848(Establishment); E-mail ID: ho@bsi.gov.in; hoo-hqrs@bsi.gov.in

Consolidated Assets Certificate

Assets Acquired Wholly/ Substantially out of Government Grants

(Register to be maintained by Grantee Institution)

Name of the Sanctioning Authority: **NATIONAL MISSION ON HIMALAYAN STUDIES (NMHS) G.B.PANT.**

1. Sl. No.: **NMHS2017-18/LG10/03**
2. Name of Grantee Institution: **Botanical Survey of India(Kolkata &Sikkim, Shillong, Noida and Dehradun).**
3. No. & Date of sanction order: GBPNI/NMHS-2017-18/LG-03 Dated: 26.02.2018
4. Amount of the Sanctioned Grant: **Rs.6,85,28,172/- (Rupees Six Crore Eighty Five Lakh Twenty Eight Thousand One Hundred Seventy Two only)**
5. Brief Purpose of the Grant: **"CONSERVATION OF THREATENED PLANTS IN INDIAN HIMALAYAN REGION: RECOVERY AND CAPACITY BUILDING"**
6. Whether any condition regarding the right of ownership of Govt. in the property or other assets acquired out of the grant was incorporated in the grant-in-aid Sanction Order: NO
7. Particulars of assets actually credited **Green House/Net House, Plant Groth Chamber, Rooting Chamber, GPS, & Weather Station** or acquired.
8. Value of the assets as on: **40Lakh Approx**.
9. Purpose for which utilized at present : **Research**
10. Encumbered or not : **yes**
11. Reasons, if encumbered: **Permanently fixed in the ground.**
12. Disposed of or not: **NA**
13. Reasons and authority, if any, for disposal : **NA**
14. Amount realized on disposal : **NA**

Any Other Remarks: **NIL.**

03/05/2023
(PROJECT INVESTIGATOR)

(Signed and Stamped)

निदेशक/Director
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
तृतीय एम. एस. ओ. भवन
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CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

03/05/2023
(FINANCE OFFICER)

(Signed and Stamped)

आहरण एवं संवितरण अधिकारी
Drawing & Disbursing Officer
भारतीय वनस्पति सर्वेक्षण
सी.जी.ओ. कॉम्प्लेक्स, साल्ट लेक
कोलकाता-700 064

03/05/2023
(HEAD OF THE INSTITUTION)

(Signed and Stamped)

निदेशक/Director
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
तृतीय एम. एस. ओ. भवन
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CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

List or Inventory of Assets/ Equipment/ Peripherals

S. No.	Name of Equipment	Quantity	Cost (INR)	Utilisation of the Equipment after project
25	Poly house	1	8,40,000.00	Being utilized for the multiplication and conservation of EET species. **[Dehradun component]**
26.	Net House	1	120750.00	
27.	Plant Growth Chamber (Remi model CHM-16+LCD)	1	2,49,882.00	
28.	Nikon Camera	1	31,950.00	Being utilized in the field tours for photography. **[Dehradun component]**
29.	pH meter Eutech pH700	1	23895.00	Being utilized in the tissue culture lab. **[Dehradun component]**
30.	GPS (*Garmin Montana 680*)	1	49500.00	Being utilized in the field tours. **[Dehradun component]**
31.	pH Electrode Eutech	1	5605.00	Being utilized in the tissue culture lab. **[Dehradun component]**
32.	Green House/ Polyhouse equipped with benches, tables in Fan & Pad System and Irrigation System	1	8,40,000.00	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
33.	Rooting Chamber with Fan and Pad System.	1	10,50,800.00	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
34.	Nanodrop analyzer (Eppendorf Biospectrometer basic and uCuvette G1.0)	1	8,37,800.00	Being utilized for the molecular study. **[Shillong component]**
35.	Field Gear (Coleman)	1	27,640.00/-	Being utilized for the field tour. **[Shillong component]**
36.	Germination Trays	1	29,700.00/-	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
37.	Camera [Nikon P-600]	1	38,700.00/-	Being utilized in the field tours for photography. **[Shillong component]**
38.	Garden Instruments [Kishan Kraft]	1	48,000.00/-	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
39.	GPS [Garmin GPS Etrex-20x 010- 801508-09]	1	16,000.00/-	Being utilized for the field tour. **[Shillong component]**
40.	pH meter, Humidity meter, Soil thermometer	1	84,524.00/-	Being utilized for the multiplication and conservation of EET species. **[Shillong component]**
41.	Laptop [Lenovo Ideapad 330]	1	72,000.00/-	Being utilized for the research work. **[Shillong component]**

				[Shillong component]
43.	Laptop [Model: Lenovo 8186000EIN (IP 130) Sl. No. 1WR207037]	1	34,000/-	Being utilized for the research work. [Kolkata component]
44.	Camera [(Model: COOLPIX P900) Sl. No.:10045780]	1	7,400/-	
45.	GPS [Garnier (Model No. GPSMAP 78S) with accessories]	1	25,960/-	
46.	GPS (Garmin, Etrex 30X)	1	1,95,166.00/-	Being utilized for the research work. [BGIR component]
47.	Desktop/Dell	2		
48.	UPS/Microtec	1		

03/05/2023

(PROJECT INVESTIGATOR)

(Signed and Stamped)

निदेशक/Director
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
तृतीय एम. एस. ओ. भवन
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CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

03/05/2023

(HEAD OF THE INSTITUTION)

(Signed and Stamped)

निदेशक/Director
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
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CGO Complex, Salt Lake
कोलकाता/Kolkata-700 064

03/05/2023

(FINANCE OFFICER)

(Signed and Stamped)

आहरण एवं संवितरण अधिकारी
Drawing & Disbursing Officer
भारतीय वनस्पति सर्वेक्षण
सी.जी.ओ. कॉम्प्लेक्स, सॉल्ट लेक,
कोलकाता-700 064

<u>**Annexure-V**</u>

Letter of Head of Institution/Department confirming Transfer of Equipment Purchased under the Project to the Institution/Department

To,

The Convener, Mountain Division
Ministry of Environment, Forest & Climate Change (MoEF&CC)
Indira Paryavaran Bhawan
Jor Bagh, New Delhi-110003

Sub.: Transfer of Permanent Equipment purchased under Research Project titled "...." funded under the NMHS Scheme of MoEF&CC – reg.

Sir/ Madam,

This is hereby certified that the following permanent equipment purchased under the aforesaid project have been transferred to the Implementing Organization/ Nodal Institute after completion of the project:

1…NA**…….**
2. …………………………….
3. …………………………….
4. …………………………….
5. …………………………….
6. …………………………….
7. …………………………….

03/05/2023

Head of Implementing Organization:
Name of the Implementing Organization:
Stamp/ Seal:
Date:

Copy to:

1. The Nodal Officer, NMHS-PMU, National Mission on Himalayan Studies (NMHS), G.B. Pant National Institute of Himalayan Environment (NIHE), Kosi-Katarmal, Almora, Uttarakhand-263643

Annexure-VI

Details, Declaration and Refund of Any Unspent Balance

Please provide the details of refund of any unspent balance and transfer the balance amount through RTGS (Real-Time Gross System) in favour of **NMHS GIA General** and declaration on the official letterhead duly signed by the Head of the Institution.

Kindly note the further Bank A/c Details as follows:

Name of NMHS A/c:

Bank Name & Branch:

IFSC Code:

Account No.:

In case of any queries/ clarifications, please contact the NMHS-PMU at e-mail: nmhspmu2016@gmail.com

PART B: PROJECT DETAILED REPORT

1. EXECUTIVE SUMMARY

The Indian Himalayan region is home to a mountain system that is exceedingly complex and diversified, both in terms of biological and physical aspects. The area exhibits rich Phyto diversity in terms of high rate of endemism, diversity of RET species and home of large amount of economically important medicinal plants. However, in the present day these diverse floras face various s kind of stress from anthropogenic activities, climate change, extensive grazing, invasion of foreign floral element etc. The present project aims at conserving the RET plants of Indian Himalayan Region using mass multiplications, propagation through micro propagation, micro propagation, species recovery, capacity building and spatial assessment of populations of threatened flora.

The work started with selecting the RET plants, collecting ting baseline data from different herbarium such as ARUN, ASSAM, BSHC, BSD, CAL, DD, LWG etc. Distributions of selected species were created with the help of Arc GIS and Google Earth. Threat assessment of selected species were done according to IUCN criteria B. Ecological Niche Modeling of nine species viz. *Gentiana kurroo*, *Aconitum heterophyllum*, *Jasminum parkeri*, *Phlomoides superba*, *Pittosporum eriocarpum*, *Ephedra gerardiana*, *Lillium polyphyllum*, *Arachnis senapatiana*, and *Cymbidium tigrinium* has been completed. More than 90,0000 seedlings were developed though macropropagation and micro propagation.

As a part of conservation measure more than 20,000 seedlings were distributed among the different stakeholders of all involved state of this project for further regeneration and plantation. Beside these 41 awareness and outreach programmes were conducted in different remote villages of Himachal Pradesh, Jammu and Kashmir, Ladakh, Sikkim, Arunachal Pradesh, Darjeeling, Nagaland, Manipur, and Uttarakhand.

Molecular taxonomy approach was utilized for rapid identification of difficult material like Allium sp. and using standard barcode markers such as nrDNA Internal Transcribed Spacers and cpDNA (trnL-F and matK). Barcoding of five species done and phylogenies was constructed. Chemical profiling of medicinally important species quantitative analysis for Alkaloid, Tannin, Saponin, Flavonoid, Cardiac glycosides, Steroids and Triterpenoids was carried out.

Finally, the research findings were presented through 39 research articles, 6 conference paper, one book, 3 popular articles and 5 pamphlets. All these findings so prepared describing the project activities and floral diversity were distributed during different awareness programmes. This project produces 24 research worker, 01 Ph.D. and 5 Ph. D registered candidate.

The project “Conservation of Threatened Plants in Indian Himalayan Region: Recovery and Capacity Building” provide prodigious platform for the young researcher to raise the issues regarding conservation of threatened plants before the different stakeholders which in turn develop different socioeconomic parameters of the villagers and local community through plantation of seedlings of different ecologically and economically threatened plant species. The project has been successful executed its objectives in all the targeted Himalayan states with desired quantifiable outputs. Emphasis has been put on all-inclusive and integrative approach to implementing the objectives recognizing the importance of active participations of stakeholders.

2. INTRODUCTION

2.1 Background of the Project:

The Himalaya is a magical realm of the nature where the majesty of the world's highest mountains, is mirrored in the rugged beauty and unique culture of the people who live in their shadow. This mountain system is comprising a series of parallel and converging ranges and forming the highest mountain region in the world. This mountain system connects the tropical rainforests of Arunachal Pradesh and Bhutan with the sparse and cold semi-deserts of the Ladakh region and the North Indian plains with the Tibetan plateau. It has developed a distinctive ecology that has become the basis for the existence of the natural as well as socio-cultural and political systems of South Asia. The Indian Himalayan region extends between 26°20' and 35°40' N and between 74°50' and 95°40' E and spreads over five states and one Union territory namely Jammu & Kashmir, Ladakh, Himachal Pradesh, Uttarakhand, Sikkim, Arunachal Pradesh, and the north most districts of West Bengal (Darjeeling & Kalimpong) encompassing approximately 5 lakhs sq.km area (16.2% of the entire country). This is one of the youngest, fragile, and complex ecosystems of the world, which includes almost all type of habitats. It is also a part of Himalayan Biodiversity Hotspot that includes several global eco-regions and centres of origin of many plant groups. It supports nearly 50% of the total flowering plants of India and 10% of which is endemic to this region. This high mountain region is the source of freshwater for many of Indian rivers: the Indus and tributaries; the holy river Ganga and tributaries; Teesta in Sikkim, and the Darjeeling areas, and the Brahmaputra in Arunachal Pradesh and Assam, and other several rivers such as Kameng, Kurung, Siang, Lohit and the Subansiri in the eastern Himalaya.

These mountain ranges not only present a beautiful landscape, but also play an important role in global atmospheric circulation, likely the hydrological cycle, and water resources availability, and provide a wide range of ecosystem services. Besides, the socio-economic-ecological significance of the regions is directly related to its geography, climate, biological diversity, history, politics, and culture in the context of Indian subcontinent. The food security, survival, and economic activity of the inhabitants of the subcontinent are directly dependent on the ecosystem health and continuous availability of its services.

Recognizing all these global significances of the Himalaya, several scientific studies on different aspects have been conducted by various individuals and organizations since colonial era which dated back to the beginning of the 17th century when European explorers started documenting the wealth of the region. After independence, the Government of India and the Himalayan states have conducted several studies and programme through different agencies, aiming at sustainable utilization of resources of the region for social and economic well-being of the people.

Recent studies are indicating that the Himalayan biodiversity has been increasingly threatened due to various anthropogenic activities, unsustainable practices, waste generation and climate change. The localized biodiversity loss, habitat degradation and recent changes in climate exert great challenge for the biodiversity of the region. It is also agreed that, the species in transition zones of Himalaya are more sensitive and vulnerable towards the climate change as there is a limited scope for the adaptability. Most of the high-altitude mountainous forests (sub-alpine and alpine forest, the Himalayan dry temperate forest, and the Himalayan moist temperate forests) are susceptible to the adverse effects of climate change. In addition to this, continuing anthropogenic disturbances such agricultural expansion, over grazing, forest fires and infrastructure development have been adversely affecting the biodiversity of the region. The constant declines in Himalayan biodiversity will have a negative impact on the livelihood and survival of millions of inhabitants of Himalayas and further cascading trans-boundary consequences on all depended communities in the Indo-Gangetic plains. Hence, an integrate scientific approach is need of the hour to understand the complexity of Himalayan diversity development of protocol for assessment of threatened species, prioritization of areas for conservation of rare endemic, threatened, and endangered species, their conservation and management, and to link it to many ecosystems services including sustainable livelihood generation involving all stake holders. Botanical Survey of India, the apex research organizations on plant taxonomy with over a two hundred years of experiences on the study of floral diversity in Himalaya, has planned to develop protocols for assessment of threatened species, prioritization of areas for conservation of rare endemic, threatened, and endangered species their conservation and management, to rehabilitate them reintroduce into identified similar habitats in Indian Himalayan region. For this purpose, 12 study sites including Jammu & Kashmir (2-sites), Himachal Pradesh (2-sites), Uttarakhand (2-sites), Sikkim (1-site), Arunachal Pradesh (3-sites), West Bengal (1-site) and Meghalaya (1-site) have been selected to develop standard protocols for assessment of threatened species, declaring the prioritization conservation areas in Indian Himalayan Region and to create an awareness among all the stall holders through an interactive local level capacity building programme. The entire project has been implemented in association with the respective forest departments and capacity building at local level through training programme and providing resource materials.

Overview of the Major Issues Addressed

The global biodiversity crisis has given rise to a growing concern at the prospect of a rapidly accelerating loss of species, populations, domesticated varieties, and natural habitat. Recent estimates suggest that more than half the habitable surface of the planet has already been significantly altered by human activities and we are on the verge of 6th mass extinction of species. Woefully incomplete knowledge of the biodiversity, variability of plants and the ecosystems in which they occur has further intensified the problem. The updated data baseline line data on threatened species is the demand of time since it was changes from day by day due to alternation or fragmentation of their natural habitat. Therefore, any permanent strategy to conserve and monitoring of populations of threatened species over the years, or evaluation of genetic variability among the existing population is necessary. In this context, Botanical Survey of India as a premier institute of the country in the field of plant taxonomy, biodiversity and conservation has been proposing to different conservation approaches of threatened plants across the Indian Himalayan region through biodiversity assessment and long-term restoration monitoring plots, species recovery, reintroduction, and capacity building.

Generation of georeferenced database:

The detailed base line georeferenced data on selected plants across the entire Indian Himalayan region was prepared in consultation of different national and international herbaria in person where possible otherwise online. Single hand information on this precious data was need of the hour for policy makers as well a prerequisite to CBD obligation. This data also used for IUCN red listing study and for habitat modeling.

Project Site/ Field Stations Developed:

Since the selected species were of different altitudinal regions, therefore, one each field stations at Eastern Regional Centre, Shillong; Northern Regional Centre, Dehradun; Sikkim Himalayan Centre, Gangtok and Arunachal Pradesh Regional Centre, Itanagar were developed for propagation and mass multiplication of these species in nursery. Small field stations/nurseries were developed with the collaboration of respective forest departments of Uttarakhand, Himachal Pradesh, Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, and Nagaland. Different NGOs, villagers of these states for the mass propagation and hardening of threatened high altitude medicinal plant species. These field stations also provided help in local capacity building through cultivation of these medicinal plants.

Propagation and Mass Multiplication:

Mass scale multiplication of the selected species was performed through the collected propagating materials from different localities and from the planted specimens as well. Different types of propagating material viz. seeds, stem cutting, bulbs, rhizome etc. were collected for propagation trials at BSI, NRC. The selected plant species were propagated through different propagation techniques including both macro and micro propagation methods to develop a stock for reintroduction, distribution, and ex-situ conservation. **(Appendix 1)**

Genomic DNA extraction and quality check of extracted DNA:

DNA extraction of 18 different species of Rhododendron was carried out with CTAB method of DNA extraction described by Doyle and Doyle, 1990. However, the results were not satisfactory and hence, extraction was carried out using Qiagen extraction kit. The quality of isolated DNA was checked in 0.8% agarose gel for all the samples extracted and visualized in Gel Documentation System and photographed.

Ecological Niche Modeling:

For the successful recruitment of the selected species in their natural habitats it is necessary to mark the suitable habitat regions for their plantation. For this purpose, Ecological Niche Modeling (ENM) is an effective tool for habitat suitability prediction and analysis of species-specific requirements in its wild habitat. In Maxent software where there is a smaller number of population data available for some species then it is better to use bootstrap model for ENM. Based on ENM results for *Pittosporum eriocarpum* it has been observed that the species prefers more eastward distribution and more habitat suitability regions are predicted in Uttarakhand than in Himachal Pradesh **(Appendix 1)**.

Threat Assessment:

Calculate EOO (measure of the geographic range size of a species) and AOO (measure of the area in which a species occurs) of the selected species **(Appendix 1)** viz. *Aesculus indica*, *Salvia hians*, *Arnebia benthamii*, *Roscoea purpurea*, *Hedychium spicatum*, *Veratrilla burkilliana* etc with the help of IUCN red listing software GeoCAT. The default is 2 km^2 cell size (as recommended in the IUCN guidelines - IUCN 2010), user defined cell size and finally $1/10^{th}$ of the maximum distance between the most distance pair of points.

Local-level capacity building and Outreach Programme:

Without the active involvement of local stakeholders, conservation methods aimed at ecosystem restoration cannot be implemented. Through this project, we have succeeded in raising awareness among local stake holders, including forest officials, students in high school and college, local NGOs, and the general public. We did this by implementing several interactive outreach initiatives, workshops to build capacity, and on-the-job training. We have also urged locals to join in these programmes, notably women and students as well as academics and the forest departments **(Appendix 3)**.

Baseline Data and Project Scope:

The wide thematic category “Biodiversity Conservation and Management" covered the proposed initiative. The project aims to study the spatial assessment of populations of threatened flora and spatial assessment of populations of threatened flora for Conservation of Threatened Plants in Indian Himalayan Region: Recovery and Capacity Building, allowing us to address the effects of climate change on the area and to find permanent strategy to conserve threatened plants and their current status. Recollections of rare and endemic plants have been made possible by revisiting the type localities of some specimens. Looking back at how these environments fared in the past and how they are now has been made possible by comparative distributional analyses of these recovered species.

The project has been successful executed its objectives in all the targeted Himalayan states with desired quantifiable outputs. Emphasis has been put on all-inclusive and integrative approach to implementing the objectives recognizing the importance of active participations of stakeholders. Each country has developed its own biodiversity strategy and action plan as required under the CBD and its own national policies legislation and mandate. In most nations, the establishment of a network of protected areas is essential for plant conservation. Species recovery efforts, reintroductions, conservation translocations, and the establishment of gene banks for the storage of germplasm like seed, pollen, cell, and tissue cultures are some examples of in situ and ex situ measures at the species and population level that complement this. Moreover, ecological restoration is currently receiving a lot of attention. Therefore, the outcome of the said project provides a baseline platform for future conservation strategy of the country.

PROJECT OBJECTIVES AND TARGET DELIVERABLES

***Project Objective(s)*:**

1. Spatial assessment of populations of threatened flora in the Indian Himalayan region and developing geo-referenced database and mapping them by using ecological niche modeling.
2. To study the demographic status, population sustainability, recruitment, and regeneration status of selected threatened species: Angiosperms (Orchids, Zingibers, Balsams, Bamboos, Trees, Medicinal Plants, Palms, Legumes, Musa etc), Macro-fungus (wild and edible Mushrooms), Pteridophytes and Lichens.
3. To identify Himalayan biodiversity priority areas and to develop a set of long-term protocols for development of germplasm banks, mass multiplications, propagation (through micro propagation, ex situ or in-situ) and species recovery mechanism for targeted species.
4. To enhance capacities of different stakeholders.

Quantifiable Deliverables:

1. Development of baseline geospatial and genetic database of 70 selected species was developed.
2. Completed the habitat modelling for 9 species and the IUCN threat assessments for 15 species.
3. The establishment of experimental garden for macropropagation in study sites was done and identify Himalayan biodiversity priority areas in Himalayan states.
4. Capacity building of local stake holders in respective IHR states.

METHODOLOGIES, STRATEGY AND APPROACH

Methodologies Used

Microprogation:

- ***Selection of plants:***
  Plants had been selected based on their rarity, threat status, exploitation, population depletion and endemism.. The data related to their distribution and occurrence was compiled from pertinent literature (IUCN reports, Re3d list of Threatened Plants (India), Local and regional floras, research papers, online articles and databases, etc. and herbarium consultation. Different perspectives were considered for the selection of species. Care was taken to include at least few economically important threatened species which are under immense economic pressure or species whose demand and supply graph is widening.
- ***Plant material and explant preparation:*** Species specific explants such as seeds, nodules, leaves, spores (ferns), root apex and shoot apex were selected for *in vitro* multiplication.
- ***Media preparation and culture conditions:*** Micro propagated shoots were routinely sub-cultured in culture media (species specific). All the cultures were incubated at culture conditions (species specific) with the survival percentage and the response of the plants regularly monitored and recorded.
- ***Hardening:*** The tissue culture raised seedlings with healthy roots and shoots were hardened in green house conditions in specific substrate compositions.

Macro propagation:

- ***Through cuttings:*** Cuttings of selected plants were treated with rooting hormone and planted in pure sand medium for rooting.
- ***Through seeds:*** Seeds of selected plants were planted in suitable medium for germination.
- ***Through rhizome/bulb:*** Collected rhizome and bulbs of selected plants were placed in cocopeat and vermiculite medium.
- ***Through suckers:*** Plants of few selected plants were propagated through offshoots and suckers.

Microbiology:

- ***Plant material and explant preparation*:** Seedlings of selected plants with root nodule were collected as starter material for in vitro bacterial culture isolation.
- ***Media preparation and culture conditions:*** The nodule was placed and crushed in a glass slide with a glass rod and the paste was used as inoculum for bacterial culture initiation. The parent cultures were then further sub-cultured onto petri-plates containing Yeast Mannitol Agar (YMA) medium. The cultures were kept under room temperature. Grams staining of the bacterial cultures isolated from root nodules were also performed.
- ***Protocol for nodule sterilization:*** Nodules were collected and washed with mild detergent using a paint brush and thoroughly rinsed with water. Glass slides were wiped with ethanol and flame sterilized before use.

Molecular Diversity:

- ***Sample collection:*** Leaf samples (fronds in case of pteridophytes) of selected species were collected for the purpose of genomic DNA extraction. Leaves were cleaned first with water followed by 70% alcohol. These leaves were then used for genomic DNA extraction.
- ***Genomic DNA extraction and quality check of extracted DNA:*** DNA extraction of selected species were carried out with CTAB method (Doyle and Doyle, 1990) and using Qiagen extraction kit. The quality of isolated DNA was checked in 0.8% agarose gel for all the samples extracted and visualized in Gel Documentation System and photographed.
- ***PCR standardization and optimization:*** PCR amplification for ITS region using ITS2 and ITS4 primer pair has been successfully standardized. PCR amplification was carried out in a 20ul reaction containing 5X reaction buffer, 2mM of $MgCl_2$, 2.5mM each dNTPs, 0.5uM forward and reverse primers and 5U/ul Taq polymerase. The PCR program for the amplification was carried out with initial denaturation followed by denaturation, annealing and final extension. The amplified products were electrophoresed and gel images were taken using gel documentation system.

Phytochemical analysis:

- ***Plant extract preparation:*** The collected plant samples were air-dried in shed at room temperature for 3 weeks, after which they were grinded to a uniform powder. The methanol extracts were prepared by macerating each of the dry powder in methanol and kept at room temperature. The solution obtained was filtered through a Whatmann filter paper No. 1. The filtrate was Vacuum dried (Rotalab, Lab India). Then the crude extract of each plant material was stored at 4 °C.
- ***Qualitative phytochemical analysis:*** Qualitative phytochemical analysis were carried out to detect the presence of the some bioactive groups (alkaloids, tannins, saponins, flavonoids, cardiac glycosides and polyphenols) from extract using different standard methods.
- ***Test for alkaloids:*** Sample was stirred with aqueous HCl on a steam bath and then filtered. After that filtrate was treated with a few drops of Mayer’s reagent and a second portion was treated similarly with Dragendorff reagent.

- ***Test for tannins:*** Dried extract was stirred with distilled water. This was filtered and ferric chloride ($FeCl_3$) reagent was added to the filtrate.
- ***Test for saponins:*** Plant extract was shaken with water in a test tube.
- ***Test of flavonoids:*** Extract solution was added to concentrated HCl and a stiff of pink magnesium.
- ***Test for cardiac glycosides:*** Glacial acetic acid, FeCl3 and concentrated H2SO4 was respectively added into the extract solution.
- ***Test for polyphenols:*** Plant extract was heated in a water bath. FeCl3 was added to the mixture then followed by the addition of potassium ferrocyanide. The mixture was filtered and the formation of polyphenols.
- ***Test for steroids and triterpenoids:*** Extract was added to chloroform along with a few drops of conc. sulphuric acid. The mixture was shaken well and kept aside for some time.

  N.B: Details methodology provided in **Appendix 1.**

DATA COLLECTED AND EQUIPMENT UTILIZED:

Scientific data collected:

***Georeferenced data collected* –** Georeferenced data of all selected RET species were collected from secondary as well as primary sources.

***Photographs*-** Field photographs of the study sites, landscapes, activities and the plants with all identifying features were taken on the field for archival.

***Phenological data collected*-** Phenological data of all selected RET species were also recorded for the prediction of accurate timing of fruiting.

Equipment used:

- Green House/Polyhouse equipped with benches, tables in Fan & Pad System and Irrigation System.
- Rooting Chamber with Fan and Pad System.
- Nanodrop Analyzer
- Field Gear
- Germination Trays
- Camera
- Garden
- Instruments
- GPS
- pH meter, Humidity meter, soil thermometer.
- Lenovo Idea pad 330
- Dell inspiron 3268 Desktop
- Lenovo 8186000EIN (IP130)
- COOLPIX P900 Camera
- Garnier (Model No. GPSMAP78S) with Accessories
- Plant growth chamber

- POLY HOUSE
- Net House

DETAILS OF FIELD SURVEY CONDUCTED, IF ANY:

In order to collect seeds and to carried out spatial assessment of the selected taxa of Himalayan states, more than 35 field tours were accomplished which included 9 tours in the North east Himalaya including Shillong, Jowai, Jarain West Jaintia Hills, Laitmawsiang and Diengsong villages East Khasi Hills and Laitmawsiang; 6 in Lal Anne and 1 in Kurung Kmey (Aruunachal Pradesh), 3 in Sikkim, Dzongri (West Sikkim) while 2 tours in Darjeeling and 27 tour were conducted in N-W Himalaya. Each field survey team was comprised of one Research Associate, at least one Junior Project Fellow and one Field Assistant along with supporting local guide and porters. The population data of RET plants were recorded and observed during each tour. However, the accurate locations of them were plotted in GIS maps and the GIS co-ordinates are provided as well. Majority of the vegetation data on woody species were collected during summer seasons (April–June) and herbaceous data in monsoon season (August–September) for herbs.

Strategic Planning for each activity with time frame

Sl. No	Activity	Year I 2018–19)				Year II (2019-20)				Year III (2020-21)				Year IV	
		Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2	Q 3	Q 4	Q 1	Q 2
1.	**Recruitment of Project staffs**	■	■												
2.	**Field training of staff**		■												
3.	**Preliminary survey of selected landscapes**		■	■											
4.	**Field tours**			■	■	■	■					■	■	■	■
5.	**Local capacity building programme**			■		■					■	■	■	■	■
6.	**Preparation of georeferenced database of IHR plants**		■	■	■			■	■	■					
7.	**Publications and dissemination of information**				■	■	■	■	■	■	■	■	■	■	■
8.	**Macro propagation and micro propagation**				■	■		■	■	■	■	■	■	■	■
9.	**Quantitative analysis of chemicals**				■	■	■	■	■	■					
10.	**Data compilation**			■				■	■	■		■	■	■	■
11.	**Preparation of periodic reports**			■	■		■		■	■			■		
12	**Preparation of FTR**														■

KEY FINDINGS AND RESULTS

Major Research Findings

Thirty-nine field tours were conducted in the duration 2018-2021 were conducted for the collection of plant propagules, seed, RET species in the selected states of Indian Himalayan Region (IHR) and for monitoring of plants propagated at nursery established at different regional centre of Botanical Survey of India. A total of 122 RET plants and were also identified and collected from the IHR study sites **(Appendix 1)**. Suitable habitat for the nine species also identified for their further conservation purpose using Ecological niche modeling study and threat assessment of 15 species was conducted according to IUCN red listing criteria **(Appendix 1)**. Georeferenced database was prepared for all the targeted species through field visit and herbarium study.

Micro propagation of 20 was carried out and among them the protocol for the *Sophora mollis* was established for the first time. Macro propagation of thirty-one species was also carried out in five different regional centre of Botanical Survey of India and further reintroduce in their different suitable habitat **(Appendix 1)**. Genetic fidelity assessment of selected plants was carried out using Start codon targeted (SCoT), Inter simple sequence repeats (ISSR) and Random amplified polymorphic DNA (RAPD) markers to authenticate the genetic stability

Assessment of tree species diversity, density and regeneration pattern under prevailing microenvironment is carried out in Sikkim Himalaya for their sustainable utilization, management and conservation. Result shows that on the whole regeneration status of tree species in the study area is fair **(Appendix 1)**. Plantation drive and awareness workshop among villagers of selected study sites were organized in alone or collaboration with different local stack holders.

The research findings of the project were disseminated through published materials (One Book, 39 research articles and 3 semi-technical articles, several pamphlets), to showcase the project outcomes and activity among all the stakeholders. The outcomes were also presented in 3 National-level Seminars/Conferences/Symposiums (6 presentations) for creating interest and awareness among other researchers **(Appendix 2)**.

Key Results:

- New localities for Six species namely *Aconitum heterophyllum*, *Didymocarpus bhutanicus*, *Gentiana kurroo*, *Sophora mollis*, *Magnolia kisopa* and *Jasminum parkeri* has been discovered during the collection survey.
- ENM study was conducted for the *Gentiana kurroo, Aconitum heterophyllum, Jasminum parkeri, Phlomoides superba, Pittosporum eriocarpum, Ephedra gerardiana, Lillium polyphyllum, Arachnis senapatiana, and Cymbidium tigrinium*
- *Jasminum parkeri* Dunn a narrow endemic species of Chamba, Himachal Pradesh was successfully introduced at Dev Van, Chakrata and Cloud end Mussoorie.
- Micropropagation protocol developed for the *Sophora mollis*, which is new to science.
- Nearly 90,000 seedling/saplings belonging to 70 targeted species have been successfully developed through traditional convention methods of seed showing. More than 20,000 seedlings have been distributed to 18 different stakeholders in 10 states.
- 12,360 tissue-cultured plantlets of 12 selected species maintained in culture condition.
- Resolved the taxonomic complex of *Arundina graminifolia* and *Arundina graminifloia* var. revoluta using ISSR, *Schima wallichi* and *S. khasiana* complex using nuclear ITS loci. The result revealed significant genetic variation which helped us to substantiate the validity of retention of these species under present taxonomic positions. Chloroplast rbcL DNA of *Diplazium nagalandicum*, an endemic fern from Nagaland also sequenced.
- Quantitative analysis for Alkaloid, Tannin, Saponin, Flavonoid, Cardiac glycosides, Steroids and Triterpenoids carried out for 12 important medicinal plants were done. HPLC/LC-MS analysis of *Illigera grandiflora* leaves detected 10 important compounds including Reticuline - known to possess analgesic properties and effective in treatment of traumatic injuries.
- 41 Capacity Building workshops and more than 75 outreach programmes conducted in 10 different IHR states (Arunachal Pradesh, Sikkim, Jammu& Kashmir, Uttarakhand, Himachal Pradesh, Manipur, Nagaland & Meghalaya). A total of 1650 school & college students, farmers/ and villagers benefitted.

Conclusion of the study

The scientific and technical activities were thought to be highly relevant to the project's thematic area and proposed objectives. It can be said that the project's activities improved our knowledge of the RET plant resources in the Himalaya while also providing a framework for upcoming pilot studies with a conservation emphasis that will address the impacts of climate change on RET species. The following are the main conclusions of the undertaking.

The RET plant wealth of the Himalaya is highly diverse which is reflected in the creation of Georeferenced data base of the region. The use of these RET flora in socioeconomic growth and conservation are both crucial. Thus, threat assessment of fifteen species with detailed georeferenced data and habitat niche modelling o selected taxa are also provided for future studies making any ecological inferences.

Both micro and macro propagation is the most ideal method for development of germplasm banks, mass multiplications, propagation and for species recovery mechanism for targeted species. Long term protocols of micropropagation for selected species also developed.

To apply any study findings or policies at the local level, it is seen as being extremely helpful for local stake holders to participate alongside intellectuals. During project activities, local stake holders were educated about the diversity of plants in their area and their responsibility in maintaining them, and this reciprocal dependence was clearly visible. As a result, state governments, forest departments, local administrative bodies, NGOs, and residents of the area provided resounding support.

OVERALL ACHIEVEMENTS

Achievement on Project Objectives

***Geospatial and genetic Database*:**

Before developing any conservation strategy, it is crucial to have a thorough understanding of the plant resources in each given area. To analyses the population status of the targeted species from various IHR states, an inventory of the Geo coordinates of all the threatened species were gathered from old herbarium sheets as well as from the primary survey data in the designated sites **(Appendix 1)**.

Study the demographic status, population sustainability and structure of selected threatened species:

The population (demographic data), growth, regeneration potential and threat assessment of the selected species (List enclosed) was recorded in the field as per IUCN guidelines to designate the threat status of the species. During the surveys other potential habitats were also explored for the occurrence and extended distribution of these species. The different demographic status and habitat of about one hundred species based on field survey and herbarium data for selected plant group prepared. ENM study of selected species viz. *Gentiana kurroo, Aconitum heterophyllum*, *Jasminum parkeri*, *Phlomoides superba* and *Pittosporum eriocarpum* were also carried out. Beside these *Aconitum ferox, Aconitum heterophyllum, Aesculus indica, Arnebia benthamii, Bischofia javanica, Caryota urens, Cautleya gracilis, Arenga westerhoutii, Cinnamomum impressinervium, Cypripedium cordigerum, Galearis spathulata, Cypripedium cordigerum, Galearis spathulata, Gymnadenia orchidis, Loxostigma griffithii, Hedychium densiflorum* etc was selected for IUCN guided threat assessment **(Appendix 1)**.

To identify Himalayan biodiversity priority areas:

For identification of priority areas for germ plasm conservation we have taken into consideration of Koloriang to Sarli region of Kurung Kumey, Arunachal Pradesh and Luing forest of East Sikkim and Varsey of West Sikkim has been chosen. To find out the populations, the occurrence points of targeted species were identified based on the field surveys **(Appendix 1)**.

To multiply and propagate the target species:

Targeted species were multiplied at mass scale through macro and micro propagation Standard nursery techniques were designed and developed for the mass multiplication of the species. The propagating materials were sustainably collected from the natural habitats and are used for both macro and micro propagation of the selected species. Multiplied species were rehabilitated in the wild under the species recovery Programme for the successful perpetuation of the species **(Appendix 1)**.

Developing local-level capacity building:

Forty-one awareness/capacity building programmes conducted in different IHR states (Manipur, Nagaland, Meghalaya, Sikkim, Arunachal Pradesh, Jammu & Kashmir, Uttarakhand and Himachal Pradesh). More than 2500 stakeholders including school & college students, farmers, villagers and forest officials were benefitted. Communication with different stake holders such Forest departments all IHR states, NGOs and local village communities have been made and official linkages were made. Research findings were presented through presented in national seminar, published as pamphlets, research papers and booklets. All these findings so prepared describing the project activities and floral diversity were distributed during different awareness programmes **(Appendix 3)**.

Establishing New Database/Appending new data over the Baseline Data

Base line information on the target species were collected from Primary and secondary data including field surveys, herbariums and literature. Geo coordinate of all the threatened species were collected from old herbarium sheets as well as from the primary survey data in the selected sites for assessment of population status of targeted species from distinct parts of IHR states. Analysis of data was performed for species distribution, modeling and predicting the suitable habitat for reintroduction.

Generating Model Predictions for different variables (if any

NA

Technological Intervention

NA

On field Demonstration and Value-addition of Products

NA

Promoting Entrepreneurship in IHR

NA

Developing Green Skills in IHR

The project made a substantial contribution to the Indian government's goal to promote green skills. Women received on-the-ground training to identify significant plants in their immediate area, enabling them to not only benefit from the green economy's socioeconomic uplift but also to conserve these resources. The stake holders were informed of several economically significant plants and their ethno-botanical uses in due course of the training.

Addressing Cross-cutting Issues

The project addressed two major cross-cutting issues of National Mission on Himalayan Studies (NMHS) scheme, i.e., Climate Change and Gender Equity. Towards understanding the climate-change-induced impacts on the Himalaya, 122 RET species were selected for spatial assessment of populations along with developing geo-referenced database and mapping them by using ecological niche modeling. 15 species were address for their threat assessment in current climatic scenario. This information can be utilized for long-term ecological monitoring and autecology of each of the RET species and predict any impacts of climate change on distribution and conservation status of these RET species.

Without the involvement of local stake holders, none of the environmental or conservation measures were successfully implemented at the grassroots level. As part of project mandate, we have organized capacity-building workshops and field training programmes to raise awareness among local stake holders about our study findings and current concerns. The inclusion of more female participants, who made up roughly 45% of all stakeholder participation in the programmes run under this project, was emphasized. This is a little but important step in the direction of gender equality in environmental concerns.

PROJECT'S IMPACTS IN IHR

Socio-Economic impact:

Impact on of Natural Resources/ Environment:

Conservation of Biodiversity/ Land Rehabilitation in IHR:

The primary objective of this project is the conservation of biodiversity through *ex situ* protocols. This project aims to identify and select plants of IHR that need sincere and timely attention for their conservation. Thus, plants have been selected based on their rarity, threat status, exploitation, population depletion and endemism. Since, non-germination of seeds and non-survival of seedlings in nature are the major reasons behind the population depletion of any species, selected plants have been propagated *in vitro* (micro propagation) and *in vivo* (macro propagation) outside their natural habitat. After successful regeneration, seedlings of selected plants have planted in their natural habitat. Therefore, an effort has been made for natural restoration of Himalayan forests.

Another outcome of this project is the identification of possible habitats for selected plant species through ENM studies which may facilitate plantation of selected plants in those habitats in near future. Phytochemical studies identified biological components useful of human beings. In future, these components may be helpful in human health and food safety. Awareness programmes on biodiversity conservation and sustainable management of forest and forest products are making possible that the science can directly reaching people residing in different regions of IHR. The affection of village people towards the nature and natural resources of IHR will be affective in biodiversity conservation.

Developing Mountain Infrastructures:

NA

Strengthening Networking in State/ UT:

NA

Exit Strategy and Sustainability

***Utility of project findings*:**

Present study in search for possible habitat of threatened species through Maxent modelling and GeoCAT conservation assessment tool of twenty-five species has revealed significant decreased in its climatic niche in the future climatic conditions due to the altered climate in the Himalaya. Consequently, there is still a risk that these species will appear being invasive, adapt to the changing climate in the future, and flourish over the entire Himalaya, displacing native species. The study also generated high number of seedlings through macro and micropropagation and distributed to these among the local stake holders. Beside these various capacity building programme among the local inhabitant of Himalayan state were carried out for developing their knowledge on sustainable use of forest resource and their conservation methods. Also, the study has described two species new to science and 01 species first time reported from India, three species rediscovered after and also resolving may taxonomically puzzle at level of species with the help of molecular tools. The updated georeferenced database that compiles current secondary and researched source data is one of the groundbreaking project outcomes.

Other Gap Areas:

Present study recommends further monitoring in the Sikkim and in Arunachal Pradesh as they have contributed significant amount of species number in terms of diversity. Most of the state of Sikkim and Arunachal Pradesh is remaining unexplored especially in the higher altitudes where the present survey was denied by the state forest department. The study also recommends development of ecovillages in the mountain state in sustainable way.

Major Recommendations/ Way Forward:

- Development of ecovillages in sustainable way and villagers will be trained time to time regarding sustainable use of forest resources.
- Species Distribution Modelling (SDM) is highly recommended for future assessment of red listed plant species.
- Establishment of Plant Micro-Reserves (PMRs) or smaller specialty reserves (SSR): The species growing in habitat specific microclimatic conditions or in micro pockets with restricted populations and could be effectively managed and conserved by establishing such PMRs or smaller specialty reserves (SSR).
- Himalayan species which are more specialized to a peculiar microclimate could be effectively conserved and managed through in situ conservation.
- Establishment of Medicinal Plant Conservation Areas (MPCAS): Species that are growing in a particular area or habitat with enough individuals can be declared as conservation area for that species. MPCAs are urgently required for the effective and successful conservation of these medicinal plant species in the Indian Himalayan Region.

Replication/ Upscaling/ Post-Project Sustainability of Interventions:

The field data generated through this project are of high replicability scope. ENM and IUCN threat assessment findings of present study can be used in species recovery program of threatened species in future for reintroduction of species in wild. New localities discovered for some threatened species offers better scope for the conservation of these species in newer localities. Micropropagation protocols developed for few species are highly reproducible and will help in ex situ conservation through rehabilitation of threatened species is wild habitat and really contributes and support conservation efforts. Protocols developed can be utilized for the long-term conservation of the species as well as cryopreservation of the species. These studies can also be replicated in other parts of IHR resulting more authentic cumulative inferences.

Project Sites:

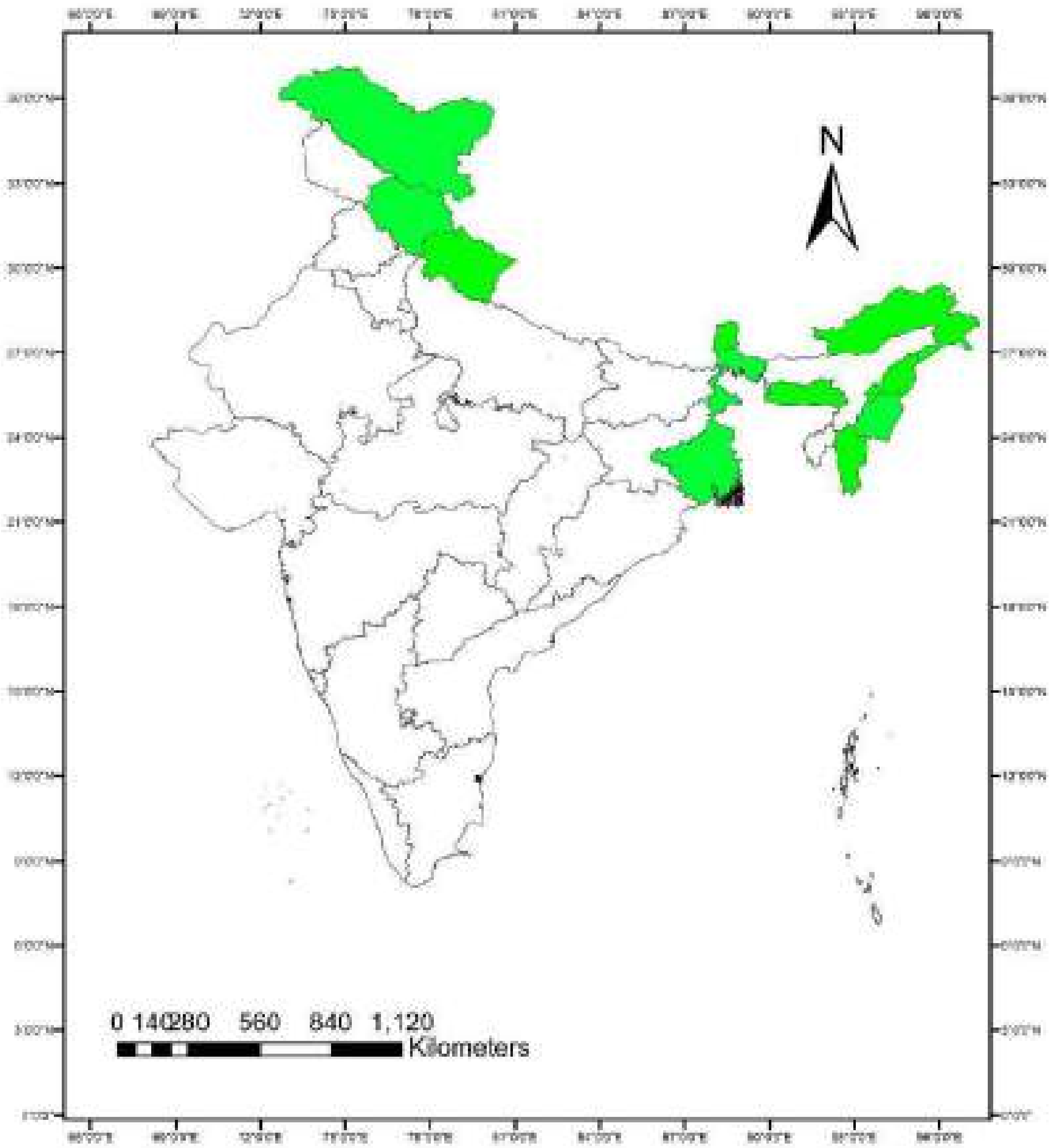

Fig. 1. Map showing the project areas in Indian Himalayan Region.

Project Site/ Field Stations Developed: Since the selected species were of different altitudinal regions, therefore, one each field stations at Eastern Regional Centre, Shillong; Northern Regional Centre, Dheradun; Sikkim Himalayan Centre, Gangtok and Arunachal Pradesh Regional Centre, Itanagar were developed for propagation and mass multiplication of these species in nursery. Two main central nurseries were setup at Dehradun and Shillong for propagation and maintenance of targeted plant species.

Small field stations/nurseries were developed with the collaboration of respective forest departments of Uttrakhand, Himachal Pradesh, Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Mizoram, and Nagaland; defferent NGO of these states for the mass propagation and hardening of threatened high altitude medicinal plant species. These field stations also provided help in local capacity building through cultivation of these medicinal crops.

Fig.2. Selected villages of Arunachal Pradesh for plantation and seedling distribution – A. Sangram; B. Koloriang; C. Sarli (Kurung Kumey district)

Fig.3. Selected villages of Sikkim for plantation and seedling distribution – A. Nandok (East district); B. Kavi (North district); C. Tingda (East district).

Ficus virens at Makhan village, Senapati, Manipur

A view of Makhan village, Senapati, Manipur

Fig.4. Selected villages of Manipur for plantation and seedling distribution

A view of Doyang lake, Wokha, Nagaland

Fig.5. Selected villages of Nagaland for plantation and seedling distribution

Table:1- The georeferenced data related to population size and geo-coordinates along with the threat factors of the selected species are provided in the table below:

SNo.	Plant name	State	Locality	longitude	latitude
1	*Schima wallichii*	Meghalaya	Nongkhlaw	91.6347° N	25.6863° E
			Mawsmai	91.7383° N	25.2442° E
			Khasi Hills	91.6333° N	25.5831° E
			Baghmara Wild Life sanctuary	91.6368° N	25.1872° E
			Balpakram Wildlife Sanctuary	91.8644° N	25.2624° E
			Jaintia hills	91.3498° N	25.5024° E
			Umsaw	91.5786° N	25.8559° E
			Umran	91.8761° N	25.7703° E
			Jarain	92.1444° N	25.3761° E
			Jowai	92.1972° N	25.4558° E
			Tura	90.2025° N	25.5107° E
		Mizoram	Sairep	91.8216° N	22.8095° E
			Thalthang	91.0608° N	22.6910° E
			Sairep forest	91.8211° N	22.8238° E
			Khanpui	91.9040° N	23.9128° E
			Thenzwal	91.7747° N	23.2792° E
			Aizawl to champai	91.3281° N	23.4565° E
			Murlen National Park	91.2785° N	23.6571° E
			Dampa Tiger Reserve	91.4180° N	23.5032° E
			Aizawl	92.6925° N	23.7207° E
			Dampa Tiger Reserve	92.4180° N	23.5031° E
		Assam	Baghorkhlos Chakrasila Wildlife sanctuary	91.3294° N	26.3375° E
			Jarnagra chakrasila wildlife sanctuary	91.3277° N	26.3363° E
			Karimganj	91.3872° N	24.5848° E
			Borail Wildlife Sanctuary	92.609° N	25.0189° E
			Kamrup	91.5976° N	26.3196° E
			Nagoan	92.6789° N	26.3460° E
			Lakhimpur	94.4882° N	27.3743V E
		Arunachal Pradesh	River Dirang	91.2402° N	27.3501° E
			Namsang Soha	91.5111° N	27.1058° E
			Wakka	91.4346° N	26.7881° E
			Baha, Kameng	91.8340° N	27.1694° E
			Begi to ziro	91.8209° N	27.5446° E
			Tirap forest dept.	91.5407° N	26.9938° E
			Bomdila	91.4148° N	27.2650° E
2	*Schima khasiana*	Meghalaya	Kynshi	91.5346° N	25.5274° E
			Shillong peak	91.8752° N	25.5419° E
			Cherrapunjee	91.7287° N	25.2686° E
			Khliehshnong	91.7171° N	25.2832° E

			Laitryngew	91.7323° N	25.3223° E
			Nongstoin	91.257° N	25.5208° E
			Sohra	91.7303° N	25.2706° E
			Mairang	91.6358° N	25.5653° E
			Kynshi	91.5345° N	25.5276° E
			Shillong peak	91.8748° N	25.5466° E
			Sohra	91.7253° N	25.2736° E
			Jowai	92.1977° N	25.4535° E
			Laitryngew	91.7327° N	25.3238° E
		Mizoram	Murlen National Park	91.2785° N	23.6571° E
			Dirang	91.3065° N	25.2602° E
			Murlen National Park	93.2784° N	23.6571° E
3	*Rhododendron coxianum*	Arunachal Pradesh	Pine grove, Subansiri	91.3378° N	27.7759° E
4	*Rhododendron arboreum*	Meghalaya	Dirang	91.3069° N	25.2601° E
			Nongbri Forest	91.6759° N	25.5453° E
			Thadlaskein	91.1399° N	25.5362° E
			Botanical garden, Shillong	91.9041° N	25.6770° E
			Mairang to Nongkhlaw	91.6347° N	25.6863° E
		Nagaland	Naga Hills	91.9962 N	26.0034° E
			Saramati	91.0290 N	25.7202° E
		Sikkim	Chungthang	91.6465 N	27.6039° E
		Arunachal Pradesh	Wakka, Tirap	91.4346 N	26.7884° E
			Kalakthang, Kameng	91.1138 N	27.1041° E
			Takepokong to Sirang	91.6041 N	28.2650° E
			Sergaon, Eastern side, Kameng	92.8029 N	27.1788° E
			Jabrang	91.5050° N	26.9110° E
			Bomdila to Rupa	92.4169° N	27.2631° E
			Sengdong to Sela	92.7996° N	27.1764° E
			Brukpata, Kameng	92.8234° N	27.1961° E
			Baishelehi, Kameng	92.8328° N	27.1844° E
5	*Rhododendron formosum*	Meghalaya	Lawkyntang Forest	91.7439° N	25.4453° E
			Lyngkeinshymier	91.2568° N	25.4427° E
			Elephant Falls	91.8226° N	25.5362° E
			Cherra road	91.8234° N	25.5345° E
			Mawphlang	91.7497° N	25.4450° E
			Lawsatum	91.8637° N	25.5590° E
			Nongstoin	91.2657° N	25.5153° E
			Jakrem	91.5055° N	25.3913° E
			Woodland camp	91.8914° N	25.5779° E
6	*Rhdodendron johnstoneanum*	Arunachal Pradesh	Mingusking	91.5119° N	26.3194° E
		Manipur	Shirui hills	91.4191° N	25.1304° E
		Nagaland	Saramati	91.0233° N	25.7049° E
			Zakhama Hills	91.1232° N	25.5960° E
			Dzuko valley	91.1341° N	25.5071° E

			Japfu hills	91.0873° N	25.6575° E
			Dzuko hills	91.0804° N	25.5611° E
		Meghalaya	Woodland campus	91.8912° N	25.5776° E
7	*Rhododendron inequale*	Meghalaya	Laitlyngkot	91.8410° N	25.4463° E
			Peak forest	91.6333° N	25.5833° E
			Riat Laban	91.8686° N	25.5588° E
			Smit	91.9056° N	25.4975° E
			Pynursla	91.9031° N	25.3097° E
8	*Rhododendron iteophyllum*	Meghalaya	Umpling	91.9246° N	25.5725° E
			Woodland campus	91.8907° N	25.5651° E
9	*Rhododendron watti*	Arunachal Pradesh	Sela, NEFA	91.1044° N	27.4988° E
			Sengedzongile to Sela, NEFA	91.1088° N	27.4917° E
10	*Rhododendron maddeni*	Arunachal Pradesh	Kalaktang, NEFA	91.11313° N	27.1033° E
			Udayale Pass, Lohit	91.1757° N	27.8998° E
			Senge, West Kameng	91.1119° N	27.4836° E
			Nyukmadong, Kameng	91.1326° N	27.4085° E
			Zanglawp–Tawang	91.8593° N	27.5856° E
			Sela to Zangla,	91.1064° N	27.4986° E
11	*Coptis teeta*	Arunachal Pradesh	Lohit	96.1724° N	27.9041° E
			Mayudia Pass	95.9252° N	28.2420° E
			West Kameng	92.3024° N	27.3427° E
12	*Aegle marmelos*	Assam	Sonapur	91.9802° N	26.1172° E
			Naogaon	92.6832° N	26.3481° E
			Kamrup	91.5798° N	26.3151° E
			Kaziranga Reserve Forest	93.1676° N	26.5763° E
			Tezpur	92.7883° N	26.6538° E
13	*Aesculus assamica*	Meghalaya	South Garo Hills	90.5630° N	25.3305° E
		Meghalaya	Umshing	91.9055° N	25.6071° E
		Meghalaya	Nongkhlaw to Khri River	91.6568° N	25.7226° E
		Mizoram	Lungchhuan (NVP)	93.0149° N	23.1488° E
		Arunachal Pradeh	N.C. Hills Umrangsho	92.7662° N	25.5128° E
		Assam	Sonai-Rupai Wildlife Sanctuary	92.3457° N	26.9332° E
14	*Nepenthes khasiana*	Meghalaya	Jarain	92.1472° N	25.3814° E
			Shillong	91.8229° N	25.5368° E
			Balpakram Nationla park	90.8632° N	25.261° E
		Assam	Sonapahar to Boko	91.1930° N	25.8333° E
			Baghmara	91.1876° N	26.6338° E
15	*Hovenia dulcis*	Meghalaya	Umsaw forest	91.8438° N	25.8865° E
			Mynso	92.2994° N	25.5238° E
			Umran	91.8764° N	25.7703° E
			Nongpoh	91.8787° N	25.9180° E
			Jail Road Shillong	91.8852° N	25.5788° E
		Assam	Pasighat	95.3258° N	28.0605° E

			Barpathar	93.8959° N	26.2749° E
			North Lakhimpur	94.0834° N	27.2407° E
		Arunachal Pradesh	Tirap	95.5426° N	26.9358° E
		Mizoram	Mualpheng	92.9772° N	23.6082° E
16	*Rhododendron mecabeanum*	Nagaland	Dzuko valley Nagaland	94.1345° N	25.5093° E
		Manipur	Khunkhu	93.7883° N	24.9765° E
		Manipur	Esii	94.0917° N	25.5239° E
17	*Aglaia perviridis*	Assam	North Cachar Hills	93.0510° N	25.3193° E
			Sylhet	92.3425° N	24.8667° E
			Sibsagar	94.6555° N	26.9720° E
			Borail Wildlife Sanctuary	92.5738° N	25.0296° E
			Rukni	92.8933° N	24.6202° E
			Sivasagar	94.6391° N	26.9542° E
		Meghalaya	Mawmluh	91.6970° N	25.2531° E
			Garo Hills	90.3388° N	25.4964° E
		Tripura	Dharmanagar	92.1412° N	24.3753° E
		Mizoram	Thenhlum	92.5877° N	23.1966° E
			Thenhlum	92.5822° N	23.1939° E
18	*Acer laevigatum*	Meghalaya	Mairang	91.6416° N	25.5716° E
		Meghalaya	Shangbangla	91.8661° N	25.9516° E
		Meghalaya	Jowai	92.2252° N	25.4628° E
		Meghalaya	Cherrapunjee	91.7334° N	25.2773° E
		Arunachal Pradesh	Kameng FD NEFA	92.6294° N	92.6294° E
19	*Mahonia nepalensis*	Meghalaya	Jarain	92.149° N	25.3815° E
		Meghalaya	Pynursula	91.8983° N	25.3095° E
		Meghalaya	Cherrapunjee	91.7192° N	91.7192° E
		Manipur	Ukhrul District	94.3575° N	94.3575° E
		Mizoram	North vanlaiphai	93.0484° N	23.1306° E
20	*Carallia brachiata*	Mizoram	Murlen National Park	93.2175° N	23.7264° E
		Mizoram	Lungchhuan	93.0144° N	23.1474° E
21	*Dendrobium fimbriatum*	Assam	Foot hill camp	93.1951° N	26.3915° E
		Assam	Darrang	92.0627° N	26.4592° E
		Assam	margherita	95.6694° N	27.2910° E
		Arunachal Pradesh	Kalaktang, Kameng	92.1153° N	27.0938° E
		Meghalaya	Jarain, Jayantia Hills	92.1395° N	25.3769° E
		Meghalaya	Khasi Hills	91.6292° N	25.5678° E
		Meghalaya	Jayantia Hills	92.3542° N	25.4891° E
		Manipur	Senapati	94.0230° N	25.2630° E
		Mizoram	Murlen National Park	93.2182° N	23.8927° E
22	*Dendrobium khasianum*	Arunachal Pradesh	Kameng	92.8178° N	27.0983° E
		Meghalaya	Shillong	91.8914° N	25.5779° E
23	*Dendrobium fimbriatum var. oculatum*	Assam	Manas National Park	91.0011° N	26.6594° E
		Arunachal Pradesh	Kalaktang	92.1137° N	27.1043° E
		Arunachal Pradesh	Rupa- Kalaktang	92.1739° N	27.0900° E
			Nongpoh	91.8336° N	25.8687° E

		Meghalaya	Cherrapunjee	91.7288° N	25.2690° E
			Orchid House	91.8985° N	25.5791° E
			Umsaw	91.9175° N	25.6002° E
		Nagaland	Tseminyu	94.1902° N	25.9097° E
24	*Trachycarpus martianus*	Meghalaya	Khasi Hill	91.6197° N	25.5811° E
25	*Areca triandra*	Meghalaya	Nongpoh	91.8208° N	25.8657° E
			Barapani BSI Garden	91.9040° N	25.6772° E
27	*Homalomena aromatica*	Meghalaya	South Garo Hills	90.5554° N	25.3274° E
			Shillong	91.8913° N	25.5767° E
			Jayantia Hills	92.3423° N	25.4956° E
			Tharia	91.7638° N	25.1941° E
		Assam	Kakoi	92.0516° N	27.3568° E
			Kokrajhar	90.2668° N	26.4010° E
			Jorhat	94.2041° N	26.7497° E
			Mikir Hills	93.5000° N	26.1661° E
			Sivsagar	94.6442° N	26.9815° E
		Mizoram	Lushai hills	92.8344° N	23.1644° E
28	*Acanthephippium stritum*	Nagaland	Naga Hills	94.5571° N	26.1531° E
		Assam	Umrangso	92.7331° N	25.5131° E
29	*Taxus baccata*	Mizoram	Murlen National Park	93.2797° N	23.6567° E
		Manipur	Esii Phi	94.07598° N	25.5416° E
			Khongjom peak	94.07223° N	24.5045° E
		Meghalaya	Mawkyrwat	91.4414° N	25.3722° E
			Nokrek Biosphere Reserve	90.3387° N	25.4580° E
			Mawphlang	91.7491° N	25.4444° E
		Assam	Balipara	92.7762° N	26.8267° E
30	*Gnetum gnemon*	Nagaland	Naga Hills	94.996° N	25.9993° E
			Rangapahar	93.7070° N	25.8590° E
		Meghalaya	Mawkyrwat	91.4512° N	25.3680° E
			Baghmara Reserve Forest	90.6320° N	25.1848° E
			Jowai	92.2093° N	25.4364° E
		Assam	Chariduar	92.7791° N	26.8682° E
			Kalanadi	91.5321° N	26.7914° E
			Sivasagar	94.6539° N	26.9735° E
			Cachar	92.8626° N	24.9258° E
			Mikir Hills	93.5007° N	26.1648° E
31	*Adinandra graffithii*	Meghalaya	Dawki	92.0240° N	25.1825° E
			Mawmluh	91.7035° N	25.2588° E
			Mawsynram	91.5780° N	25.2958° E
			Shangpung Jowai	92.34431	25.48383
			Balpakram Reserve Forest	90.86363	25.26254
32	*Garcinia cowa*	Meghalaya	Garo Hills	90.33208	25.49909
			Umsaw	91.57723	25.85849
			Dawki	92.01973	25.18997

			Tharia	91.77502	25.19389
		Assam	Lakhimpur	94.18428	27.26119
			Cachar	92.87282	24.81933
			Mahadev	91.70224	26.16885
			Kamrup	91.60333	26.32035
			Kokhrajar	90.26712	26.40145
33	*Hydnocarpus kurzii*	Assam	North Lakhimpur	94.09518	27.22594
			Barapathar	93.8891	26.27616
			Mikir Hills	93.50153	26.16448
			Maharani	93.51498	26.31864
		Mizoram	Aizawl	92.93616	23.15501
			Hauruang	92.71338	22.87436
			Dampa Tiger Reserve	92.40961	23.50682
		Meghalaya	South Garo Hills	90.54674	25.29885
			Laitmawsiang	91.75994	25.31968
34	*Baccaurea ramiflora*	Meghalaya	Pynursla	91.89285	25.18086
			Umling	91.85699	25.97384
			Dawki	92.02459	25.18756
			Mairang	91.63505	25.56974
			Tura	90.19699	25.50783
		Assam	Lakhimpur	94.23246	27.21836
			Garampani	92.63905	25.47992
			Mikir Hills	93.51	26.17372
			Nameri Reserve Forest	92.87722	26.9324
			Gharbanga	91.70631	26.04157
35	*Chrysophyllum roxburghii*	Assam	Bhuban	92.91856	24.69804
			Nagoan	92.6869	26.34721
			Lakhimpur	94.06708	26.80601
		Meghalaya	Diengsong	91.74455	25.34329
			Ur ba-ar	91.76457	25.30481
36	*Prunus cerasoides*	Meghalaya	Pynursla	91.93193	25.28799
			Ward Lake	91.88665	25.28799
			Raj Bhavan Shillong	90.15641	25.28799
			BSI Shillong	91.89859	25.28799
		Mizoram	Murlen National Park	93.27901	25.28799
			Aizawl	92.70305	25.28799
		Nagaland	Kohima	94.09946	25.28799
37	*Artocarpus lakoocha*	Assam	Lakhimpur	94.15138	27.20637
			Sivasagar	94.64245	26.98261
			Mikir Hills	93.5	26.16666
			Kamrup	91.5984	26.31583
			Kokrajhar	90.2667	26.40151
			Goalpara	90.62515	26.16414
		Meghalaya	Nokrek	90.32175	25.46194
		Mizoram	Dampa Tiger Reserve Forest	92.41797	23.50343

			Murlen National Park	93.30203	23.64264
38	*Artocarpus heterophyllus*	Mizoram	Pukzing	92.42294	23.35103
		Assam	Barnadi wildlife sanctuary	91.75531	26.78089
			Kokrajhar	90.23381	26.39835
		Meghalaya	Nongpoh	91.83372	25.86991
39	*Artocarpus chama*	Meghalaya	South Garo Hills	90.56361	25.3301
			Khasi Hills	91.60853	25.58151
		Assam	Borail wildlife Sanctuary	92.6751	25.03622
			Kokrajhar	90.23381	26.39835
			Kamrup	91.60829	26.33436
			Jorhat	94.19341	26.74739
40	*Ormosia pinnata*	Meghalaya	Jowai	92.2034	25.46363
			Mawbein	91.76619	25.29909
		Assam	Cachar	92.92492	24.99595
			Sivasagar	94.66	26.97748
41	*Diplazium nagalandicum*	Nagaland	Tuensang	94.81178	26.23587
42	*Syzygium tetragonum*	Meghalaya	Jowai	92.25492	25.45349
			Pynursla	91.89025	25.31007
43	*Cararium strictum*	Nagaland	Pangti	94.32346	26.2624
44	*Cinnamomum granduliferum*	Meghalaya	Khasi Hills	91.64769	25.57481
			Laitkor	91.89121	25.50338
			Nokrek	90.42996	25.44999
			Pynursla	91.88267	25.30961
			Upper shillong	91.90101	25.58433
			Tura	90.20653	25.52769
			Rongrenggre	90.58264	25.54359
			Goro Hills	90.33333	25.5
		Assam	Jorhat	94.20538	26.75029
			Lakhimpur	94.1308	27.20909
45	*Podocarpus neriifolius*	Assam	Lakhimpur	94.12273	27.20303
			Kakoi	94.05183	27.35784
			Katakhal	92.62265	24.83238
			cachar	92.88675	24.77619
		Meghalaya	Jaintia hills	92.35	25.50633
			Sohra	91.73813	25.27367
			Khasi Hills	91.6328	25.58527
			Darrang	92.02122	25.20756
46	*Cephalotaxus manii*	Meghalaya	Khasi Hills	91.63005	25.58631
		Nagaland	Mungchen	94.5075	26.53366
47	*Ilex godajam*	Meghalaya	Khasi Hills	91.64418	25.59384
		Assam	Sivasagar	94.66032	26.97749
48	*Ilex venulosa*	Assam		93.37215	26.43443
		Meghalaya	Khasi Hills	91.62513	25.57106
			Jarain	92.14975	25.38079

		Nagaland	Naga hills	95.00435	25.99808
49	*Ilex khasiana*	Meghalaya	Shillong	91.96822	25.57066
			Khasi Hills	91.63549	25.58617
			Pynursla	91.90676	25.31246
			Nongbri	91.67572	24.55172
			Shillong peak	91.87589	25.54675
			Jowai	92.21546	25.44966
		Assam	Goalpara	90.62604	26.16524
			Lathimari	92.55199	24.88548
50	*Michelia champaca*	Meghalaya	Nanpalok	91.88635	25.57475
			Garo hills	90.33406	25.50677
			Shillong	91.88629	25.57154
			Khasi Hills	91.6107	25.59551
		Assam	Katachal	92.62283	24.83398
			Sivasagar	94.64193	26.97742
			Glong Silchar	92.77695	24.80549
			Jorhat	94.20543	26.75011
			Chakrasila	91.28514	25.92712
			Kokrajhar	90.26682	26.4012
		Nagaland	Naga hills	95.01188	25.99179
		Arunachal Pradesh	Pasighat	95.32645	28.06184
51	*Syzygium cumini*	Mizoram	Phaileng	92.477	23.70111
52	*Eugeria cumini*	Assam	Sonai Rupai Wildlife Sanctuary	92.34189	26.91881
			lakhimpur	94.15233	27.19883
			Cachar	92.85979	24.777
			Kokrajhar	90.27018	26.39873
			Kamrup Zoological Botanical Garden	91.65996	26.15141
			Kaziranga National Park	93.18006	26.57491
		Meghalaya	South Garo Hills	90.56494	25.32958
		Mizoram	Dampa	92.41649	23.50365
			Khanpui	92.90358	23.85692
53	*Garcinia xanthochymus*	Meghalaya	Umsaw forest	91.58043	25.85686
			Mawmluh	91.70757	25.25849
			Umiam	91.90872	25.67357
			Sohra	91.73997	25.27743
			40 miles	91.90262	25.56313
			South Garo Hills	90.56722	25.32826
		Assam	Kamrup	91.59991	26.31994
			Lakhimpur	94.14916	27.20223
			Sivasagar	94.63309	26.98023
			Darrang bank Sivasagar	94.62666	26.97909
			Garampani, Naharbari	93.87909	26.39318
		Mizoram	Dampa forest	92.41767	23.50192
			Sesawang	92.85335	23.75417

			Kolasib	92.67749	24.22389
			Pualrang	92.83408	24.28572
54	*Arundina graminifolia*	Manipur	Tamenglong	93.49416	24.98793
		Mizoram	Murlen	93.28413	23.66097
		Arunachal Pradesh	Tuling	96.22537	27.71357
			Nampong	96.12827	27.28735
			Jairampur	96.01608	27.35167
		Assam	Kakoi forest beat	94.04509	27.36219
			Daimari	92.15016	26.73003
			Lakhimpur	94.15208	27.20455
			Bagmara	91.18998	26.63587
		Meghalaya	Jarain	92.14862	26.3856
			South Garo Hills	90.56444	25.40797
			Pynursla	91.90326	25.30981
			Mawsmai	91.74191	25.24221
55	*Brainea insignis*	Meghalaya	Umiam	91.90119	25.66166
			BSI garden	91.89862	25.57938
		Assam	Woodland compound	91.76647	26.16912
				91.8942	25.64414
56	*Calanthe biloba*	Meghalaya	BSI garden	91.89862	25.57938
		Assam	North lakhimpur	94.10671	27.2245
		Mizoram	Siang	93.22473	23.97902
57	*Calanthe masuca*	Meghalaya	Nongpoh	91.83315	25.87104
		Assam	Lohit district	96.15526	27.92996
			North lakhimpur	94.10648	27.23945
			Jorhat Hoollonggapar Gibbon Sanctuary	94.35355	26.66278
			Darrang Bhebarghat	92.03486	26.45329
			Goalpara bhatipara	90.61383	26.17985
58	*Quercus griffithi*	Meghalaya	Mawsynram	91.58368	25.30084
			Jowai	92.42529	25.42529
			Shillong	91.84708	25.55049
			Mawphlang	91.75068	25.44636
		Mizoram		93.32481	23.65111
59	*Myrica esculenta*	Meghalaya	Jowai	92.21076	25.43719
			Pynursla	91.89969	25.30444
			Cherrapunjee	91.72148	25.29299
			Ladmawphlang	91.7388	25.35777
		Mizoram	Champhai	93.33942	23.47348
			Phongphui	93.29231	23.64869
60	*Myrica nagi*	Mizoram	Namdu Sigri	93.3382	23.47362
		Meghalaya	Upper shillong	91.84751	25.54736
			Mylliem	91.80446	25.46917
			Mawrah	91.79897	25.42006
61	*Castanopsis triboloides*	Meghalaya	Ladmawphlang	91.74957	25.37549
			Laitmawsiang	91.75833	25.3191

			Nongstoin	91.25568	25.5092
			Nartiang	92.21989	25.57315
		Mizoram	Rampui	92.48974	23.81937
			Keifang	93.28317	23.59539
			Phongphui	93.25933	23.64025
			Ratu	92.92038	24.112
		Assam	Barpathar	93.88685	26.27576
			sibsagar	94.63842	27.0306
62	*Castonopsis indica*	Meghalaya	Jarain	92.14315	25.37636
			Barapani	91.90739	25.67782
			Nokrek National Park	90.42909	25.44625
			Balpakram	90.86975	25.41357
			Mawklot	91.82828	25.55426
		Mizoram	Phuldungsei	92.42311	23.47767
		Assam	Sadeya, Lakhimpur	94.12599	27.15696
			Barpathar	93.89071	26.26768
			Ginnon Jorhat	94.35349	26.66222
63	*Betula alnoides*	Meghalaya	Barapani	91.90734	25.676
			Jowai	92.17008	25.41615
			Nongstoin	91.31044	25.48272
			Cherrapunjee	91.73422	25.33282
				91.89278	25.48878
		Mizoram	Sailsuk	92.74932	23.39731
			Murlan National Park	93.27967	23.65769
64	*Alnus nepalensis*	Meghalaya	Upper Shillong	91.84311	25.55113
			Mawryngkneng	92.04287	25.54271
			Laitlyngkot	91.86423	25.4208
		Mizoram	Murlan National Park	93.2792	23.6571
			Champhai	93.32249	23.46047
		Nagaland	Wokha	94.25768	26.06465
			Ungma	94.51402	26.29229
			Tuensang	94.80981	26.22336
65	*Docynia indica*	Meghalaya	Upper Shillong	91.82931	25.54105
			Mairang	91.64592	25.54999
			Raliang	92.40168	25.50213
			Nongstoin	91.26625 N	25.51138 E
		Nagaland	Dzukou valley	94.09016 N	25.55288 E
		Manipur	Makhan Hills	93.86073 N	24.97276 E
66	*Prunus nepaulensis*	Meghalaya	Diengsong	91.7449 N	25.3419 E
			Shangpung	92.34955 N	25.48196 E
			Nongstoin	91.2426 N	25.51456 E
		Mizoram	Mualpheng	92.97444 N	23.60886 E
			Murlen National Park	93.27874 N	23.65715 E
67	*Bursera serrata*	Meghalaya	Daribokgre	90.32636 N	25.49152 E
			Damra	90.72127 N	25.94188 E
			daina dubi	90.7714 N	25.90723 E

		Assam	Goalpara	90.61156 N	26.16494 E
			Kamrup	91.32865 N	26.52883 E
			Cachar	92.86212 N	24.8186 E
			Kokrajhar	90.23539 N	26.38561 E
		Nagaland	Naga Hills	93.72996 N	25.93972 E
68	*Celtis tetrandra*	Assam	Sibsagar	94.66123 N	26.97822 E
			Akhoi	94.65676 N	27.047 E
		Meghalaya	Nongkhlaw	91.64159 N	25.68616 E
			Damra	90.74246 N	25.9471 E
			Shillong	91.89875 N	25.57938 E
		Manipur	Mao	94.13187 N	25.51646 E
69	*Cymbidium cyperifolium*	Meghalaya	Pynursla	91.9044 N	25.30653 E
			Mawphlang	91.75038 N	25.44566 E
			Nongpoh	91.83606 N	25.86791 E
		Nagaland	Khonoma	94.02376 N	25.65155 E
70	*Cymbidium ebuerneum*	Meghalaya	Cherrapunjee	91.73101 N	25.23834 E
			Jarain	92.15465 N	25.38874 E
		Nagaland	Khonoma	94.02399 N	25.65264 E
71	*Dillenia indica*	Assam	Mizo Kolasib camp	93.02517 N	24.71567 E
			Nagoan	92.68452 N	26.34701 E
			Kamrup	91.6051 N	26.31941 E
			North Lakhimpur Kadam bagan	94.13366 N	27.30877 E
			Katakhal Reserve Forest	92.62283 N	24.83262 E
			Chakrasila	90.32948 N	26.33766 E
			Manas National Park	91.00113 N	26.65942 E
			Cachar	92.87916 N	24.77713 E
			Bagwati	91.7781 N	26.15595 E
		Nagaland	Garampani, Dimapur	93.87234 N	26.39653 E
		Meghalaya	Umling	91.8577 N	25.97291 E
			Nongpoh	91.83435 N	25.86861 E
			Nokrek	90.42859 N	25.4475 E
72	*Saraca asoca*	Meghalaya	Pynursla	25.22583 N	91.96722 E
73	*Citrus maxima*	Meghalaya		91.87803 N	25.84804 E
				91.99361 N	25.38389 E
74	*Paris polyphylla*	Nagaland	Pangsa	94.79738 N	26.22227 E
			Khonoma	94.02999 N	25.65806 E
			Longkhum	94.41021 N	26.26459 E
			Wokha	94.26172 N	26.11461 E
		Manipur	Phungyar	94.36375 N	24.81411 E
			Tadubi	94.13017 N	82.65667 E
		Meghalaya	Pomlum	91.81316 N	25.52988 E
			Mairang	91.63671 N	25.56631 E
		Arunachal Pradesh	Anini	95.92001 N	28.79753 E
			Pangthang	88.62828 N	27.34495 E
75	*Gynocardia odorata*	Meghalaya	Mawsyram	91.56436 N	25.2972 E

		Dawki	92.02434 N	25.20828 E
		Nongkhlaw	91.63324 N	25.6888 E
		Umran forest	91.86023 N	25.55129 E
		Nokrek	90.42802 N	25.44773 E
		Pynursula	91.89731 N	25.3087 E
		Umling	91.8564 N	25.97299 E
	Mizoram	Murlen national Park	93.27856 N	23.65684 E
		Dampa Tiger reserve	92.36279 N	23.49212 E
	Assam	Darrang	92.03711 N	26.40159 E
76. ***Gentiana kurroo***		Sangrah	30.6886 N	77.4396 E
		Deoban	30.7644 N	77.8976 E
		Suwakholi	30.4538 N	78.1688 E
		Bhadraj	30.4772 N	77.9450 E
		Bhairon ghati, Vaishno Devi	33.0220 N	74.9497 E
		Gharmaraini, Chamba	32.5419 N	76.1743 E
		Kullu	31.8318 N	77.1601 E
77. ***Jasminum parkeri***		Dam side, Holi	32.3408° N	76.5369° E
		Deol	32.3091° N	76.5793° E
		FRH, Holi	32.3273° N	76.5563° E
		Grima 1	32.4433° N	76.4946° E
		Grima 2	32.4078° N	76.4874° E
		Kuleth 1	32.3211° N	76.5653° E
		Kuleth 2	32.3251° N	76.5577° E
		Sinur	32.4092° N	76.5041° E
		Taxi stand, Holi	32.3289° N	76.5543° E
		Tiari	32.339° N	76.5492° E
78. ***Phlomoides superba***		Kangra	31.87577° N	76.4103° E
		Khundian	31.6667° N	76.1667° E
		Mohand	30.2123° N	77.9241° E
		Jallow	32.7949° N	75.2294° E
		Sunderbani	33.0834° N	74.4421° E
		Tarha	32.82329 N	75.00737 E
		Domel	32.89006 N	74.95204 E
79. ***Pittosporum eriocarpum***		Barlowganj	30.44421 N	078.08263 E
		Kempty fall	30.50041 N	78.01131 E
		Sahastradhara	30.39124 N	78.13417 E
		Bhatta gaon	30.42462 N	078.07323 E
		Maldevta	30.32609 N	78.1654 E
		Nagni	30.30851 N	78.34414 E
		Nainital	29.37745 N	79.47039 E
80. ***Aconitum heterophyllum***		Badrinath	30.74627 N	79.50895 E
		Valley of flowers	30.71945 N	79.59534 E
		Pangi	32.92629 N	76.55427 E
		Gangotri	30.99317 N	78.93925 E
		Churdhar	30.83783 N	77.45318 E
		Kedarnath	30.73482 N	79.06485 E
81. ***Mahonia jaunsarensis***		Chakrata	30°42′21.74″N	77°51′51.74″E
		Deoban	30°44′ 2.15″N	77°51′38.12″E

82. ***Magnolia kisopa***	Mandal Pandukeshwar	30°27′30.37″N, 30°38′16.47″N	79°16′5.65″E 79°32′23.01″E
83. ***Sophora mollis***	Sahastradhara	30°23′5.07″N	78° 8′11.76″E
84. ***Acer oblongum*** **var.** ***membranaceum***	Mussoorie	30°26′28.59″N	78° 5′4.98″E

85. *Aconitum ferox*	Darjeeling	Singalila Range	27.112833 N	88.013539 E
			27.160026 N	88.015911 E
			27.110468 N	88.011507 E
	Sikkim	Sandakphu-	27.100304 N	88.009406 E
	Darjeeling	Bikhabhanjan	27.116144	87.993600
		Singhalila Range	27.090682	88.043214
	Sikkim	Sandakphu	27.092303	88.016483
		Sandakphu	27.107572	88.003311
	Darjeeling	Phalloot	27.157773	88.010545
	Sikkim	Tongloo	27.034021	88.083083
			27.721048	88.749249
			27.738057	88.546117
		Sandakphu	27.110993	87.991534
		Phalloot	27.158938	88.037701
		Sandakphu-Subarkham	27.112991	88.010393
	Darjeeling	Phalloot	27.144675	88.049789
	Sikkim	J0-Ko-La	27.290702	88.903033
		Sandakphu	27.107465	88.003314
	Darjeeling	Singalila Range	27.039560	88.075222
	Kumaon	Ralam Valley	30.309687	80.282726
	Sikkim Himalaya		27.682844	88.773990
	Kumaon	Ralam Valley	30.321345	80.300412
		Ralam Valley	30.277869	80.266384
		Ralam Valley	30.265713	80.265700
		Mussourie Range	30.743760	77.867024
	Sikkim	Sandakphu	27.163269	88.019744
	Himalaya		27.373411	88.747197
	Kumaon	milum	30.470420	80.119263
		Pindunee	30.333078	80.180554
		Burjee kang	29.973478	80.423187
	Uttarakhand	Gurhwal	30.763824	79.061499
	Nepal	Thami Chautare	27.849271	85.660435
		Nampa Gadh	29.935241	80.904930
86. ***Aconitum heterophyllum***	Kashmir	Seoj	33.07722	76.07444
	Darjeeling	Singalelah	27.13496	88.01885
		towards Kidarkanta	31.02698	78.16054
		Pangi	31.59571	78.27724
		Chamba	32.66604	76.25541
		Gulmarg	34.00868	74.40858
		Dalhousie	34.09833	74.94951
		Kashmir	34.51652	74.51601
		Kolhoi Glacier	34.15571	75.25665
	N.W Himalaya	Inhal	33.5028	75.21136

		Deosai	34.767	75.14635
		Sach Pass	32.98834	76.20442
		temp region	31.09978	77.18202
		Koksar	32.41125	77.23692
		Simla,Mahasu	31.09474	77.27349
		Kyelang , Karelang	32.55708	77.02981
		From Suros to Sanko	32.90862	76.21708
		Amritganga Valley	30.82499	78.66716
		Kyelang (upper)	32.57304	77.03272
		Milam glacier	30.46923	80.10201
87. ***Aesculus indica***		Hazara	34.410118	72.406189
		Kotegurh	34.506384	74.157391
		Garhwal	30.403724	79.434923
		Chamba	30.347977	78.409473
		Gulmarg	34.018035	74.401606
			33.803950	74.911813
		Garhwal	30.427163	79.284385
	N. W. Himalaya	Kumaon	29.660286	79.295702
		Kumaon	29.668557	79.285687
			31.833652	76.891697
		Pangee	31.581663	78.276473
		Garhwal	30.278991	79.009166
		Chamba	32.526867	76.040629
		Chamba	32.557491	76.091496
		Shimla	31.108883	77.175831
			31.108679	77.241658
			31.119450	77.208286
88. ***Arenga westerhoutii***		Siang district	28.8122	95.16783
			28.81201	95.16745
	Arunachal pradesh		28.64346	95.04491
			28.62359	95.05199
			28.81201	95.16614
89. ***Arnebia benthamii***			34.606247	74.694632
			34.472565	74.776822
			34.709057	74.305134
			34.660347	74.480468
	Jammu & Kashmir		34.743859	74.580563
			34.660783	74.579959
			34.719662	74.329379
			34.630095	74.519505
			34.839149	74.462269
			34.791554	74.864951
90. ***Bischofia javanica***	W.Bengal	Karshiang	26.889004	88.290711
	Uttarakhand	Dehradoon	30.412817	78.082890
		Ryang	27.332466	88.333358
			27.181198	88.651711
	Sikkim		27.116458	88.351510
		Singtum	27.138093	88.392745
		Singtum	27.140260	88.400346
			27.343120	88.209302
91. ***Caryota urens***	Sikkim		27.0018	88.34039
			27.00036	88.33853

		Rongbi Jhora	27.00135	88.35547
92. ***Cautleya gracilis***	Dibang valley	Mayudia	28.24641	95.92667
	East himalaya	Rongbe	26.98133	88.34393
	Sikkim himalaya	rungbee	26.98692	88.3481
	Arunachal Pradesh	sikyak	28.75971	95.23383
	Dibang valley	sikiyak	28.77204	96.25411
	Darjeeling	Senchal WLS	26.92395	88.36417
93. ***Cinnamomum impressinervium***	West Bengal	Darjeeling Dist	27.0634	88.2670
	Sikkim	Lebry	27.5557	88.5009
			27.4524	88.4897
			27.453027	88.555815
			27.379697	88.638841
	Assam	Khasi and Jayantia Hills	25.193422	92.468761
		Umran, Khasi and Jayantia Hills	25.160039	92.580185
		Loharband, Cachar	25.145156	92.744046
	Arunachal Pradesh	Aiwzi to Begi (Subansip dt.)	27.464853	93.869508
			27.640805	93.891254
			27.164092	93.396976
	Sikkim		27.481333	88.470958
			27.495363	88.552963
			27.560870	88.532547
			27.476916	*88.492730*
94. ***Cypripedium cordigerum***		*Shimla*	*31.098577*	*77.276514*
			31.120877	77.232683
		Dungagalli	34.062014	73.429839
		harkidun, tehri	31.142634	78.431332
			30.699279	79.590589
		nag-tiba	30.578678	78.157421
			30.579127	78.157715
	N.W. Himalaya		34.163967	75.228901
			29.400075	79.468769
			32.004934	77.481179
			30.599372	78.152833
			30.5955 N	78.1405 E
			30.5823 N	78.1415 E
			30.7423 N	79.4787 E
			30.0573 N	80.2106 E
			30.5584 N	79.1438 E
			31.1316 N	77.2243 E
			30.5705 N	78.1335 E
		deoban	30.7492 N	77.8586 E
			34.4292 N	74.6759 E
95. ***Euonymus assamicus***	Assam	Delei valley	28.08 N	96.5 E
			28.1466 N	96.5633 E
			28.1494 N	96.5169 E
96. ***Galearis spathulata***			27.4316 N	88.2193 E
		Yunthang (Lachung valley)	27.5591 N	88.3581 E
	Sikkim Himalaya		27.7300 N	88.5258 E
			27.5974 N	88.2728 E
			27.7935 N	88.7033 E

			27.5119 N	88.3819 E
		Lingtam	27.4948 N	88.4273 E
			27.4414 N	88.1233 E
			27.6371 N	88.2959 E
	Tehri-garhwal	ridge above jhala	31.0119 N	78.4588 E
		laulea under srikanta	30.7328 N	79.6111 E
		singalelah range	27.4572 N	88.1132 E
		singalelah range	27.4575 N	88.1229 E
		singalelah range	27.4673 N	88.1346 E
		Lachung valley	27.6870 N	88.7246 E
		Lachung valley	27.7446 N	88.7344 E
		Lachung valley	27.7224 N	88.7635 E
	Sikkim	singalelah range	27.4829 N	88.1372 E
	Himalaya	yeumtong (Lachung valley)	27.7988 N	88.7038 E
		lungtor	27.2747 N	88.7966 E
		lingter	27.2932 N	88.8064 E
			27.3364 N	88.8194 E
		Lachung valley	27.6869 N	88.7279 E
		tangu, nulla behind hut	27.8938 N	88.5387 E
		tangu, nulla	27.8930 N	88.5306 E
		behind hut	27.7027 N	88.5420 E
		yeumtong	27.7824 N	88.7163 E
		(Lachung valley)	27.8248 N	88.5512 E
		lingter	27.2844 N	88.8099 E
97. ***Gymnadenia orchidis***	N.W. himalaya	Pangee	31.5761 N	78.2549 E
		mussoorie	30.4703 N	77.9666 E
		above tangee, Teesta valley	27.629367	88.245914
	Sikkim		27.826813	88.682247
	Himalaya	Punga phu	27.863718	88.548224
		seunthung	27.598364	88.695665
		olakthang	27.506977	89.376466
			27.726805	88.591752
98. ***Hedychium densiflorum***	Dibang valley	mayudia	28.360122	95.945427
		mayudia	28.417731	95.881153
		mayudia	28.394488	95.783053
		mayudia	28.401259	95.784126
		mayudia	28.340834	95.950307
		mayudia	28.366722	95.911383
		mayudia	28.319286	95.968737
		sikkim	27.343507	88.344418
		Lachung valley	27.659843	88.724831
	Sikkim		27.202415	88.600202
	Himalaya		27.495440	88.548231
			27.307580	88.211459
			27.185167	88.210609
		sikkim	27.401255	88.631069
		sikkim	27.448708	88.333725
		sikkim	27.380122	88.361787
	Darjeeling	rungbee	26.973008	88.330923
99. ***Loxostigma griffithii***	Sikkim	Forest north east of Gangtok	27.342907	88.636245

	Darjeeling	Rimbick to Pahuajua	27.117718	88.108395
		Karseong	26.889176	88.295384
		Maiurun forest	27.061676	88.260377
		Surina	27.048528	88.254629
		Rishap	27.135535	88.667917
			27.289648	88.377449
			27.263589	88.315464
			27.180550	88.652251
		Rungbee	26.992875	88.326808
	Sikkim	Rungbee	26.985264	88.332838
	Himalaya		27.005980	88.326947
		Rungbee	26.994383	88.330671
			27.541462	88.616110
			27.543257	88.452428
		Rungbee	26.991654	88.334356
		Hanumautak	27.341735	88.623572
			27.279428	88.512619
	N.E.F.A	Ninguing	28.1451 N	94.7542 E
		Ynting to Koppu	28.1421 N	94.7064 E
		Hapoli	27.5334 N	93.8222 E
		Niusa to Wanu	26.9222 N	95.4487 E
		Runbhi Jhora	27.0532 N	88.3564 E
			27.5118 N	88.5176 E
		Rishap	27.1052 N	88.6444 E
		Rishap	27.1202 N	88.6527 E
		Rungbee	26.9938 N	88.3435 E
	Sikkim	Riang	27.2825 N	88.4959 E
		Rungbee	26.9920 N	88.3306 E
		Rungbee	26.9918 N	88.3335 E
		Rungbee	26.9820 N	88.3401 E
		Mongpo	26.9824 N	88.3418 E
		Mongpo	26.9867 N	88.3368 E
			27.3555 N	88.2302 E
			27.3051 N	88.2287 E
	Darjeeling	Rungbee	26.9882 N	88.3173 E
	Darjeeling	Rungbee	26.9764 N	88.3328 E
	Darjeeling	Rungbee	26.9693 N	88.3455 E
			27.4497 N	88.5037 E
	Sikkim		27.3462 N	88.3062 E
	Himalaya		27.4118 N	88.5722 E
			27.3768 N	88.2255 E
	Chumbi Valley	Jaeaaka Valley	27.3326 N	88.2351 E
			27.2642 N	88.2692 E
	Sikkim		27.3865 N	88.5560 E
	Himalaya		27.4112 N	88.6216 E
100. ***Magnolia doltsopa***	East Himalya	Darjeeling district	27.0234 N	88.2651 E
	Sikkim	Senchal forest, Darjeeling	27.0041 N	88.2906 E
		Kursong	26.8804 N	88.2888 E
		Senchal	26.9291 N	88.3626 E
	Darjeeling	Darjeeling	27.0261 N	88.2679 E
	Sikkim	Gangtok	27.3458 N	88.6196 E
		Development area, Gangtok	27.3445 N	88.6184 E

	Sikkim	Tarchi Forest 8 Km from Gangtok	27.3668 N	88.6471 E
		Kursong	26.8860 N	88.2843 E
		Above Rangbu	26.9897 N	88.2494 E
		Above Reshah	27.1835 N	88.6511 E
		Temp region	27.3994 N	88.6270 E
		Darjeeling district upto Longloo	26.9971 N	88.2743 E
		Dumtong	27.4038 N	88.6169 E
			27.414905	88.583410
	Darjeeling	Darjeeling	27.038638	88.257284
		Darjeeling	27.027992	88.266171
101. ***Mallotus philippensis***	Sikkim	Rungpoo	27.185417	88.531272
	Bengal	Mongpoo	26.979955	88.372495
		Rungio	27.102321	88.331772
	Sikkim		27.532934	88.512208
			27.229188	88.500652
	West Bengal	Pankhabari	26.836187	88.268868
		Dehradoon	30.385637	78.026115
		Dehradoon	30.341750	78.090860
		Dehradoon	30.386214	78.132562
			30.378222	77.957778
	N.W. Himalaya	Musouree	30.463445	78.065491
		Almora	29.601231	79.641623
			30.495828	78.145983
		Musouree	30.474627	78.037171
		Almora	29.583959	79.638921
		Chauba	32.565574	76.130293
			30.279581	78.978637
			32.099662	76.268661
			32.997603	74.933544
			32.979547	75.175571
102. ***Picrorhiza kurrooa***		Upper Chenab	33.286710	75.589391
		Kashmir	34.174764	75.216970
	N.W. Himalaya		34.285298	74.942052
		Kashmir (Kammul Lidder valley)	34.716330	74.329957
		Kashmir	34.775744	74.324183
		Marganla	35.591641	73.455304
		Chotadorri	35.052252	74.935329

103. ***Ponerorchis chusua***	gangtok	27.370257	88.660134
	gangtok	27.366170	88.630369
	tankia	27.484854	88.171152
	gangtok	27.371418	88.654206
	chumbi	27.399530	88.709653
		27.422468	88.740257
		27.422480	88.740249
		27.413913	88.692060
		27.392455	88.707197
	tangu, nulla behind hut	27.903950	88.555814
	lonok	27.823553	88.463336
	phaloot and lachen	27.719268	88.544423

	gangtok	27.303329	88.644701
	Bakri udyar	30.142486	80.123968
	mussoorie	30.476214	78.018955
	gangtok	27.360396	88.565885
	udyar-chipla	29.956236	80.444932
	lachen	27.723440	88.555914
	kumaon	30.181597	80.353661
	palang gadh byans	32.525194	76.525154
		30.123749	80.182044
	lachen valley	27.716270	88.547875
	Zeus valley	27.596575	88.290315
	lachen	27.729461	88.541892
	singalelah range	27.456362	88.112987
	phaloot and lachen	27.188882	88.022188
	singalelah range	27.456764	88.114467
	singalelah range	27.461017	88.112547
	singalelah range	27.457679	88.122501
	Talum, Samdong	27.346532	88.529118
	Talum, Samdong	27.354452	88.541756
	Talum, Samdong	27.354186	88.538256
	Lachen	27.733005	88.562113
	Lachen	27.745492	88.540687
	Lachen	27.770016	88.543258
	chumbi	27.457326	88.178292
	Chumbi&Phari	27.396854	88.196948
	Karponong	27.372680	88.717055
	andra to tahupani, beyond mipi	28.875473	96.041244
	Lachung valley	27.658899	88.724068
	Zeus valley	27.608506	88.266894
	Zeus valley	27.618397	88.259793
	Zeus valley	27.629398	88.245985
	Zeus valley	27.598646	88.275898
		27.364037	88.774382
	singalelah range	27.462733	88.117773
		27.386204	88.715263
		27.421750	88.677840
	choongthang	27.581921	88.649436
	Lachung valley	27.668920	88.760825
		27.439944	88.573487
		27.830933	88.694703
104. ***Rheum spiciforme***	Kumaon	30.101314	80.526314
		30.102741	80.646629
	Spiti (Losar)	32.424189	77.733792
	Ladakh	35.796484	74.968748
		34.198601	77.435245
		34.568021	75.902776
		27.316858	88.830152
		27.647029	88.787503
		27.380760	88.755053
105. ***Salvia hians***	Sach Pass	33.043012	76.319958
	Satrundi	33.001200	76.212085
	Thaywas	34.278267	75.099106
	Thilan	33.643642	75.774953
	G.S.C. Fuller, Esq., Dist.- Forest Office	34.000903	74.362987

	Rajdianga Cashmere	34.605810	74.493095
		35.889300	74.294622
	Gilgit	35.887122	74.323824
		35.912866	74.872182
	Ahabad	35.733391	74.539669
	Gulmarg	34.027089	74.395751
	Kolahoi, head of Liddar Valley	34.153676	75.254095
	Kolahoi glacier	34.147750	75.298738
		35.432054	74.563967
	Above Sonmarg	34.288427	75.285261
		34.080119	75.616521
		35.778572	74.335439
		27.752695	88.779516
	Rambara-kedarnath	30.698458	79.054388
	Dombita? Gadh?	31.639719	77.265479
106. *Saurauia punduana*	Kalimpong- Teesta River	27.078996	88.468520
	Forest near Twam Village, Lohit Dist.	27.978924	96.244549
	Terni	27.392950	88.637219
	Rishah	27.122358	88.628601
	Kalimpung	27.098040	88.526303
	Darjeeling	27.012257	88.284591
	Baha Hill	26.256147	93.353626
	Dikchu	27.401605	88.523823
	Dikchu	27.400008	88.519538
	Mongpu	26.981712	88.369733
		27.006368	88.301386
	Chuten Orchid Sanctuary	27.242442	88.191096
	Tadong, Gangtok	27.314472	88.604513
	Rungbee	26.993367	88.336428
	Pynursla	25.309451	91.891252
	Kalimpong- Teesta River	27.07487	88.451535
	Naga Hills	26.000649	94.998675
	Khasia Hills	25.585572	91.633839
	Rishop	27.106446	88.647691
		25.542143	91.854501
	Mairang	25.571891	91.639653
	Umran, Khasi Hills	25.776835	91.896168
	Jayantia Hills	25.539890	92.363029
	Kohima, Naga Hills	25.652549	94.081535
	Cherapunjee	25.273746	91.741834
	Hmuntha, lusai hills	23.505179	92.954079
	Dympep	25.41231	91.788694
	Palin	27.681207	93.607336
	Nongpoh	25.709511	91.855916
	Khonoma	25.652795	94.024957
107. *Sinopodophyllum hexandrum*	Panwali	30.203125	79.998921
	Seshnag	34.090926	75.485066
	Rouk Hill	34.380076	75.008497
	Purkia	30.318812	80.208521
	Jumnotri	30.998826	78.463483
	Ad. Mt.Kidarkanta	31.026545	78.127453
	1 day W.of Changi	27.373538	88.748087
	Chamnago	27.384982	88.751827
	Sikkim	27.437007	88.563571

		33.982460	75.191600
	Zoji La	34.104572	75.442370
	Ahbad	34.530226	74.632098
	Shapujon	34.537551	75.116700
	Soonder dunja valley	34.617667	75.220895
	Temp	30.998924	78.463613
	Snow line	35.931704	74.597463
	Temp	27.763749	88.542068
	Seshnag	34.097169	75.499204
	Kalatop forest, Chamba	32.553159	76.018600
	Kalatop forest, Chamba	32.549450	76.020484
	Mandali	30.748762	77.831554
	Pindari	30.206579	79.999762
	Kinani Pani	30.753924	77.830954
	Deoban	30.746140	77.850191
	Datmir	31.071054	78.287133
	Sela- Zang	27.490265	92.108937
108. *Taxus wallichiana*		33.429650	75.844174
		27.685558	88.730703
		27.497053	88.597336
		27.516567	88.657155
		27.420502	88.679680
	Jonghoo	27.509394	88.437867
		27.538422	88.401248
	Jaugloo	27.575743	88.455199
	Kumaon	29.409262	79.434876
	Tihri-Garhwal	30.706184	79.596218
	Simla	31.095155	77.272602
	Simla	31.117838	77.364210
		27.400752	88.634297
		27.436065	88.562977
		33.503345	75.801958
	Sandakaphu	27.343764	88.063256
	Mawphlang	27.280453	92.436939
	Singalila N. Park	27.112999	88.084441

CASE STUDY 1:
‘New’ species are not always new: A case study of *Ephedra sumlingensis* and *E. khurikensis* (Ephedraceae)

Introduction

Taxonomy, a discipline dealing with discovery, description, identification, naming and classification of the biological world, provides the basic scientific tools in documenting global biodiversty (Khuroo et al. 2007; Thiele et al. 2021; Holzer et al. 2021). Historically, and even today, discovery of new species has remained one of the primary research activity driving the discipline of taxonomy (Zachos 2018). In recent times, with rapid and rising rates of species extinctions, there has been an increased research focus towards discovery of new species (Costello et al. 2015; Connette et al. 2017). It is believed that speeding up the documentation of still unknown biodiversity is crucial in addressing the taxonomic impediment which is hindering our capacity to meet the global biodiversity goals (Valdecasas and Camacho 2003; Dar and Khuroo 2013; Dar and Khuroo 2020; Engel et al. 2021). At present, majority of the new species discovered are still based on morphological description with molecular and allied biological data serving as important supplementary sources (Islam et al. 2021; Lee et al. 2021; Skuhrovec et al. 2021). However, in the rush to speed up the discovery rate of new species, it is crucial to follow objective, stable and reproducible taxonomic criteria (Fraser-Jenkins 1997; Ickert-Bond and Renner 2016). New species’ descriptions based purely on subjective, unstable and non-reproducible characters can be cause of artificial taxonomic inflation in biodiversity data (Khuroo et al. 2007; Dar et al. 2012; Khuroo et al. 2012). The new species described following such unscientific subjective taxonomic practices can be cause of confusion rather than any tangible contribution towards better understanding of the global biodiversity (Ickert-Bond and Renner 2016). Recent revisionary studies adopting integrative taxonomic approaches (ITA) have highlighted the arbitrariness of such doubtful new species’ discoveries and drastically reduced the number of species previously known in many taxa, e.g., *Epidendrum* in Brazil, *Mesocriconema* in Vietnam, and *Ceratozamia* in Mexico (Martínez-Domínguez et al. 2017; Pessoa et al. 2021; Nguyen et al. 2021).

Like the afore-mentioned situation, several new species have been recently described in the genus *Ephedra* L. in India (Sharma and Uniyal 2008; Sharma et al. 2010; Sharma and Singh 2015; Sharma and Singh 2016). However, the validity of such new species’ discoveries in Indian *Ephedra* is debatable (Ickert-Bond and Renner 2016; Pessoa et al. 2021). In India, *Ephedra* grows in cold-arid regions of the Himalaya and hot-arid regions of Thar Desert (Rather et al. 2019; Meena et al. 2019). The recent discovery of its ten new taxa mostly described from the Western Himalaya has led to the

taxonomic inflation (Khuroo et al. 2007), and the genus is now considered as most diverse gymnosperm genus in India, (Sharma and Uniyal 2008; Sharma et al. 2010; Sharma and Singh 2015; Sharma and Singh 2016: Khuraijam and Mazumdar 2019). Such recently described species have created taxonomic confusions (Ickert-Bond and Renner 2016) and need detailed systematic scrutiny (Freitag and Maier-Stolte 2011). Using empirical evidences from multiple sources, here we critically evaluate the validity of two recently described new species of *Ephedra* in India (*E. sumlingensis* P. Sharma & P. L. Uniyal and *E. khurikensis* P. Sharma) to underscore that all ‘new’ species are not always new.

Materials and Methods

Herbarium specimens including the type specimens deposited in national and international herbaria of these two newly described species of genus *Ephedra* in India were studied in detail (Rather et al. 2021). Field surveys and sampling was carried out across the distributional belt of genus *Ephedra* in India from 2017-2019. Type localities of these two species: Sumling and Khurik, Himachal Pradesh (India) were physically visited to collect morphological and molecular samples. All the voucher specimens have been deposited in University of Kashmir herbarium (KASH). Morphological studies

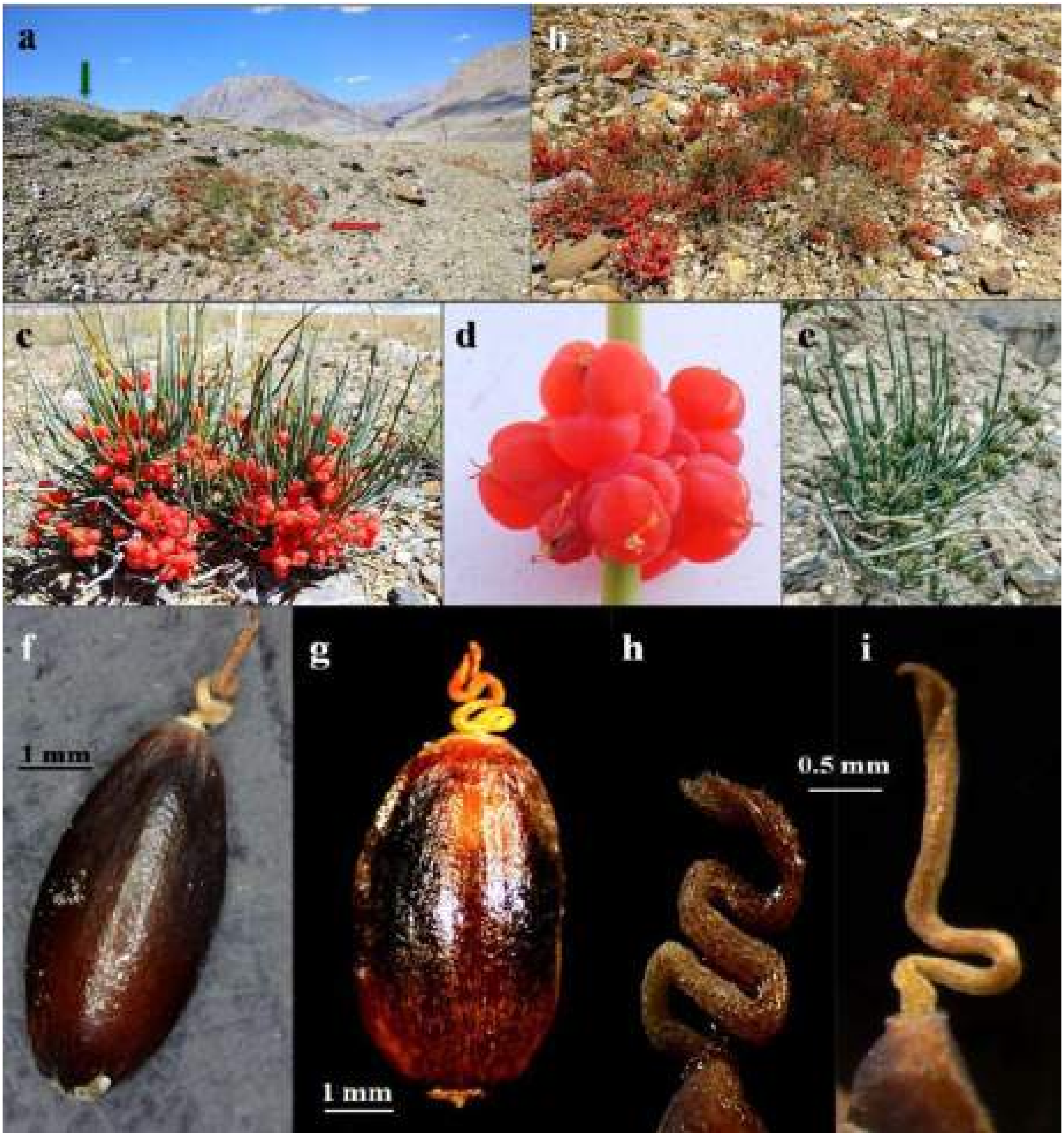

Fig.6: *Ephedra* species at type localities: a landscape view showing two species, i.e., *E. gerardiana* (green arrow) and *E. intermedia* (red arrow). Details of *E. intermedia*: b female plant with procumbent habit, c fruiting plant with old branches (yellow green) and young branches (silver green), d a bunch of fruits born on node, e female plant with old branches (light green) and young branches (dark green). Seed shape: f elliptical, g oval. Tubillus: h highly twisted, I fairly twisted

were carried out under stereozoom microscope (Leica S9D Germany) and smartphone integrated field microscope (Rather et al. 2020) and anatomical studies on compound microscope (Leica DM750 Germany). Morphometric analysis was carried to statistically validate discrimination of the studied taxa by integrating data from different taxonomic sources (morphology, anatomy and palynology) employing principal component analysis in VARSEDIG package in R environment (Guisande et al. 2019). Molecular studies were carried out using DNAsy Qiagen kit (Germany) for DNA extraction and amplification of internal transcribed spacers (ITS) and ribulose bisphosphate carboxylase (*rbc*L) markers. Bayesian Mr Bayes v.3.3.6-svn, r1040 X 64 (Ronquist et al. 2012), and Maximum Likelihood analyses using RaXML v. 1.8.18 (Stamatakis et al. 2014) were performed to analyze sequence data using the CIPRES science gateway platform (Miller et al. 2010).

Results & Discussion

The two species, i. e. *E. sumlingensis* and *E. khurikensis* have been delimited from *E. intermedia* from two adjacent localities, Sumling and Khurik respectively falling in Kaza area, Himachal Pradesh (India), which are not more than 1 km away from each other (Sharma and Uniyal 2008; Sharma et al. 2010). *Ephedra sumlingensis* has been delimited from *E. intermedia* by characters such as "brownish black stem bark, light green thin branchlets, bigger scale leaves with acute to acuminate apex, bigger stalked and narrowly elliptic male strobili having five pairs of flowers, bigger stalked female strobili having three pairs of bracts enclosing maroonish brown, elliptic seeds bearing twisted tubillus which used to get straight at the apex" (Sharma and Uniyal 2008). *Ephedra khurikensis* has been separated from *E. intermedia* by characters such as "brownish stem bark, green thin branchlets, smaller scale leaves with acute to acuminate apices, smaller stalked, elliptic male strobili having four pairs of flowers, and larger stalked female strobili having four pairs of bracts enclosing brown to black, elliptic seeds bearing twisted tubillus which are straight at the apex" (Sharma et al. 2010). Their descriptions and diagnoses heavily rely on straight vs. coiled tubillus, stalked vs. sessile strobili characters, colour of stem and bark which are of limited significance in *Ephedra* systematics (Freitag and Maier-Stolte 1993, 1994; Kakiuchi et al. 2011; Ickert-Bond and Renner 2016). For these two species, the type specimens mentioned in the protologue were found missing at Delhi University Herbarium (DUH), Botanical Survey of India, Dehradun (BSD) and Forest Research Institute (DD). However, detailed herbarium studies on the *Ephedra* collection at BSD, CNH, DD and IPUH revealed that the specimens collected from the type localities Sumling (IPUH01786-0223, 0224) and Khurik (BSD-100143, 109021, 109023) are typical *E. intermedia*. The additional specimens cited in *E. khurikensis* protologue (Himachal Pradesh, Khorangi-Pangi, alt. 7,000–9,000 ft., Aug 1891, Lace 1012 and Rowli, Chamba, alt. 8,300 ft, July 1919, Parker 21684 at DD) were also found to be typical *E. intermedia* on the basis of size of internode (3-6 cm long), seed size (4-6 mm long) and seed shape (oval-elliptical), which is substantiated by the earlier correct determination as *E. intermedia* Schrenk and C.A.Mey. by Florin in 1932 *E. intermedia* is distributed throughout Asia including north-western India and has high degree of phenotypically plastic characters (Stapf 1889; Freitag and Maier-Stolte 1993, 1994; Kakiuchi et al. 2011; Rather et al. 2019).

As mentioned above, despite our all the possible efforts, we failed to trace the type specimens. Therefore, to further authenticate our findings, we physically visited the type localities (Sumling and Khurik, Himachal Pradesh) to study the taxonomically important morphological characters of live specimens such as size and number of flowers in male strobili, number of bracts in female strobili, pollen grains shape and size, length and nature of tubillus, fruit colour, seed size and shape, internode length and other anatomical characters and to collect molecular samples. Comparison of the morphological characters of the live *Ephedra* specimens collected from Sumling (KASH-44649, 44650, 44678, 44714, 44817) and Khurik (KASH-44637, 44691, 44712 and 44816) with the protologue and type specimen of *E. intermedia* revealed that *E. sumlingensis* and *E. khurikensis* possess similar characters as *E. intermedia* such as internode length (3-6 cm long), leaf length (3-5 mm), tubillus length (3-5 mm long), seed shape and size (oval-elliptical, 4-6 × 2-3 mm wide), 4-8 pairs of flowers in male strobili. In addition, another species of Indian *Ephedra* (*E. gerardiana*) was also observed growing at both the localities (KASH-44628, 44662)**.** Critical examination of the live and herbarium specimens collected from Sumling and Khurik revealed that the so-called diagnostic characters such as stem bark (brownish black in *E. sumlingensis* and brownish in *E. khurikensis*), thin

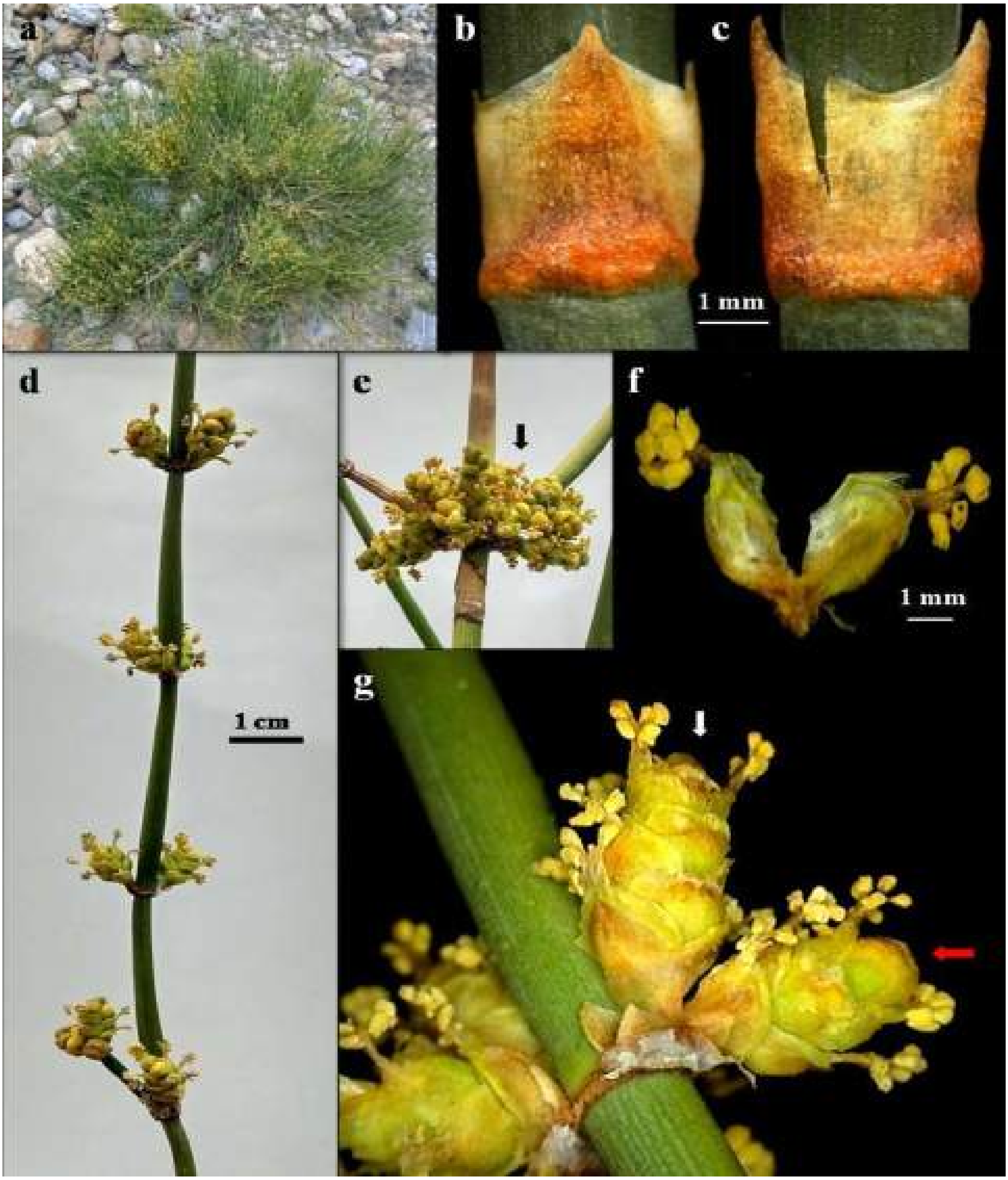

Fig.7: a Male plant of *Ephedra intermedia*

branchlets (light green in *E. sumlingensis* and green in *E. khurikensis*), and nature of strobili (bigger stalked in *E. sumlingensis* and smaller stalked in *E. khurikensis*) are highly plastic characters and vary even on the same individual plant and hence should be avoided for taxonomic delimitation in genus *Ephedra* (Freitag and Maier-Stolte 1993, 1994; Kakiuchi et al. 2011). same node. e Male strobili at node showing variation in number of flowers. f Male flower pair. g Male strobili borne on same side of node with 6 (white arrow) and 5 flower pairs (red arrow).

Additional characters used in the protologue such as leaves (2-4.5 mm long in *E. sumlingensis* and 3-3.5 mm long in *E. khurikensis*), male strobili (6-8 mm × 4-4.5 mm in *E. sumlingensis* having five pairs of flowers and 4 × 2.5 mm having four pairs of flowers in *E. khurikensis*), female strobili (6 × 4.5 mm having three pairs of bracts in *E. sumlingensis* and 9 × 5 mm having four pairs of bracts in *E. khurikensis*), seeds (maroonish brown, 4.5-5 × 2.5 mm in *E. sumlingensis* and brown to black 4 × 2 mm in *E. khurikensis*), and tubillus (1-3 mm long in *E. sumlingensis* and 2mm long in *E. khurikensis*) again represent typical characters of *E. intermedia* (Stapf 1889; Sharma and Uniyal 2008; Sharma et al. 2010).

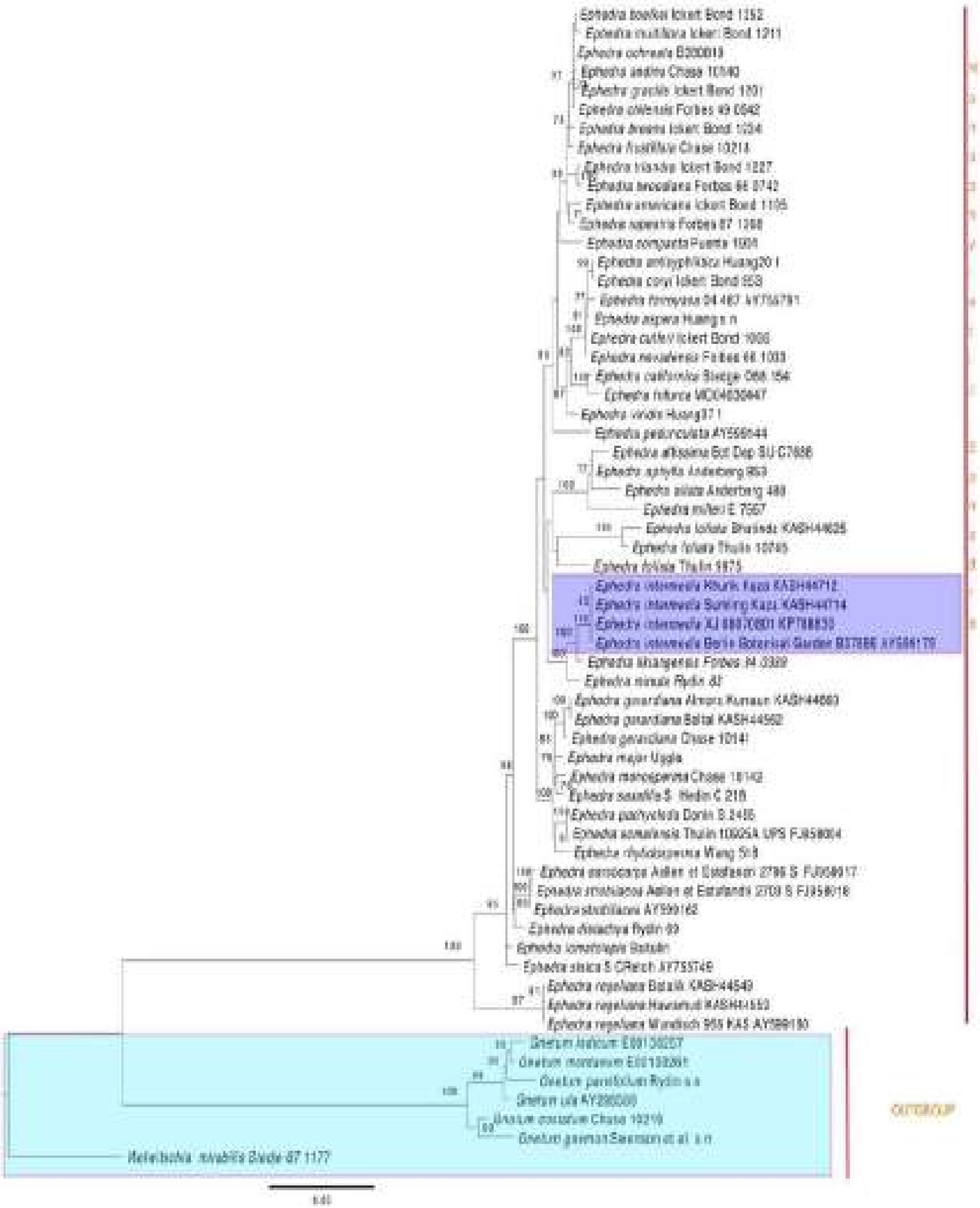

Fig.8: Maximum Likelihood tree inferred with RAxML from 61 sequences of the nrDNA ITS2 and cpDNA rbcL from 51 Ephedra species. Outgroups were based on Ickert-Bond & Renner (2016), and Rydin et al. (2021). RAxML bootstrap values ≥ 75% indicated above the branches and Bayesian osterior probability values ≥ 0.95 indicated below the branches. (In the tree, *Ephedra khurikensis* = *Ephedra intermedia* Khurik Kaza (KASH44712) and *Ephedra sumlingensis* = *Ephedra intermedia* Sumling Kaza (KASH44714)

Our detailed observation of live and herbarium specimens of the type localities (Sumling and Khurik) revealed that the elliptical to oval male strobili, ranging from 6-10 × 6-8 mm with 4-8 flower pairs contradicts with the male strobili range of 6-8 × 4-4.5 mm bearing five pairs of flowers mentioned in *E. sumlingensis* protologue, and 4 × 2.5 mm bearing four pairs of flowers in *E. khurikensis* protologue. Our results showed that the number of flowers in male strobili is inconsistent and the strobili with different flower numbers occurs even on the same node of the same plant**,** therefore the use of four and five flowers per male strobili used in delimitation of *E. khurikensis* and *E. sumlingensis,* respectively does not hold valid. While as leaf lengths 2-4.5 mm mentioned in *E. sumlingensis* and 3-3.5 mm in *E. khurikensis* protologues falls within the leaf range 3-5 mm observed in the live and herbarium specimens of the type localities. Similarly, the size of female strobili ranged from 6-9 × 3-5 mm as compared to poor taxonomic characterization based on single individual, i.e. 9 × 5 mm in *E. khurikensis* and 6 × 4.5 mm in *E. sumlingensis*. Our field observations revealed that the size of strobili depends upon the developmental stage of the plant: budding, flowering and dehiscence in case of male strobili whereas budding, flowering and fruiting in case of female strobili. The seeds were observed to fall within the range of 4-6 × 2.5-3 mm which contradicts with that in the protologues: 4.5-5 × 2.5 mm in *E. sumlingensis* and 4 × 2 mm in *E. khurikensis*. Tubillus length ranged from 3-5 mm which again contradicts with that of 1-3 mm mentioned in the protologue of *E. sumlingensis* and 2 mm in *E. khurikensis*. Our observations of the live material from the type localities revealed that larger vs. smaller and stalked vs. sessile strobili as used in delimitation of these two species are taxonomically poor characters because these characters can be borne on the same node of a single individual.

On comparing description with figure details provided in *E. sumlingensis* protologue, we found some major discrepancies. The male strobili in the description have been reported to be narrowly elliptic (6-8 × 4-4.5 mm) and seed size ranging from 4.5-5 mm in length, however we found that the male strobili were oval in shape (5 × 3 mm) and seeds 2.75 mm long in the figure 1, thereby reflecting clear discrepancy (Sharma and Uniyal 2008). In the protologue of *E. sumlingensis*, orange-coloured fruits have been illustrated in plate 1H but the description lacks such fruit characters. It is relevant to mention here that this orange colour fruit has been used as a diagnostic character in another recently described species, *Ephedra yangthangensis* Prabha Sharma & Rita Singh (Sharma and Singh 2016). Similarly, internode (3-6 cm long) and leaf length (3-5mm) in figure 2B of *E. khurikensis* protologue do not match with the description where internode length has been reported to be 2.5-3cm and leaf length 3-3.5mm. The size of the male and female branches in figure 2A and 2B of the protologue too vary with the description (Sharma et al. 2010). Wrongly, same scale bar has been used for different plant parts whether small (tubillus, leaf, antheriodiophore) or larger (strobili), thus creating confusion in measuring the actual size. For instance, the length of tubillus varies from 1 mm, 1.5 mm and 3.5 mm in the figures 2G, 2H and 2I, respectively, which clearly contradicts with the tubillus size (2 mm) stated in the description of the same protologue.

The Principal Component Analysis (PCA) of “continuous reproduction characters” based on the data surprisingly from a single population is statistically flawed (Sharma et al. 2010). In comparison, the PCA analysis of the morphological data collected during the present study from the type localities (Sumling and Khurik) revealed that both the newly described species (*E. sumlingensis* and *E. khurikensis*) clearly fall well within the cluster of *E. intermedia*. The molecular data (ITS and *rbc*L) also revealed that both these species cluster well within *E. intermedia* in the combined phylogram.

Therefore, based on extensive herbarium, field, morphological and molecular evidences, we recognize *E. sumlingensis* and *E. khurikensis* as new synonyms of *E. intermedia*. We also provide updated description of *E. intermedia* with photo illustrations and specimens examined.. The synonymy of *E. khurikensis* is also supported by the critical comments by Freitag and Maier-Stolte (2011) in *Systematic Botany*. Nikitin 1957 also described a couple of new species in early times from *E. intermedia* based on such phenotypically plastic characters which are now considered as synonyms.

Taxonomic treatment

Ephedra intermedia Schrenk and C. A. Mey. Bull. Cl. Phys. Math. Acad. Imp. Sci. Saint Pétersbourg 5: 35. 1845

Type: China. Province Balti, Skardo to Satpar valley (South of Skardo), 1856/09/02, Schlagintweit H.A.R. (Muséum National d'Histoire Naturelle (P00738833) = *Ephedra sumlingensis* P. Sharma and P. L. Uniyal ***Syn. nov***. = *Ephedra khurikensis* P. Sharma and P. L. Uniyal ***Syn. nov***.

Type: India: Himachal Pradesh, Spiti district, Sumling, 3000 m, 24.8.2007. Sharma and Uniyal DU (01786 - 0441) (holotype: DU; isotype: BSD and Herbarium DU, Department of Botany).

Type: India. Himachal Pradesh: Spiti district, Khurik, 2,800 m alt., 24 Aug 2007, P. Sharma and P. L. Uniyal 0416, (holotype: DU; isotype: BSD, DD, DU).

Description: An erect to procumbent, 30–200 cm tall, shrubs to sub-shrubs; branchlets light to dark green; bark pinkish gray to brownish black and longitudinally fissured and sheathed. Leaves scaly, ephemeral, 2–3 per node, 2–6 mm long with 60–80% connation. Male strobili 1–18 per node, ovoid to oblong, 6–12 × 6–8 mm, sessile to pedunculate, bimerous to trimerous; bracts opposite, decussate with 2–3 proximal sterile bract whorls and 4–8 fertile bract whorls. Female strobili 2–18, 6–9 × 3–5 mm, sessile to pedunculate, bimerous to trimerous, bracts opposite, decussate with 5–8 whorled sterile bracts and a single fertile bract whorl and rarely two at the top. Fruit fleshy, red or orange or yellow, sessile to sub-sessile, oblong to ovoid, 8–12 × 6–10 mm, distal most bract whorl 70–90% connate bearing 2 (rarely 1 or 3) seeds per fruit. Seed brown to black, oblong to ovoid, 4–6 × 2.5–3.5 mm; tubillus twisted to straight, 2.5–5 mm long.

Specimens examined: Pangi one way to Killard, June 1878, Herb. G. Watts 00550160 (E); Pangi Killar, 2 June 1878, Watt and George 00550156 (E); In the way to Sulgram, Chamba, 5 June 1878, Watt and George 00550161 (E); Shalai Simla, 21 April 1889, G. Watt 00550139 and 00550140 (E); Khorangipanji Bashahr, 22 August 1891, J.H. Lack 445750 (CNH); Khoranger to Pangi, 22 August 1891, Lace 1012 (DD); Khoranger to Pangi, 22 August 1891, Lace 00550157 (E); Pangi, Chamba, January 1919, A.N. Varkow 21685 (DD); Pooh Kinnaur, 24 July 1921, Forest ranger 57056 and 57057 (DD); Kahza, Spiti, Kangra, September 1933, Walter Koelz 2060656 (US); PWD Rest house Kinnaur, June 1972, K.P. Janardhanan 56916 and 56917 (BSD); Ralli, Dashala, Shimla, May 1972, Kartar Singh 6851 and 6852 (DD); Kiato Spiti, 29 July 1972, U.C. Battacharya 49085 (BSD); Samdho-khurik, September 2002, Dr. S. Singh 109021 (BSD); Tilling, Pin valley, 26 August 2002, K. Chandra Sekar 105903 (BSD); Ka village on the way to chilling, Spilo, October 2003, Dr. Rita Singh (01786) -0093 (IPUH); Pangi nala, 11 October 2003, Helmut Freitag *et al.*, 01786) -0089 (IPUH); Kinnaur. Sutej call., 0.5 km SW of Puh, August 2004, H. E. Freitag 2485392 (IH); Ka village, 31 August 2004, Helmut Freitag *et al.* (01786) -0214 and (01786) -0233 (IPUH); Leo, 31 August 2004, Helmut Freitag *et al.* (01786) -0213 (IPUH); Pooh, Kinnour, 31 August 2004, Helmut Freitag *et al.* (01786) -0231 (IPUH); Samdho Check post, Yangthang, 31 August 2004, Helmut Freitag *et al.* (01786) -0229 (IPUH); Kurith and Rothang, September 2004, Helmut Freitag *et al.* (01786) -0222 (IPUH); Pangi nala, 29 August 2004, Helmut Freitag *et al.* (01786) -0093, 203, 204, 205 and 206 (IPUH); Yangthang, 31 August 2004, Helmut Freitag *et al.* (01786) -0218, 234 and 238 (IPUH); Sumling, September 2004, Helmut Freitag *et al.* (01786) -0223 and 224 (IPUH); Yangthang to Pangi, 6 July 2018, Zubair and Anzar 44680 (KASH); Tabo Himachal Pradesh, 5 July 2018, Zubair and Anzar 44681 (KASH); Khurik Kaza, 5 July 2018, Zubair and Anzar 44687 and 44691 (KASH); Chango Spiti, 6 July 2018, Zubair and Anzar 44630 (KASH); Sumling Kaza, 5 July 2018, Zubair and Anzar 44649 and 44650 (KASH); Yangthang, 6 July 2018, Zubair and Anzar 44646 (KASH); Pooh Kinnour, 6 July 2018, Zubair and Anzar 44603 (KASH); Stingri Lahul, 3 July 2018, Zubair and Anzar 44604 and 44619 (KASH); Dhomkhar Kaza, 5 July 2018, Zubair and Anzar 44692 (KASH); Ka village Kinnaur, 6 July 2018, Zubair and Anzar 44710 (KASH); Yangthang, 14 September 2019, Zubair and Anzar 44653 (KASH); Panji nala Kinnour, 14 September 2019, Zubair and Anzar 44655 and 44656 (KASH); Yangthang Himachal Pradesh, 13 September 2019, Zubair and Anzar 44652 (KASH); Sumling Kaza, 13 September 2019, Zubair and Anzar 44629 and 44678 (KASH); Khurik Kaza, 5 July 2019, Zubair and Anzar 44637 (KASH); Yangthang Himachal Pradesh, 13 September 2019, Zubair and Anzar 44632 (KASH); Khurik Kaza 13, September 2019, Zubair and Anzar 44712 (KASH); Yangthang, 14 September 2019, Zubair and Anzar 44713 (KASH); Sumling Kaza, 13 September 2019, Zubair and Anzar 44714 (KASH).

Conclusions and looking ahead

To meet the global biodiversity goals, documentation of new species is a basic tool in combating species extinction and taxonomic impediment (Thiele et al. 2021; Holzer et al. 2021). World over, with twin challenges of climate change and biodiversity loss, proper species characterization by following standard taxonomic practices for new species discovery is of paramount importance (Gouda et al. 2020). Avoiding the pitfalls of using phenotypically plastic characters in species diagnosis should be first criterion strictly adhered by the authors, reviewers, journal editor, while discovering and describing new species (Krell 2004; Khuroo et al. 2007; Dar et al. 2012; Khuroo et al. 2012).

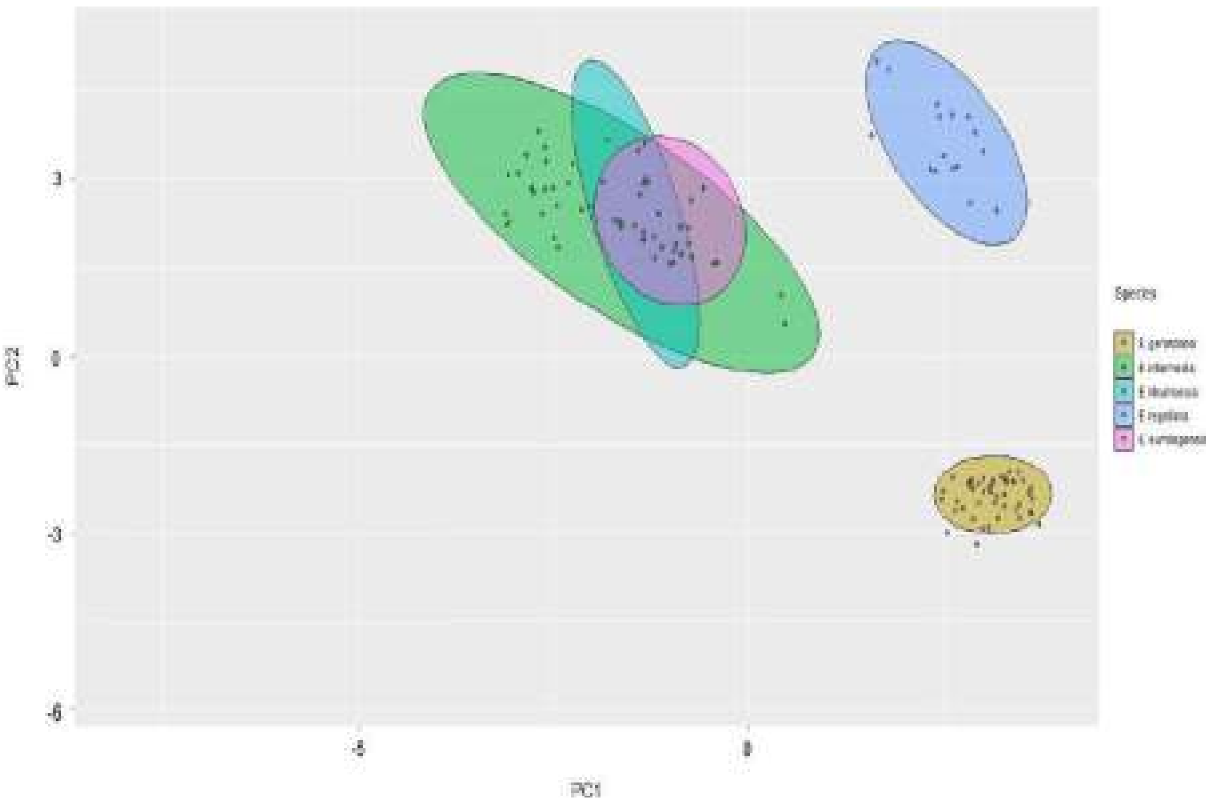

Fig. 9. Principal component analysis revealing clustering of *Ephedra sumlingensis* and *E. khurikensis* with *E. intermedia* and separation from other two co-occurring species

CASE STUDY 2:

A Brief Analysis of IUCN Red listed threatened Plants of India

The newest assessment of Indian plant richness stands at 54733 taxa which include 21849 angiosperms, 15504 fungi, 8979 algae, 2791 bryophytes, 2961 lichens, 1257 microbes, 1310 pteridophytes and 82 gymnosperms. Of these, the IUCN Red List for Indian plants includes 416 angiosperms, 12 gymnosperms, 2 pteridophytes, 7 bryophytes and 1 fungal species under various threat categories. In current communication, the authors discuss various IUCN threat categories and analyse in brief the Red listed threatened plants of India.
Key words: Biodiversity, Hotspots, Endemic, Endangered

In a time when anthropogenic activities, global climate changes, habitat destruction and species loss are on rise at an alarming rate, conservation policies play pivotal role towards curtailing biodiversity loss (Marchese, 2015). The idea of biodiversity or biological diversity has been known to humankind ever since he started to observe carefully the living things in its surroundings. The term biodiversity became a popular term to public only after the United Nations Conference on the Environment and Development (UNCED), also recognized as the 'Earth Summit' organized at Rio de Janeiro, Brazil, 3-14 June 1992. The Conference brought biodiversity to the forefront, and since then immense strees laid to save our earth planet and its biological diversity. Subsequently, many research organizations have adopted biodiversity as their central focus and countless agreements, strategies had been made to save the biodiversity. tremendous interest among scientists, policy makers, and general community in understanding the causes of loss of biodiversity. The main reason that stands behind the conservation is fear of graveyard consequences of biodiversity loss that can ultimately result into loss of benefits from nature, such as clean water and air, food and fiber and many other vital things (Reid et al., 2005). In this communication, the authors analyse in brief the threatened plants of India.

Red Listing at Global Level

Athreatened species is determined based on the amount of risk of extinction which it faces within a part or the whole of its geographic range. However, the concept of endangered species is a human idea andoften subjected to debate and varied interpretation. Many organizations practice variable criteria for listing a species as endangered. The most familiar and widely accepted organization is the International Union for Conservation of Nature (IUCN). This organization included members from both government and civil society organisations. It offers scientific knowledge and tools which are immensely helpful in conservation of biodiversity along with sustainable development. IUCN has developed an assessment system that prepares global Red List of threatened species. Now it is over more than five decades it has been continuously helping in nature conservation. The IUCN maintains the Thus, there is and Natural Resources.

IUCN Red List of Threatened Species, a comprehensive assessment of the prevailing risk of extinction of thousands of plant and animal species. The global IUCN Red List is updated on a regular basis and the latest version was released in 2020 as version 2020-2 (IUCN Red List, 2020). IUCN has 38 members from India and over 500 experts represented in the six IUCN Commissions. Initially, IUCN used to bring together the Red List but afterwards 1994 appropriate conservation and environmental organizations and expert networks are engaged in the assessment process through a rigorous process of data collection on certain criteria, validation of collected data, scoring, and assigning of Red List categories (IUCN Red List, 2020). The IUCN Red List of Threatened Species makes every effort to provide status reports for all species of organisms worldwide. Threatened species are assigned in to diverse classes based on the amount of threat of their disappearance. These classes depend on a number of conditions comprising health and distribution, drifts in population size, etc. IUCN has categorized them into the following nine groups: extinct, extinct in the wild, critically endangered, endangered, vulnerable, near threatened, least concern, data deficient, and not evaluated.

At present, there are more than 1,20,000 species are listed in the IUCN Red List, with more than 32,000 species exposed with elimination, including 41% of amphibians, 34% of conifers, 33% of reef building corals, 26% of mammals and 14% of birds (IUCN, 2020). The IUCN Red List includes over 43,000 plant species (IUCN, 2020); however, this constitutes a small portion of the world's documented plants. India is a country rich in biological diversity. Arecent assessment revealed that a total of 21, 849 species of angiosperms, 82 species of Gymnosperms, 1310 species of Pteridophytes, 15504 species of Fungi, 8979 species of Algae, 2791 species of Bryophytes, 2961 species of Lichens in India and 1257 species of microbes have been recorded till now from the India (Fig. 2) which account for approximated 14% of all plant species in the world (Mao et al., 2020). Of the above-mentioned plants of India, 416 angiosperms, 12 gymnosperms, 2 pteridophytes, 7 bryophytes and 1 fungal taxa have been red listed under various threat categories (Table 1, Fig. 3). Highest number of threatened plants in angiosperms is in family Rubiaceae (28) followed by Dipterocarpaceae (27), Fabaceae (26), Myrtaceae (26), Lauraceae (25), Orchidaceae (17), Eriocaulaceae (15), Phyllanthaceae (12), Annonaceae (11), Poaceae (11) and so on (Fig. 4). Two species namely, Corypha taliera Roxb. (Arecaceae) and Euphorbia mayuranathanii Croizat (Euphorbiaceae) has been listed as extinct in the Wild while six species namely, Madhuca insignis (Radlk.) H.J. Lam (Sapotaceae), Wendlandia angustifolia Wight ex Hook. f. (Rubiaceae), Sterculia khasiana Debb. ex Biswas (Malvaceae), Cynometra beddomei Prain (Fabaceae), Hopea shingkeng (Dunn) Bor (Dipterocarpaceae), Ilex gardneriana Wight (Aquifoliaceae) are categorised as Extinct (Table 1, Fig. 5). However, one of the species mentioned as extinct in IUCN Red List is collected by Dr. H.B. Naithani from Pashi Ghat, Arunachal Pradesh as per information provided by one Where the categories extinct, extinct in the wild, data deficient and not evaluated are self-explanatory, the other five categories are more subtle.

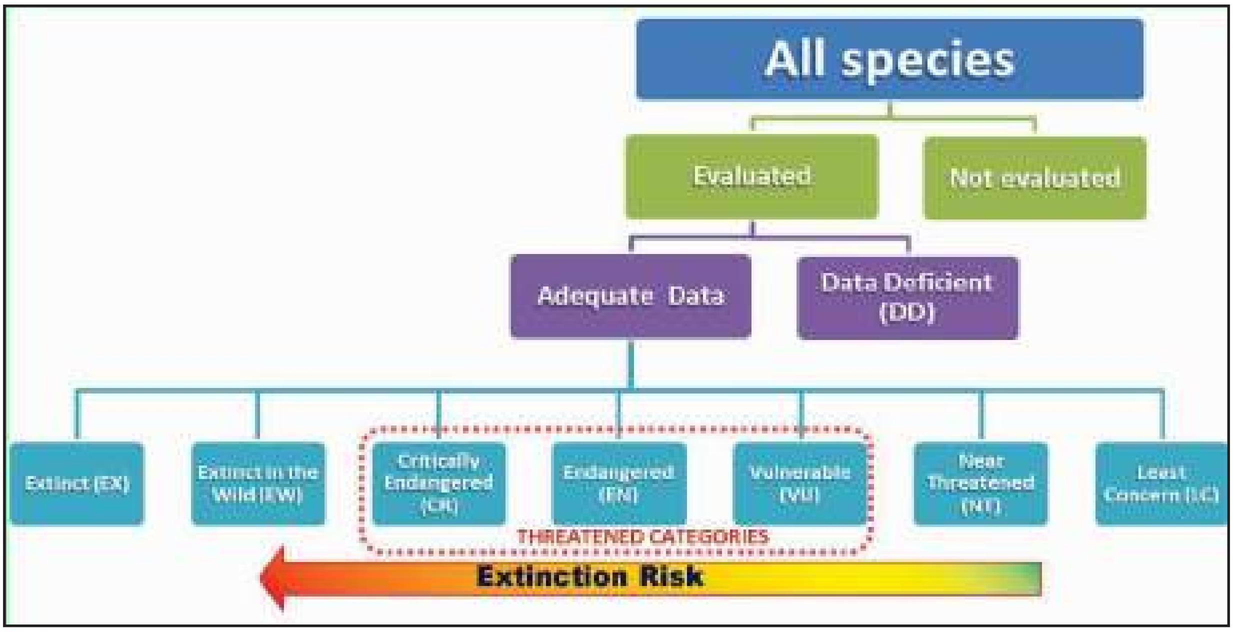

Fig. 10. IUCN Red List categories as per Version 3.1, IUCN (2001).

Table.2: Threatened plants of India as per list of Botanical Survey of India

S. No.	Scientific name	Geographic range in India	Family	Red list category	Red list criteria	Criteria version
1.	*Hygrophila madurensis* (N.P. Balakr. & Subram.) Karthik. & Moorthy	Nallakulam, Alagar Hills, Eastern Ghats, Madurai district, Tamil Nadu	Acanthaceae	CR	B1ab(ii,iii)+2ab(ii,iii); D	3.1
2.	*Nilgirianthus ciliatus* (Nees) Bremek.	Western Ghats from South Kanara to Travancore, Kerala	Acanthaceae	VU	A2cd	3.1
3.	*Hydnocarpus macrocarpus* (Bedd.) Warb.	Madras, Tamil Nadu	Achariaceae	VU	B1+2c	2.3
4.	*Hydnocarpus pentandrus* (Buch.-Ham.) Oken	Native range, South India	Achariaceae	VU	A2cd	3.1
5.	*Crinum malabaricum* Lekhak & S.R. Yadav	Periya village, Kasaragod, Kerala	Amaryllidaceae	CR	B1ab(iii,v)+2ab(iii,v)	3.1
6.	*Buchanania barberi* Gamble	Travancore, Kerala	Anacardiaceae	CR	B2ab(iii,v); D	3.1
7.	*Buchanania lanceolata* Wight	Quilon, Travancore, Kerala	Anacardiaceae	VU	B1+2c	2.3
8.	*Buchanania platyneura* Kurz	Andaman & Nicobar Islands	Anacardiaceae	VU	D2	2.3
9.	*Mangifera austroindica* Kosterm.	Native to Karnataka and Tamil Nadu	Anacardiaceae	EN	B2ab(iii)	3.1
10.	*Mangifera nicobarica* Kosterm.	Nicobar Islands	Anacardiaceae	EN	B1+2c	2.3
11.	*Nothopegia aureo-fulva* Bedd. ex Hook. f.	Tirunelveli Hills, Tamil Nadu	Anacardiaceae	CR	B1+2c	2.3
12.	*Nothopegia beddomei* var. *wynaadica* J.L. Ellis & V. Chandras.	Wayanad, Kerala	Anacardiaceae	EN	B1+2c	2.3
13.	*Nothopegia castaneifolia* (Roth) Ding Hou	SW. Maharashtra, NW. Karnataka	Anacardiaceae	CR	B1+2c	2.3
14.	*Goniothalamus rhynchantherus* Dunn	Trivandrum, Kerala & Tirunelveli, Tamil Nadu	Annonaceae	EN	B1+2c	2.3
15.	*Goniothalamus simonsii* Hook.f. & Thomson	Assam, Meghalaya	Annonaceae	EN	B1+2c	2.3
16.	*Miliusa nilagirica* Bedd.	Chembra peak, Kerela & Tamil Nadu	Annonaceae	VU	B1+2c	2.3
17.	*Mitrephora grandiflora* Bedd.	South Canara, Karanataka	Annonaceae	VU	B1+2c	2.3
18.	*Monoon shendurunii* (Basha & Sasidh.) B. Xue & R.M.K. Saunders	Kollam, Kerala	Annonaceae	EN	B1+2c	2.3
19.	*Orophea thomsonii* Bedd.	Tamil Nadu	Annonaceae	EN	B1+2c	2.3
20	*Orophea uniflora* Hook.f. & Thomson	Karnataka, Kerala, Tamil Nadu	Annonaceae	VU	B1+2c	2.3

S. No.	Scientific name	Geographic range in India	Family	Red list category	Red list criteria	Criteria version
21.	*Polyalthia rufescens* Hook.f. & Thomson	Kerala & Tamil Nadu	Annonaceae	EN	B1+2c	2.3
22.	*Popowia beddomeana* Hook.f. & Thomson	Kerala & Tamil Nadu	Annonaceae	EN	B1+2c	2.3
23.	*Pseuduvaria prainii* Merr.	Andaman & Nicobar Islands	Annonaceae	VU	B1+2c	2.3
24.	*Sageraea grandiflora* Dunn	Kerala	Annonaceae	EN	B1+2c	2.3
25.	*Angelica glauca* Edgew.	Himachal Pradesh, Jammu & Kashmir, Uttarakhand	Apiaceae	EN	A2cd	3.1
26.	*Hydrocotyle conferta* Wight	Nilgiri and Pulney Mountains, Tamil Nadu	Apiaceae	EN	B2ab(ii,iii)	3.1
27.	*Pimpinella tirupatiensis* N.P. Balakr. & Subram.	Andhra Pradesh	Apiaceae	EN	B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	3.1
28.	*Decalepis hamiltonii* Wight & Arn.	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu	Apocynaceae	EN	A2cd	3.1
29.	*Gymnema khandalense* Santapau	Andaman & Nicobar Islands, Assam, Goa, Kerala, Maharashtra, Tamil Nadu.	Apocynaceae	EN	B2ab(i,ii,iii)	3.1
30.	*Utleria salicifolia* Bedd. ex Hook.f.	Kerala, Tamil Nadu, Lakshadweep Islands.	Apocynaceae	CR	B2ab(ii,iii)	3.1
31.	*Aponogeton bruggenii* S.R. Yadav & Govekar	Nerurpar, west of Kudal, Sindhudurg, Maharashtra	Aponogetonaceae	VU	D2	3.1
32.	*Aponogeton satarensis* Sundararagh. & A.R. Kulk. & S.R. Yadav	Mhavashi, Satara, Maharashtra	Aponogetonaceae	EN	B1ab (ii,iii) + 2ab(ii,iii)	3.1
33.	*Ilex embelioides* Hook.f.	Khasi hills, Meghalaya	Aquifoliaceae	VU	B2ab(ii,iii,iv,v)	3.1
34.	*Ilex gardneriana* Wight	Sispara, Nilgiri, Tamil Nadu	Aquifoliaceae	Extinct		2.3
35.	*Ilex khasiana* C.S. Purkay.	Khasi hills, Meghalaya	Aquifoliaceae	CR	B1+2c, C2b, D	2.3
36.	*Ilex venulosa* Hook.f.	Khasi hills, Arunachal Pradesh	Aquifoliaceae	EN	B1+2c	2.3
37.	*Cryptocoryne cognata* Schott	Concan, Karnataka	Araceae	EN	B2ab(ii,iii)	3.1
38.	*Aralia malabarica* Bedd.	Kerala, Tamil Nadu	Araliaceae	VU	B1+2c	2.3
39.	*Schefflera bourdillonii* Gamble	Travancore Hills, Kerala	Araliaceae	EN	B1+2c	2.3
40.	*Arenga wightii* Griff	Karnataka, Kerala, Tamil Nadu	Arecaceae	VU	B1+2c	2.3
41.	*Bentinckia condapanna* Berry ex Roxb.	Kerala,Tamil Nadu (S Travancore & Tirunelveli Hills)	Arecaceae	VU	A1c	2.3
42.	*Bentinckia nicobarica* (Kurz) Becc.	Nicobar Islands	Arecaceae	EN	C2a	2.3
43.	*Corypha taliera* Roxb.	West Bengal	Arecaceae	Extinct in the Wild		2.3
44.	*Rhopaloblaste augusta* (Kurz) H.E. Moore	Northern group, Nicobar Islands	Arecaceae	VU	A1c	2.3
45.	*Chlorophytum borivilianum* Santapau & R.R. Fern.	Gujarat, Maharashtra	Asparagaceae	CR	A2cd	3.1
46.	*Anacyclus pyrethrum* (L.) Lag.	Naturalised in India But native to Mediterranean Europe and parts of North Africa.	Asteraceae	VU	A3cd; B2ab (i,ii,iii,iv,v)	3.1
47.	*Anaphalis beddomei* Hook. f.	Palani Hills, Tamil Nadu	Asteraceae	VU	B1ab (ii,iii)	3.1
48.	*Anaphalis leptophylla* DC.	Kerala, Tamil Nadu.	Asteraceae	VU	B2ab (ii,iii)	3.1
49.	*Anaphalis wightiana* DC.	Karnataka, Kerala, Tamil Nadu	Asteraceae	VU	B2ab (ii,iii)	3.1
50.	*Lamprachaenium microcephalum* Benth.	Maharashtra (Ahmednagar, Pune, Satara, Thane), Karnataka (Chikmagalur, Shimoga) & Goa	Asteraceae	EN	B1ab(iii)+2ab(iii)	3.1
51.	*Notonia shevaroyensis* Fyson	Shevaroy Hills, Salem, Tamil Nadu	Asteraceae	VU	B1ab(iii); D2	3.1
52.	*Saussurea costus* (Falc.) Lipsch.	Himachal Pradesh, Jammu & Kashmir Uttarakhand.	Asteraceae	CR	A2cd	3.1
53.	*Berberis nilghiriensis* Ahrendt	Nilgiri Hills, Tamil Nadu	Berberidaceae	CR	B1+2c	2.3
54.	*Boswellia ovalifoliolata* N.P. Balakr. & A.N. Henry	Andhra Pradesh	Burseraceae	VU	A2cd; B1ab(i,ii,iii)	3.1
55.	*Commiphora wightii* (Arn.) Bhandari	Gujarat, Karnataka, Madhya Pradesh, Rajasthan.	Burseraceae	CR	A2cd	3.1
56.	*Calophyllum apetalum* Willd.	Karnataka, Kerala, Maharashtra, Tamil Nadu.	Calophyllaceae	VU	A2cd	3.1
57.	*Mesua manii* (King) Kosterm.	South, Andaman Island	Calophyllaceae	CR	B1+2c	2.3
58.	*Capparis pachyphylla* M. Jacobs	Arunachal Pradesh, Manipur	Capparaceae	EN	B1+2c	2.3
59.	*Nardostachys jatamansi* (D. Don) DC.	Arunachal Pradesh, Jammu & Kashmir, Sikkim, Uttarakhand	Caprifoliaceae	CR	A2cd	3.1
60.	*Valeriana leschenaultii* DC.	Nilgiri Hills, Tamil Nadu	Caprifoliaceae	CR	B2ab(iii)	3.1
61.	*Euonymus angulatus* Wight	Karnataka (Coorg) Kerala (Palghat Dt) Tamil Nadu (Nilgiri Hills)	Celastraceae	VU	B1+2c	2.3
62.	*Euonymus assamicus* Blakelock	Delei Valley, Assam	Celastraceae	EN	B1+2c	2.3

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63.	*Euonymus paniculatus* Wight ex M.A. Lawson	Tamil Nadu	Celastraceae	EN	B1+2c	2.3
64.	*Euonymus serratifolius* Bedd.	Tamil Nadu	Celastraceae	EN	B1+2c	2.3
65.	*Glyptopetalum lawsonii* Gamble	Tamil Nadu	Celastraceae	VU	B1+2c	2.3
66.	*Microtropis densiflora* Wight	Southern Western Ghats, Idukki, Kerala	Celastraceae	EN	B1+2c	2.3
67.	*Salacia oblonga* Wall.	Andhra Pradesh, Goa, Karnataka, Maharashtra, Tamil Nadu.	Celastraceae	VU	A2cd	3.1
68.	*Atuna indica* (Bedd.) Kosterm.	Tamil Nadu	Chrysobalanaceae	EN	B1+2c	2.3
69.	*Atuna travancorica* (Bedd.) Kosterm.	Travancore, Tamil Nadu	Chrysobalanaceae	EN	B1+2c	2.3
70.	*Agasthiyamalaia pauciflora* (Bedd.) S. Rajkumar & Janarth.	Tamil Nadu	Clusiaceae	CR	B1+2c	2.3
71.	*Garcinia cadelliana* King	Andaman Islands	Clusiaceae	CR	B1+2c	2.3
72.	*Garcinia imberti* Bourd.	Kerala	Clusiaceae	EN	B1+2c	2.3
73	*Garcinia indica* (Thouars) Choisy	Karnataka; Kerala (Wynaad)	Clusiaceae	VU	A2cd	3.1
74.	*Garcinia kingii* Pierre ex Vesque	Andaman Islands	Clusiaceae	EN	B1+2c	2.3
75.	*Garcinia rubro-echinata* Kosterm.	Kerala, Tamil Nadu	Clusiaceae	VU	B1+2c	2.3
76.	*Garcinia travancorica* Bedd.	Travancore, Tamil Nadu; Kerala	Clusiaceae	VU	B1+2c	2.3
77.	*Garcinia wightii* T. Anderson	Kerala, Tamil Nadu	Clusiaceae	VU	B1+2c	2.3
78.	*Iphigenia stellata* Blatt.	Satara & Kolhapur, Maharashtra	Colchicaceae	EN	B2ab(i,ii,iii,v)	3.1
79.	*Terminalia pallida* Brandis	Andhra Pradesh	Combretaceae	VU	A2cd	3.1
80.	*Murdannia lanceolata* (Wight) Kammathy	Kerala, Tamil Nadu	Commelinaceae	VU	D2	3.1
81.	*Fimbristylis crystallina* Govind.	Tamil Nadu	Cyperaceae	EN	B2ab(iii)	3.1
82.	*Fimbristylis dauciformis* Govind.	Karnataka, Kerala, Maharashtra	Cyperaceae	EN	B2ab(i,ii,iii)	3.1
83.	*Fimbristylis hirsutifolia* Govind.	Kerala	Cyperaceae	CR	B1ab(i,ii,iii)+2ab(i,ii,iii)	3.1
84.	*Fuirena swamyi* Govind.	Kerala, Tamil Nadu	Cyperaceae	VU	D2	3.1
85.	*Kyllinga pluristaminea* Govind. & Ramani	Thuvanam, Madurai, Tamil Nadu	Cyperaceae	EN	B1ab(iii)+2ab(iii)	3.1
86.	*Dipterocarpus alatus* Roxb. ex G. Don	Andaman Islands, West Bengal	Dipterocarpaceae	VU	A2cd	3.1
87.	*Dipterocarpus bourdillonii* Brandis	Tamil Nadu, Karnataka, Kerala	Dipterocarpaceae	CR	A1cd+2cd, B1+2c	2.3
88.	*Dipterocarpus costatus* C.F. Gaertn.	Andaman Islands & Tripura	Dipterocarpaceae	VU	A2cd	3.1
89.	*Dipterocarpus gracilis* Blume	Andaman Islands & Assam	Dipterocarpaceae	VU	A2cd	3.1
90.	*Dipterocarpus grandiflorus* Blanco	Andaman Islands	Dipterocarpaceae	EN	A2cd	3.1
91.	*Dipterocarpus hasseltii* Blume	Andaman Islands	Dipterocarpaceae	EN	A2cd	3.1
92.	*Dipterocarpus indicus* Bedd.	Kerala, Tamil Nadu, Karnataka	Dipterocarpaceae	EN	A1cd+2cd, B1+2c	2.3
93.	*Dipterocarpus kerrii* King	Andaman Islands	Dipterocarpaceae	EN	A2cd	3.1
94.	*Dipterocarpus retusus* Blume	Assam, Nagaland, Arunachal Pradesh	Dipterocarpaceae	EN	A2cd	3.1
95.	*Dipterocarpus turbinatus* Gaertn.	Andaman Islands	Dipterocarpaceae	VU	A2cd	3.1
96.	*Hopea canarensis* Hole	Karnataka	Dipterocarpaceae	EN	B1ab(i,iii,v)	3.1
97.	*Hopea erosa* (Bedd.) Slooten	Tamil Nadu	Dipterocarpaceae	CR	A1d+2d, B1+2e, C1, D	2.3
98.	*Hopea glabra* Wight & Arn.	Tamil Nadu, Kerala, Karnataka	Dipterocarpaceae	EN	A1cd+2cd	2.3
99.	*Hopea helferi* Brandis	Andaman Islands	Dipterocarpaceae	EN	A2cd	3.1
100.	*Hopea jacobi* C.E.C. Fisch.	Coorg, Karnataka	Dipterocarpaceae	CR	B1+2c, C1, D	2.3
101	*Hopea odorata* Roxb.	West Bengal, Andaman Islands	Dipterocarpaceae	VU	A2cd	3.1
102	*Hopea ponga* (Dennst.) Mabb.	Tamil Nadu, Kerala, Karnataka, Goa, Maharashtra	Dipterocarpaceae	EN	A1cd+2cd, B1+2c	2.3
103	*Hopea racophloea* Dyer	Kerala, Karnataka	Dipterocarpaceae	EN	A1cd+2cd, B1+2c	2.3
104.	*Hopea shingkeng* (Dunn) Bor	Arunachal Pradesh	Dipterocarpaceae	Extinct		2.3
105.	*Hopea utilis* (Bedd.) Bole	Tamil Nadu, Kerala	Dipterocarpaceae	EN	C2a, D	2.3
106.	*Shorea assamica* Dyer	Assam, Arunachal Pradesh, Nagaland	Dipterocarpaceae	CR	A1cd, B1+2c	2.3
107.	*Shorea roxburghii* G. Don	Andhra Pradesh, Karnataka, Tamil Nadu	Dipterocarpaceae	VU	A2cd	3.1
108.	*Shorea tumbuggaia* Roxb.	Tamil Nadu, Andhra Pradesh	Dipterocarpaceae	EN	B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	3.1
109.	*Vateria indica* L.	Kerala, Karnataka, Tamil Nadu, Maharashtra	Dipterocarpaceae	CR	A1cd	2.3
110.	*Vateria macrocarpa* B.L. Gupta	Kerala	Dipterocarpaceae	CR	A1cd, D	2.3
111.	*Vatica chinensis* L.	Kerala, Karnataka	Dipterocarpaceae	CR	A1cd, C2a	2.3
112.	*Vatica lanceaefolia* Blume	Nagaland, Arunachal Pradesh, Assam	Dipterocarpaceae	CR	A1cd, C2a	2.3
113.	*Aldrovanda vesiculosa* L.	Manipur, West Bengal	Droseraceae	EN	B2ab (iii,v)	3.1
114.	*Diospyros atrata* (Thwaites) Alston	Tamil Nadu, Kerala	Ebenaceae	VU	B1+2c	2.3
115.	*Diospyros barberi* Ramaswami	Tamil Nadu, Kerala	Ebenaceae	VU	B1+2c	2.3
116.	*Diospyros candolleana* Thwaites	Andhra Pradesh, Goa, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu	Ebenaceae	VU	A2cd	3.1

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117.	*Diospyros crumenata* Thwaites	Andaman & Nicobar Islands, Karnataka, Maharashtra, Tamil Nadu	Ebenaceae	EN	B1+2c	2.3
118.	*Diospyros paniculata* Dalzell	Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu	Ebenaceae	VU	A2cd	3.1
119.	*Diospyros trichophylla* Alston	Andaman & Nicobar Islands, Karnataka, Kerala	Ebenaceae	VU	A1c, B1+2c	2.3
120.	*Elaeagnus conferta* subsp. *dendroidea* (Schltdl.) Servett.	Meghalaya	Elaeagnaceae	CR	B1+2c	2.3
121.	*Elaeocarpus blascoi* Weibel	Tamil Nadu	Elaeocarpaceae	EN	B1+2c	2.3
122.	*Elaeocarpus gaussenii* Weibel	Tamil Nadu	Elaeocarpaceae	CR	B1+2c	2.3
123.	*Elaeocarpus prunifolius* (Müll.Berol.) Wall. ex Mast.	Meghalaya, Manipur	Elaeocarpaceae	VU	B1+2c	2.3
124.	*Elaeocarpus recurvatus* Corner	Tamil Nadu	Elaeocarpaceae	VU	B1+2c	2.3
125.	*Elaeocarpus venustus* Bedd.	Tamil Nadu, Kerala	Elaeocarpaceae	VU	B1+2c	2.3
126.	*Rhododendron dalhousieae* var. *rhabdotum* (Balf. f. & R.E. Cooper) Cullen	Arunachal Pradesh	Ericaceae	VU	B1+2c	2.3
127.	*Rhododendron subansiriense* D.F. Chamb. & Pet.A. Cox	Arunachal Pradesh	Ericaceae	VU	D2	2.3
128.	*Rhododendron wattii* Cowan	Manipur	Ericaceae	VU	D2	2.3
129.	*Eriocaulon anshiense* Punekar & Malpure & Lakshmin	Goa, Karnataka	Eriocaulaceae	EN	B1ab(iii)+2ab(iii)	3.1
130.	*Eriocaulon bolei* Bole & M.R. Almeida	Satara (Mahabaleshwar), Maharashtra	Eriocaulaceae	CR	B1ab(i,iii)+2ab(i,iii)	3.1
131.	*Eriocaulon dalzellii* Körn.	Goa, Maharashtra, Karnataka	Eriocaulaceae	EN	B1ab(ii,iii)+2ab(ii,iii)	3.1
132.	*Eriocaulon karnatakense* S.P. Gaikwad & Sardesai & U.S. Yadav & S.R.Yadav	Kemmangundi hills, Karnataka	Eriocaulaceae	VU	D2	3.1
133.	*Eriocaulon kolhapurense* S.P. Gaikwad & Sardesai & S.R. Yadav	Rangna fort, Kolhapur, Maharashtra	Eriocaulaceae	VU	D2	3.1
134.	*Eriocaulon konkanense* Punekar & Malpure & Lakshmin	Ratnagiri, Maharashtra	Eriocaulaceae	VU	D2	3.1
135.	*Eriocaulon maharashtrense* Punekar & Lakshmin.	Nive village, Mulshi, Pune, Maharashtra	Eriocaulaceae	VU	D2	3.1
136.	*Eriocaulon pectinatum* Ruhland	Kerala (Anaimudi, Idukki; Periyar Tiger Reserve and Tamil Nadu (Nilgiri, Kodaikanal and Palani hills)	Eriocaulaceae	VU	B1ab(iii)+2ab(iii)	3.1
137.	*Eriocaulon ratnagiricum* S.R. Yadav & S.P. Gaikwad & Sardesai	Dharmashala, Ratnagiri, Maharashtra	Eriocaulaceae	CR	B1ab(ii,iii,v)+2ab(ii,iii,v)	3.1
138.	*Eriocaulon richardianum* (Fyson) R. Ansari & N.P. Balakr.	Western Ghats of Karnataka and Kerala	Eriocaulaceae	EN	B2ab(ii,iii)	3.1
139.	*Eriocaulon rouxianum* Steud.	Bombay and Nasik, Maharashtra	Eriocaulaceae	CR	B1ab(ii,iii)+2ab(ii,iii)	3.1
140.	*Eriocaulon santapaui* Moldenke	Khandala, Pune, Maharashtra	Eriocaulaceae	CR	B1ab(iii)+2ab(iii)	3.1
141.	*Eriocaulon sharmae* R. Ansari & N.P. Balakr.	Amboli, Sindhudurg, Maharashtra	Eriocaulaceae	CR	B1ab(iii)+2ab(iii)	3.1
142.	*Eriocaulon sivarajanii* R. Ansari & N.P. Balakr.	Kozhikode, Kerala	Eriocaulaceae	CR	B1ab(iii)+2ab(iii)	3.1
143.	*Eriocaulon tuberiferum* A.R. Kulk. & Desai	Satara and Kolhapur, Maharashtra State	Eriocaulaceae	VU	B1ab(ii,iii)+2ab(ii,iii); D2	3.1
144.	*Croton lawianus* Nimmo	Bababudan range, Karanataka	Euphorbiaceae	CR	B1+2c	2.3
145.	*Tritaxis beddomei* Benth.	[= *Dimorphocalyx beddomei* (Benth.) Airy Shaw] Kerala, Tamil Nadu	Euphorbiaceae	EN	B1+2c	2.3
146.	*Euphorbia epiphylloides* Kurz	Andaman Islands	Euphorbiaceae	EN	C2a, D	2.3
147.	*Euphorbia mayuranathanii* Croizat	Palghat Gap, Western Ghats between Tamil Nadu and Kerala.	Euphorbiaceae	Extinct in the Wild		2.3
148	*Euphorbia santapaui* A.N. Henry	Mt. Agasthya on the Kerala-Tamil Nadu border	Euphorbiaceae	EN	B1+2cd	2.3
149.	*Euphorbia vajravelui* Binojk. & N.P. Balakr.	Kalakkad Forest, Kodyar, Sirumalai and Highways, Tamil Nadu	Euphorbiaceae	VU	D2	2.3
150.	*Jatropha nana* Dalzell & A. Gibson	Bihar, Jharkand, Maharashtra, West Bengal	Euphorbiaceae	VU	B2ab(iii,v)	3.1
151.	*Koilodepas calycinum* Bedd.	Tamil Nadu	Euphorbiaceae	EN	B1+2c	2.3
152.	*Mallotus atrovirens* Müll. Arg.	Western Ghats, Tamil Nadu	Euphorbiaceae	VU	B1+2c	2.3
153.	*Vachellia campbellii* (Arn.) A.Desghp. & Maslin [=*Acacia campbellii* Arn.]	Andhra Pradesh	Fabaceae	VU	A1cd	2.3

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154.	*Chamaecrista kolabensis* (Kothari & Moorthy & M.P. Nayar) V.Singh	Raigad, Maharashtra	Fabaceae	EN	B1ab(iii)	3.1
155.	*Crudia balachandrae* Sanjappa	Great Nicobar Island	Fabaceae	VU	D2	2.3
156.	*Cynometra beddomei* Prain	Western Ghats, Karnataka and Kerala.	Fabaceae	Extinct		2.3
157	*Cynometra bourdillonii* Gamble	South Kanara, Karnataka and Agastyamalai range, Kerala.	Fabaceae	EN	B1+2c	2.3
158.	*Cynometra travancorica* Bedd.	Karnataka (Sollekallu,Chikmagalur) Kerala (Palghat), Tamil Nadu (Travancore range)	Fabaceae	EN	B1+2c	2.3
159.	*Dalbergia congesta* Graham ex Wight & Arn.	Endemic to the Nilgiri Hills of the south western Ghats	Fabaceae	EN	B1ab(iii)	3.1
160.	*Dalbergia latifolia* Roxb.	Andhra Pradesh, Karnataka, Sikkim, Tamil Nadu, Uttar Pradesh	Fabaceae	VU	A1cd	2.3
161.	*Dialium travancoricum* Bourd.	Ponmudi and Ariankavu, Kerala	Fabaceae	CR	B1+2c	2.3
162.	*Eleiotis rottleri* Wight & Arn.	Karnataka, Maharashtra	Fabaceae	VU	B1ab(iii)	3.1
163.	*Gleditsia assamica* Bor	Aka Hills, Naga Hills and Garo Hills	Fabaceae	VU	B1+2c	2.3
164.	*Gymnocladus assamicus* Kanjilal ex P.C. Kanjilal	Northeast India (West Kameng, Arunachal Pradesh and Nagaland)	Fabaceae	CR	A2cd	3.1
165.	*Humboldtia bourdillonii* Prain	Kerala, Tamil Nadu (Peermade and Courtallum at the southern end of the Western Ghats)	Fabaceae	EN	B1+2c	2.3
166.	*Humboldtia laurifolia* Vahl	Western Ghats, Kerala	Fabaceae	VU	A1c, B1+2cd	2.3
167.	*Humboldtia unijuga* var. *trijuga* J. Joseph & V.Chandras.	Travancore range, Kerala	Fabaceae	CR	B1+2c	2.3
168.	*Humboldtia unijuga* var. *unijuga* Bedd.	Travancore range, Kerala and Tamil Nadu	Fabaceae	EN	B1+2c	2.3
169.	*Humboldtia vahliana* Wight	Tamil Nadu (Nilgiri and Tirunelveli. Kerala (Malabar region, Pathanamthitta and Thrissur)	Fabaceae	EN	B2ab(i,ii,iii,v)	3.1
170.	*Intsia bijuga* (Colebr.) Kuntze	Andaman & Nicobar Islands, Odisha, West Bengal.	Fabaceae	VU	A1cd	2.3
171.	*Kingiodendron pinnatum* (Roxb. ex DC.) Harms	Karnataka (South Kanara) and Tamil Nadu (southern tip of the Western Ghats)	Fabaceae	EN	A1cd	2.3
172.	*Pithecellobium gracile* Bedd.	Kerala	Fabaceae	VU	B1+2c	2.3
173.	*Pterocarpus dalbergioides* Roxb.	Andaman Islands	Fabaceae	VU	A2d	3.1
174.	*Pterocarpus indicus* Willd.	Maharashtra, Tamil Nadu, West Bengal	Fabaceae	EN	A3cd+4cd	3.1
175.	*Rhynchosia heynei* Wight & Arn.	Endemic to peninsular India (Andhra Pradesh, Karnataka and Tamil Nadu).	Fabaceae	VU	B2ab(iii)	3.1
176.	*Saraca asoca* (Roxb.) W.J.de Wilde	South and central Western Ghats	Fabaceae	VU	B1+2c	2.3
177.	*Sesbania speciosa* Taub. ex Engl.	Peninsular India	Fabaceae	VU	B2ab(iii)	3.1
178.	*Sophora wightii* Baker	North of the Nilgiris, Tamil Nadu	Fabaceae	EN	B1+2c	2.3
179.	*Tephrosia jamnagarensis* Santapau	Jamnagar and Junagadh, Gujarat	Fabaceae	EN	B1ab(i,ii,iv)+2ab(i,ii,iv)	3.1
180.	*Gentiana kurroo* Royle	Himachal Pradesh, Jammu-Kashmir, Uttarakhand	Gentianaceae	CR	A2cd	3.1
181.	*Halophila beccarii* Asch.	Kerala, Tamil Nadu, throughout Bay of Bengal	Hydrocharitaceae	VU	B2ab(iii)c(ii,iii)	3.1
182.	*Ixonanthes khasiana* Hook.f.	Meghalaya (Syreyngam, Khasi, Jaintea Hills), Assam (Bhutan Hill)	Ixonanthaceae	VU	B1+2c	2.3
183.	*Actinodaphne bourneae* Gamble	Palani Hills, Kodaikanal, Tamil Nadu	Lauraceae	EN	B1+2c	2.3
184.	*Actinodaphne campanulata* Hook.f. subsp. *campanulata*	Tamil Nadu (Agastyamalai range in Tirunelveli Hills and Elamalai)	Lauraceae	VU	B1+2c	2.3
185.	*Actinodaphne campanulata* var. *obtusa* Gambel	Agastyamalai Hills, Travancore, Kerala	Lauraceae	EN	B1+2c	2.3
186.	*Actinodaphne lanata* Meisn.	Nilgiri Hills, Tamil Nadu	Lauraceae	CR	B1+2c	2.3
187.	*Actinodaphne lawsonii* Gamble	Tamil Nadu (Nilgiris), Karnataka (South Kanara, Anamalai range)	Lauraceae	VU	B1+2c	2.3
188.	*Actinodaphne salicina* Meisn.	Tamil Nadu (Nilgiri Hills), Kerala (Travancore range)	Lauraceae	EN	B1+2c	2.3
189.	*Cinnamomum chemungianum* M. Mohanan & A.N. Henry	Chemungi Hills, Thiruvananthapuram, Kerala	Lauraceae	CR	D	3.1
190.	*Cinnamomum filipedicellatum* Kosterm.	Kerala, Tamil Nadu	Lauraceae	EN	B1+2c	2.3
191.	*Cinnamomum gamblei* Geethakum. & Deepu & Pandur.	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Lauraceae	EN	C2a(i)	3.1

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192.	*Cinnamomum macrocarpum* Hook.f.	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Lauraceae	VU	A2cd	3.1
193.	*Cinnamomum perrottetii* Meisn.	Nilgiri Hills and the Anaimalai range in Kerala and Tamil Nadu	Lauraceae	VU	B1+2c	2.3
194.	*Cinnamomum riparium* Gamble	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Lauraceae	VU	B1+2c	2.3
195.	*Cinnamomum sulphuratum* Nees	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Lauraceae	VU	A2cd	3.1
196.	*Cinnamomum walaiwarense* Kosterm.	Tamil Nadu (Tinnevelly), Kerala (Idukki)	Lauraceae	CR	B1+2c	2.3
197.	*Cinnamomum wightii* Meisn.	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Lauraceae	EN	B1ab(i,ii,iii,iv)	3.1
198.	*Cryptocarya anamalayana* Gamble	Kerala, Tamil Nadu	Lauraceae	EN	B1+2c	2.3
199.	*Cryptocarya beddomei* Gamble	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Lauraceae	VU	B1+2c	2.3
200.	*Cryptocarya ferrarsi* King ex Hook.f.	Middle Andaman Island	Lauraceae	CR	B1+2c	2.3
201.	*Cryptocarya stocksii* Meisn.	Karnataka (Bababudan), Tamil Nadu (Agastyamalai Hills), Kerala (Tamancore Hills)	Lauraceae	VU	B1+2c	2.3
202.	*Litsea beddomei* Hook.f.	Kerala, Tamil Nadu	Lauraceae	EN	B1+2c	2.3
203.	*Litsea leiantha* Hook.f.	South Andaman Island	Lauraceae	EN	B1+2c	2.3
204.	*Litsea ligustrina* (Nees) Fern.-Vill.	Kerala, Tamil Nadu	Lauraceae	VU	B1+2c	2.3
205.	*Litsea nigrescens* Gamble	Kerala, Tamil Nadu	Lauraceae	EN	B1+2c	2.3
206.	*Litsea travancorica* Gamble	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Lauraceae	EN	B1+2c	2.3
207.	*Neolitsea fischeri* Gamble	Kerala (Anamalai and Palni Hills, Idukki), Tamil Nadu (Coimbatore and Nilgiri)	Lauraceae	VU	B1+2c	2.3
208.	*Utricularia albocaerulea* Dalzell	Maharashtra (Satara: Panchgani and Mahabaleshwar; Kolhapur; Sindhudurg)	Lentibulariaceae	VU	B1ab(i,ii,iii)+2ab(i,ii,iii)	3.1
209.	*Utricularia cecilii* P. Taylor	Karnataka (Kulshekar, Mangalore), Kerala (Beemanadi, Periya, Mullariya, Kasaragod)	Lentibulariaceae	EN	B1ab(i,ii,iii)+2ab(i,ii,iii)	3.1
210.	*Utricularia wightiana* P. Taylor	Tamil Nadu (Nilgiri and Kodaikanal hills), Kerala (Attapadi hills)	Lentibulariaceae	VU	B1ab(iii)	3.1
211.	*Lilium polyphyllum* D. Don	Jammu and Kashmir, Himachal Pradesh and Uttarakhand	Liliaceae	CR	A2cd	3.1
212.	*Lindernia manilaliana* Sivar.	Kerala	Linderniaceae	EN	B1ab(ii,iii)	3.1
213.	*Lindernia minima* (Benth.) Mukerjee	Chengalpattu and Tirunelveli, Tamil Nadu	Linderniaceae	EN	B1ab(ii,iii,v)+2ab(ii,iii,v)	3.1
214.	*Ammannia nagpurensis* T. Mathew & M.P. Nayar	Nagpur, Maharashtra	Lythraceae	EN	B1ab (ii, iii) + 2ab(ii,iii)	3.1
215.	*Lagerstroemia minuticarpa* Debberm. Ex P.C. Kanjilal	Assam (Kerempani), Sikkim (Singtam)	Lythraceae	EN	B1+2c	2.3
216.	*Rotala cookii* K.T. Joseph & Sivar.	Ernakulam and Mallapuram, Kerala	Lythraceae	EN	B1ab(i,iii)+2ab(i,iii)	3.1
217.	*Rotala floribunda* Koehne	Ratnagiri, Satara and Kolhapur, Maharashtra	Lythraceae	VU	B1ab(iii)+2ab(iii)	3.1
218.	*Rotala malabarica* Pradeep & K.T. Joseph & Sivar.	Kannur, Kerala	Lythraceae	CR	B1ab(i,ii,iii)+2ab(i,ii,iii)	3.1
219.	*Rotala ritchiei* Koehne	Southwest India [Kerala (Idukki), Maharashtra (Pune), Tamil Nadu (Coimbatore)]	Lythraceae	EN	B1ab(ii,iii)+2ab(ii,iii)	3.1
220.	*Sonneratia griffithii* Kurz	Andaman & Nicobar Islands, Odisha, West Bengal	Lythraceae	CR	A2cd	3.1
221.	*Magnolia gustavii* King	Makum forest, Assam	Magnoliaceae	CR	C2a(i)	3.1
222.	*Magnolia mannii* (King) Figlar	Assam	Magnoliaceae	VU	B1ab(i,iii)	3.1
223.	*Magnolia nilagirica* (Zenker) Figlar	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Magnoliaceae	VU	A2cd	3.1
224.	*Magnolia pealiana* King	Assam	Magnoliaceae	EN	B1ab(iii)	3.1
225.	*Magnolia pleiocarpa* (Dandy) Figlar & Noot.	Lakhimpur, Assam	Magnoliaceae	CR	B1ab(i,iii)	3.1
226.	*Bombax insigne* var. *polystemon* Prain	Nicobar Islands	Malvaceae	CR	D	2.3
227.	*Eriolaena lushingtonii* Dunn	Eastern Ghats (Andhra Pradesh, Tamil Nadu)	Malvaceae	VU	B1+2c	2.3
228.	*Heritiera fomes* Buch.-Ham.	Sundarbans, West Bengal	Malvaceae	EN	A2cde	3.1

S. No.	Scientific Name	Geographic rangein India	Family	Red list category	Red list criteria	Criteria version
229.	*Hildegardia populifolia* Schott & Endl.	Eastern Ghats (Andhra Pradesh, Tamil Nadu)	Malvaceae	CR	D	2.3
230.	*Julostylis polyandra* Ravi & Anil Kumar	North and south of the Travancore range, Kerala	Malvaceae	EN	B1+2c	2.3
231.	*Pterospermum reticulatum* Wight & Arn.	Western Ghats (Karnataka, Kerala and Tamil Nadu)	Malvaceae	VU	B1+2c	2.3
232.	*Sterculia khasiana* Debb. ex Biswas	Khasi Hills, Meghalaya	Malvaceae	Extinct		2.3
233.	*Memecylon flavescens* Gamble	Kundha and Avalanche (Nilgiri Hills), Tamil Nadu	Melastomataceae	EN	B1+2c	2.3
234.	*Memecylon lawsonii* Gamble	Anamalai Hills, Nilgiris and Wayanad area of Kerala and Tamil Nadu	Melastomataceae	VU	B1+2c	2.3
235.	*Memecylon sisparense* Gamble	Sispara, Nilgiri Hills, Tamil Nadu	Melastomataceae	CR	B1+2c	2.3
236.	*Memecylon subramanii* A.N. Henry	Agastyamalai range, Tamil Nadu	Melastomataceae	EN	B1+2c	2.3
237.	*Aglaia apiocarpa* Hiern	Tamil Nadu	Meliaceae	VU	A1c	2.3
238.	*Aglaia bourdillonii* Gamble	Agastyamalai range, Tamil Nadu	Meliaceae	VU	B1+2c	2.3
239.	*Aglaia malabarica* Sasidh.	Wayanad, Kerala	Meliaceae	CR	D	2.3
240.	*Aglaia perviridis* Hiern	Andaman Island	Meliaceae	VU	A1c	2.3
241.	*Dysoxylum beddomei* Hiern	Northern Kerala	Meliaceae	EN	B1+2c	2.3
242.	*Dysoxylum ficiforme* Gamble	Anamalai and Travancore ranges, Kerala	Meliaceae	VU	B1+2c	2.3
243.	*Dysoxylum malabaricum* Bedd. ex C.DC.	Maharashtra, Karnataka, Kerala and Tamil Nadu	Meliaceae	EN	A2cd	3.1
244.	*Nymphoides krishnakesara* K.T. Joseph & Sivar.	Kannur, Kerala	Menyanthaceae	EN	B1ab(ii,iii)+2ab(ii,iii)	3.1
245.	*Nymphoides macrosperma* R.V. Nair	Kerala	Menyanthaceae	CR	B2ab(iii)	3.1
246.	*Nymphoides sivarajanii* K.T. Joseph	Chettipadi, Malappuram, Kerala	Menyanthaceae	CR	B2ab(i,ii,iii)	3.1
247.	*Ficus andamanica* Corner	Andaman Island	Moraceae	EN	B1+2c	2.3
248.	*Ficus angladei* C.E.C. Fisch.	Palni Hills, Tamil, Nadu	Moraceae	CR	B1+2c	2.3
249.	*Gymnacranthera canarica* (Bedd. ex King) Warb.	Kerala, just extending into South Kanara (Karnataka)	Myristicaceae	VU	B1+2c, D2	2.3
250.	*Knema andamanica* (Warb.) W.J.de Wilde subsp. *andamanica*	Andaman & Nicobar Islands	Myristicaceae	VU	B1+2c	2.3
251.	*Knema andamanica* subsp. *nicobarica* (Warb.) W.J.de Wilde	Nicobar Island	Myristicaceae	VU	D2	2.3
252.	*Myristica andamanica* Hook.f.	Andaman & Nicobar Islands	Myristicaceae	VU	B1+2c	2.3
253.	*Myristica beddomei* subsp. *sphaerocarpa* W.J.de Wilde	Kerala, Tamil Nadu	Myristicaceae	EN	B1+2c	2.3
254.	*Myristica beddomei* subsp. *ustulata* W.J.de Wilde	Kerala and East Madras (Tamil Nadu)	Myristicaceae	EN	B1+2c	2.3
255.	*Myristica dactyloides* Gaertn.	Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu	Myristicaceae	VU	A2cd	3.1
256.	*Myristica magnifica* Bedd.	Northern Kerala and North Kanara in Karnataka	Myristicaceae	EN	B1+2c	2.3
257.	*Myristica malabarica* Lam.	Western Ghats, Karnataka, Kerala, Maharashtra, Tamil Nadu	Myristicaceae	VU	B1+2c	2.3
258.	*Ardisia amplexicaulis* Bedd.	Agastyamalai Hills & Wayanad, Kerala,	Myrsinaceae	EN	B1+2c	2.3
259.	*Ardisia blatteri* Gamble	Kerala, Tamil Nadu	Myrsinaceae	EN	B1+2c	2.3
260.	*Ardisia sonchifolia* Mez	Travancore range, Kerala	Myrsinaceae	EN	B1+2c	2.3
261.	*Maesa velutina* Mez	North Kanara, Karnataka and Wayanad, Kerala.	Myrsinaceae	EN	B1+2c	2.3
262.	*Rapanea striata* Mez	Mysore, Karnataka	Myrsinaceae	EN	B1+2c	2.3
263.	*Eugenia calcadensis* Bedd.	Along the Tamil Nadu/Kerala border at the southern end of the Western Ghats.	Myrtaceae	VU	B1+2c	2.3
264.	*Eugenia cotinifolia* subsp. *codyensis* (Munro ex Wight) P.S. Ashton	Karnataka, Tamil Nadu, Kerala	Myrtaceae	EN	B1+2c	2.3
265.	*Eugenia discifera* Gamble	Kerala, Tamil Nadu	Myrtaceae	EN	B1+2c	2.3
266.	*Eugenia floccosa* Bedd.	Tamil Nadu	Myrtaceae	EN	B1+2c	2.3
267.	*Eugenia indica* (Wight) Chithra	Southern end of the Western Ghats, Tamil Nadu)	Myrtaceae	EN	B1+2c	2.3
268.	*Eugenia rottleriana* Wight & Arn.	Along the Tamil Nadu/Kerala border.	Myrtaceae	VU	B1+2c	2.3
269.	*Eugenia singampattiana* Bedd.	Kalakad Mundadurai Tiger Reserve, Tirunelveli, Tamil Nadu	Myrtaceae	CR	A1c	2.3
270.	*Meteoromyrtus wynaadensis* (Bedd.) Gamble	Theerthundamala, Cannanore, Tamil Nadu	Myrtaceae	CR	B1+2c	2.3

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271.	Syzygium alternifolium (Wight) Walp.	Southern Eastern Ghats, Andhra Pradesh	Myrtaceae	EN	A2cd	3.1
272.	Syzygium andamanicum (King) N.P. Balakr.	Andaman Islands	Myrtaceae	CR	B1+2c	2.3
273.	Syzygium beddomei (Duthie) Chithra	Agastyamalai Hills, Anaimalai range, Tamil Nadu	Myrtaceae	EN	B1+2c	2.3
274.	Syzygium benthamianum (Wight ex Duthie) Gamble	Nilgiris, Agastyamalai Hills (Kerala, Tamil Nadu)	Myrtaceae	VU	B1+2c	2.3
275.	Syzygium bourdillonii (Gamble) Rathakr. & N.C. Nair	Merchiston, Trivandrum; Colatoorpolay, Quilon, Kerala	Myrtaceae	EN	B1+2c	2.3
276.	Syzygium chavaran (Bourd.) Gamble	Kerala	Myrtaceae	EN	B1+2c	2.3
277.	Syzygium courtallense (Gamble) Alston	Courtallam hills, Tamil Nadu	Myrtaceae	CR	B1+2cde	2.3
278.	Syzygium densiflorum Wall. ex Wight & Arn.	Nilgiris, Anamalai and Palni hills (Karnataka, Kerala, Tamil Nadu)	Myrtaceae	VU	B1+2c	2.3
279.	Syzygium manii (King) N.P. Balakr.	Middle Andaman Island	Myrtaceae	CR	B1+2c	2.3
280.	Syzygium microphyllum Gamble	Agastyamalai Hills, Tamil Nadu	Myrtaceae	EN	B1+2c	2.3
281.	Syzygium myhendrae (Bedd. ex Brandis) Gamble	Travancore range, Agastyamalai hills (Kerala, Tamil Nadu)	Myrtaceae	EN	B1+2c	2.3
282.	Syzygium occidentale (Bourd.) Gandhi	Karnataka, Kerala	Myrtaceae	VU	A1d	2.3
283.	Syzygium palghatense Gamble	Palghat hills, Kerala	Myrtaceae	CR	B1+2abcde	2.3
284.	Syzygium parameswaranii M. Mohanan & A.N.Henry	Agastyamalai hills and Elamalai hills, Tamil Nadu	Myrtaceae	EN	B1+2c	2.3
285.	Syzygium ramavarma (Bourd.) Chithra	Agastyamalai hills, Anaimalai hills (Kerala, Tamil Nadu)	Myrtaceae	VU	B1+2c	2.3
286.	Syzygium stocksii (Duthie) Gamble	Wayanad, Kerala; South Canara, Karnataka	Myrtaceae	EN	B1+2c	2.3
287.	Syzygium travancoricum Gamble	Travancore, Kerala	Myrtaceae	CR	C2a	2.3
288.	Syzygium zeylanicum var. ellipticum A.N. Henry & Chandrab. & N.C. Nair	Agastyamalai hills, Tamil Nadu	Myrtaceae	EN	B1+2c	2.3
289.	Nepenthes khasiana Hook.f.	Jaintia hills, Garo hills, Khasi hills, Meghalaya.	Nepenthaceae	EN	B2ab(iii)	3.1
290.	Anacolosa densiflora Bedd.	Kerala, Tamil Nadu	Olacaceae	EN	B1+2c	2.3
291.	Chionanthus leprocarpa var. courtallensis K.K.N. Nair & K.P. Janardh.	Kerala, Tamil Nadu	Oleaceae	EN	B1+2c	2.3
292.	Chionanthus linocieroides (Wight) Bennet & Raizada	Agastyamalai hills, (Kerala, Tamil Nadu)	Oleaceae	EN	B1+2c	2.3
293.	Cypripedium cordigerum D. Don	Himachal Pradesh, Uttarakhand	Orchidaceae	VU	B2ab(ii,iii,iv,v)	3.1
294.	Cypripedium elegans Rchb.f.	Sikkim, Uttarakhand	Orchidaceae	EN	B2ab(ii,iii,v)	3.1
295.	Cypripedium himalaicum Rolfe ex Hemsl.	Jammu-Kashmir, Sikkim, Uttarakhand	Orchidaceae	EN	B2ab(ii,iii,v); D	3.1
296.	Habenaria dichopetala Thwaites	Tamil Nadu	Orchidaceae	EN	B2ab(i,ii,iii)	3.1
297.	Luisia volucris Lindl.	Meghalaya	Orchidaceae	VU	B1ab(iii)	3.1
298.	*Malaxis muscifera* (Lindl.) Kuntze	Jammu and Kashmir, Himachal Pradesh, Uttarakhand Sikkim and Arunachal Pradesh	Orchidaceae	VU	A2cd	3.1
299.	*Paphiopedilum appletonianum* (Gower) Rolfe	Assam	Orchidaceae	EN	B2ab(ii,iii,v)	3.1
300.	*Paphiopedilum charlesworthii* (Rolfe) Pfitzer	Assam	Orchidaceae	EN	B2ab(i,ii,iii,iv,v)	3.1
301.	*Paphiopedilum druryi* (Bedd.) Stein	Kerala, Tamil Nadu	Orchidaceae	CR	A2abcd+3bcd+4abcd; B1ab(ii,iii,v)+2ab(ii,iii,v); C1	3.1
302.	*Paphiopedilum fairrieanum* (Lindl.) Stein	Chumbi, Tinkitam, Sikkim; Kameng, Arunachal Pradesh	Orchidaceae	CR	A2acd+3cd+4acd; B2ab(i,ii,iii,v); C1+2a(i); D	3.1
303.	*Paphiopedilum hirsutissimum* (Lindl. ex Hook. f.) Stein	Mizoram, Manipur, Meghalaya, Nagaland	Orchidaceae	VU	B2ab(ii,iii,v)	3.1
304.	*Paphiopedilum insigne* (Wall. ex Lindl.) Pfitzer	Meghalaya	Orchidaceae	EN	B1ab(ii,iii,v)+2ab(ii,iii,v)	3.1
305.	*Paphiopedilum spicerianum* (Rchb.f.) Pfitzer,	Assam, Manipur, Mizoram	Orchidaceae	EN	B2ab(ii,iii,v)	3.1
306.	*Paphiopedilum venustum* (Wall. ex Sims) Pfitzer	Assam, Meghalaya, Sikkim	Orchidaceae	EN	A2acd; B2ab(ii,iii,v)	3.1

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307.	*Paphiopedilum villosum* (Lindl.) Stein	Assam, Meghalaya, Mizoram	Orchidaceae	VU	B2ab(ii,iii,v)	3.1
308.	*Vanda spathulata* Spreng.	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu	Orchidaceae	VU	A2cd	3.1
309.	*Zeuxine rolfiana* King & Pantl.	Andaman and Nicobar Islands	Orchidaceae	CR	B1ab(iii,v)+2ab(iii,v); C2a(i,ii); D	3.1
310.	*Adinandra griffithii* Dyer	Arunachal Pradesh, Meghalaya	Pentaphylacaceae	EN	A1c, B1+2c	2.3
311.	*Cleyera japonica* var. *grandiflora* (Wall. ex Choisy) Kobuski	Meghalaya	Pentaphylacaceae	EN	B1+2c	2.3
312.	*Aporosa bourdillonii* Stapf	Karnataka, Kerala	Phyllanthaceae	EN	B1+2c	2.3
313.	*Bridelia kurzii* Hook.f.	Kamorta Island in Nicobars and Andaman Islands	Phyllanthaceae	VU	B1+2c	2.3
314.	*Cleistanthus malabaricus* Müll.Arg.	Karnataka, Kerala	Phyllanthaceae	VU	B1+2c	2.3
315.	*Cleistanthus travancorensis* Jabl.	Kerala, Tamil Nadu	Phyllanthaceae	EN	B1+2c	2.3
316.	*Glochidion bourdillonii* Gamble	Travancore hills, Kerala	Phyllanthaceae	VU	B1+2c	2.3
317.	*Glochidion ellipticum* var. *ralphii* generic GAMBEL	Travancore hills, Kerala	Phyllanthaceae	EN	B1+2c	2.3
318.	*Glochidion johnstonei* Hook.f.	Goa, Kerala	Phyllanthaceae	VU	B1+2c	2.3
319.	*Glochidion pauciflorum* Gamble	Bababudan range, Nilgiri range. Palni (Karnataka & Tamil Nadu)	Phyllanthaceae	EN	B1+2c	2.3
320.	*Glochidion sisparense* Gamble	Nilgiris, Tamil Nadu	Phyllanthaceae	EN	B1+2c	2.3
321.	*Glochidion tomentosum* Dalzell	Karnataka, Tamil Nadu	Phyllanthaceae	EN	B1+2c	2.3
322.	*Phyllanthus indofischeri* Bennet	Tamil Nadu, Andhra Pradesh, Karnataka and Kerala	Phyllanthaceae	VU	A2cd	3.1
323.	*Pseudoglochidion anamalayanum* Gamble	Anamalai hills, Coimbatore, Tamil Nadu	Phyllanthaceae	CR	B1+2c	2.3
324.	*Piper barberi* Gamble	Pullathupara, Kollam and Sholayar, Thrissur (Kerala)	Piperaceae	EN	B1ab(i,ii,iii,v)+2ab(i,ii,iii,v)	3.1
325.	*Piper pedicellatum* C.DC.	Arunachal Pradesh, Sikkim	Piperaceae	VU	A2cd	3.1
326.	*Pittosporum eriocarpum* Royle	Uttarakhand (Dehradun, Tehri, Nainital, Almora, Pithoragarh) and Himachal Pradesh (Chamba, Shimla, Solan)	Pittosporaceae	EN	B1+2c	2.3
327.	*Pittosporum viridulum* M.P. Nayar & G.S.Giri & V. Chandras.	Nilgiris, Tamil Nadu	Pittosporaceae	CR	B1+2c	2.3
328.	*Dimeria hohenackeri* Hochst. ex Miq.	Western coast and Western Ghats, Maharashtra, Goa, Karnataka and Kerala.	Poaceae	EN	B2ab(ii,iii,iv,v)	3.1
329.	*Glyphochloa santapaui* (Jain & Desh.) Clayton	Ratnagiri, Sindhudurg, Maharashtra	Poaceae	VU	D2	3.1
330.	*Hubbardia heptaneuron* Bor	Gersoppa falls, Karnataka; Tillari Ghat, Kolhapur, Maharashtra	Poaceae	VU	D2	3.1
331.	*Isachne bicolor* Naik & Patunkar	Kolhapur (Amba), Satara, Ahmednagar and Aurangabad, Maharashtra	Poaceae	VU	B1ab(ii,iii)+2ab(ii,iii)	3.1
332.	*Isachne meeboldii* C.E.C. Fisch.	Shimoga, Kumsi, Karnataka; Aurangabad, Maharashtra	Poaceae	CR	B2ab(i,ii,iii)	3.1
333.	*Isachne swaminathanii* V. Prakash & S.K.Jain	Bombay, Pune, Ratnagiri, Satara and Thane, Maharashtra	Poaceae	EN	B2ab(i,ii,iii)	3.1
334.	*Isachne veldkampii* K.G. Bhat & Nagendran	Manipal, Udupi, Karnataka	Poaceae	CR	B1ab(i,ii,iii)+2ab(i,ii,iii)	3.1
335.	*Ischaemum jayachandranii* R. Ansari & V.S. Ramach. & Sreek.	Kannur, Kerala	Poaceae	CR	B1ab(ii,iii)+2ab(ii,iii)	3.1
336.	*Ischaemum vembanadense* R.B. Patil & D'Cruz	Vemband Kayal, Alappuzha, Kerala	Poaceae	EN	B1ab(iii)+2ab(iii)	3.1
337.	*Limnopoa meeboldii* (C.E.C. Fisch.) C.E. Hubb.	Karnataka, Kerala	Poaceae	EN	B2ab(iii)	3.1
338.	*Oryza malampuzhaensis* Krishnasw. & Chandras.	Kerala	Poaceae	VU	B1ab(iii,v)	3.1
339.	*Farmeria indica* Willis	Tamil Nadu (Tamirabarani river in Tirunelveli); Kerala (Idukki and Thiruvananthapuram)	Podostemaceae	EN	B1ab(i,ii,iii)+2ab(i,ii,iii)	3.1
340.	*Farmeria metzgerioides* Willis	Kerala	Podostemaceae	VU	B2ab(iii,v)	3.1
341.	*Podostemum munnarense* (Nagendran & Arekal) C.J. Mathew & V.K.Satheesh	Munnar, Idukki, Kerala	Podostemaceae	EN	B1ab(iii)+2ab(iii)	3.1
342.	*Polypleurum filifolium* (Ramam. & J. Joseph) A.S. Rao & Hajra	Palakkad and Thrissur, Kerala; Jeypore, Orissa	Podostemaceae	VU	B1ab(iii,v)+2ab(iii,v)	3.1

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343.	*Willisia selaginoides* Warm. ex Willis	Kerala, Tamil Nadu	Podostemaceae	VU	B1ab(i,ii,iii)	3.1
344.	*Drypetes andamanica* Pax & K. Hoffm.	South Andaman Island	Putranjivaceae	EN	B1+2c	2.3
345.	*Drypetes porteri* Pax & K. Hoffm.	Tamil Nadu	Putranjivaceae	EN	B1+2c	2.3
346.	*Drypetes travancorica* (Bourd.) Santapau & S.K. Jain	Kollam, Kerala,	Putranjivaceae	EN	B1+2c	2.3
347.	*Drypetes wightii* Pax & K. Hoffm.	Nilgiri range, Anaimalai range (Kerala, Tamil Nadu)	Putranjivaceae	VU	B1+2c	2.3
348.	*Aconitum chasmanthum* Stapf ex Holmes	Himachal Pradesh, Jammu-Kashmir	Ranunculaceae	CR	A2cd	3.1
349.	*Aconitum heterophyllum* Wall.	Jammu and Kashmir, Himachal Pradesh and Uttarakhand	Ranunculaceae	EN	A2cd	3.1
350.	*Aconitum violaceum* Jacquem. ex Stapf	Jammu and Kashmir, Himachal Pradesh and Uttarakhand	Ranunculaceae	VU	A2cd	3.1
351.	*Coptis teeta* Wall.	Mishmi hills, Dibang Valley, Arunachal Pradesh	Ranunculaceae	EN	A2cd	3.1
352.	*Photinia serratifolia* var. *tomentosa* (Gamble) Vivek. & B.V. Shetty	Nilgiris,Tamil Nadu	Rosaceae	EN	B1+2c	2.3
353.	*Byrsophyllum tetrandrum* (Bedd.) Hook.f.	Agastyamalai hills (Kerala, Tamil Nadu)	Rubiaceae	EN	B1+2c	2.3
354.	*Canthium neilgherrense* var. *chartacea* (Gamble) Swamin.	Nilgiris and Agastymalai hills, Tamil Nadu	Rubiaceae	VU	B1+2c	2.3
355.	*Coffea arabica* L.	Andaman & Nicobar Islands.	Rubiaceae	EN	A3b	3.1
356.	*Coffea neobridsoniae* A.P. Davis	Western Ghats (Kerala, Tamil Nadu and Karnataka).	Rubiaceae	EN	B2ab(iii)	3.1
357.	*Coffea travancorensis* Wight & Arn.	Western Ghats, Malabar and Travencore (Kerala and Tamil Nadu)	Rubiaceae	VU	B2ab(i,ii,iii)	3.1
358.	*Ixora johnsonii* Hook.f.	Ernakulam, Kerala	Rubiaceae	CR	B1+2c	2.3
359.	*Ixora lawsonii* Gamble	Karnataka, Kerala	Rubiaceae	EN	B1+2c	2.3
360.	*Ixora malabarica* (Dennst.) Mabb.	Karnataka, Kerala	Rubiaceae	VU	B1+2c	2.3
361.	*Ixora saulierei* Gamble	Palani hills, Tamil Nadu	Rubiaceae	EN	B1+2c	2.3
362.	*Lasianthus ciliatus* Wight	Anaimalai hills, Tamil Nadu	Rubiaceae	VU	D2	2.3
363.	*Lasianthus rostratus* Wight	Anaimalai hills and the Travancore range (Kerala)	Rubiaceae	VU	B1+2c	2.3
364.	*Litosanthes capitulatus* (Wight) Deb & M.Gangop.	Pushpagiri hills to the Nilgiris and Anaimalai range (Karnataka, Kerala, Tamil Nadu)	Rubiaceae	VU	B1+2c	2.3
365.	*Nauclea gageana* King	Middle and South Andaman Islands	Rubiaceae	CR	B1+2c	2.3
366.	*Nostolachma crassifolia* (Gamble) Deb & J. Lahiri	Agastyamalai hills (Kerala, Tamil Nadu)	Rubiaceae	EN	B1+2c	2.3
367.	*Ochreinauclea missionis* (Wall. ex G. Don) Ridsdale	Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu	Rubiaceae	VU	B1+2c	2.3
368.	*Prismatomeris andamanica* Ridl.	South Andaman Island	Rubiaceae	CR	B1+2c	2.3
369.	*Psychotria beddomei* Deb & M. Gangop.	Agastyamalai hills (Kerala)	Rubiaceae	EN	B1+2c	2.3
370.	*Psychotria globicephala* Gamble	Southern Nilgiris, Agastyamalai hills, (Kerala, Tamil Nadu) Tirunelveli, Tamil Nadu	Rubiaceae	EN	B1+2c	2.3
371.	*Psychotria macrocarpa* Hook.f.	Travancore range (Kerala, Tamil Nadu)	Rubiaceae	EN	B1+2c	2.3
372.	*Psychotria nilgiriensis* var. *astephana* (Hook.f.) Deb & M. Gangop.	Nilgiris and Palni hills (Tamil Nadu)	Rubiaceae	EN	B1+2c	2.3
373.	*Psydrax ficiformis* (Hook.f.) Bridson	Kerala, Tamil Nadu	Rubiaceae	EN	B1+2c	2.3
374.	*Psydrax pergracilis* (Bourd.) Ridsdale	South Kerala	Rubiaceae	EN	B1+2c	2.3
375.	*Saprosma fragrans* Bedd.	Kerala, Tamil Nadu	Rubiaceae	VU	B1+2c	2.3
376.	*Tarenna agumbensis* Sundararagh.	Southern Karnataka.	Rubiaceae	EN	B1+2c	2.3
377.	*Tarenna monosperma* (Wight & Arn.) N.P. Balakr.	Nilgiris, Anamalai and Agastyamalai hills (Kerala, Tamil Nadu)	RubiaceaeEN	B1+2c		2.3
378.	*Tarenna nilagirica* (Bedd.) Bremek.	Karnataka, Kerala	Rubiaceae	VU	B1+2c	2.3
379.	*Wendlandia andamanica* Cowan	Port Blair, South Andaman Islands	Rubiaceae	CR	B1+2c	2.3
380.	*Wendlandia angustifolia* Wight ex Hook. f.	Tirunelvi, Tamil Nadu	Rubiaceae	Extinct		2.3
381.	*Chloroxylon swietenia* DC.	Andhra Pradesh, Kerala, Tamil Nadu	Rutaceae	VU	A1c	2.3
382.	*Melicope indica* Wight	Nilgiris, Tamil Nadu	Rutaceae	EN	B1+2c	2.3
383.	*Casearia wynadensis* Bedd.	Wayanad, Kerala Nilgiris (Kerala, Tamil Nadu)	Salicaceae	VU	B1+2c	2.3
384.	*Homalium jainii* A.N. Henry & Swamin.	Agastyamalai hills, Tamil Nadu	Salicaceae	EN	B1+2c	2.3

S. No.	Scientific name	Geographic rangein India	Family	Red list criteria	Criteria version
385.	*Homalium travancoricum* Bedd.	Travancore range, Agastyamalai hills	Salicaceae	B1+2c	2.3
386.	*Xylosma latifolium* Hook. f. & Thomson	Nilgiris (Kerala, Tamil Nadu) Bababudan range, Karnataka; Wayanad, Kerala	Salicaceae	B1+2c	2.3
387.	*Santalum album* L.	Andhra Pradesh, Karnataka, Kerala, Tamil Nadu	Santalaceae	A2de	3.1
388.	*Acer oblongum* var. *membranaceum* Banerji	Mussoorie hills, Dehradun, Uttarakhand	Sapindaceae	B1+2d	2.3
389.	*Acer oblongum* var. *microcarpum*	Mishmee hills, Lohit, Arunachal Pradesh	Sapindaceae	D2	2.3
390.	*Acer osmastonii* Gamble	Sikkim, Uttarakhand, West Bengal	Sapindaceae	B2ab (iii)	3.1
391.	*Acer tibetense* Fang	Arunachal Pradesh	Sapindaceae	B1ab (iii)	3.1
392.	*Isonandra stocksii* C.B. Clarke	Karnataka, Kerela, Maharashtra, Tamil Nadu	Sapotaceae	B1+2c	2.3
393.	*Isonandra villosa* Wight	Velligonda hills, south of the Eastern Ghats and Quilon (Kerala, Tamil Nadu)	Sapotaceae	B1+2c	2.3
394.	*Madhuca bourdillonii* (Gamble) H.J. Lam	Ariankavu, Shendurni Valley, Quilon, Trissur (Kerala)	Sapotaceae	A1cd+2c	2.3
395.	*Madhuca diplostemon* (C.B. Clarke) P.Royen	Paravur, Kollam, Kerala	Sapotaceae	B1+2c	2.3
396.	*Madhuca insignis* (Radlk.) H.J. Lam	Kaup (Udupi), Venur, Nadoli (Dakshina Kannada), Kasaragod, Kerala; Shimoga, Mangalore Karnataka	Sapotaceae	B1+2c	2.3
397.	*Palaquium bourdillonii* Brandis	Agastyamalai hills (Kerala, Tamil Nadu)	Sapotaceae	B1+2c	2.3
398.	*Palaquium ravii* Sasidh. & Vink	Anamalai hills (Kerala, Tamil Nadu)	Sapotaceae	A2cd	2.3
399.	*Illicium griffithii* Hook.f. & Thomson	Arunachal Pradesh, Manipur, Meghalaya, Nagaland	Schisandraceae	B1+2c	3.1
400.	*Gomphandra comosa* King	Nicobar and Andaman Islands	Stemonuraceae	B1+2c	2.3
401.	*Symplocos anamallayana* Bedd.	Anamalai and Palni Ranges (Kerala, Tamil Nadu)	Symplocaceae	B1+2c	2.3
402.	*Symplocos barberi* Gamble	Agastyamalai and Tirunelveli hills, Tamil Nadu	Symplocaceae	B1+2c	2.3
403.	*Symplocos macrocarpa* subsp. *Kanarana* (Talbot) Noot.	Kalinadi River in Karnataka to the Agastyamalai Hills in Kerala	Symplocaceae	B1+2c	2.3
404.	*Symplocos nairii* A.N. Henry & Gopalan & Swamin.	Tamil Nadu	Symplocaceae	B1+2c	2.3
405.	*Symplocos oligandra* Bedd.	Agastyamalai hills, Tamil Nadu	Symplocaceae	B1+2c	2.3
406.	*Symplocos pulchra* subsp. *coriacea* Gopalan & A.N. Henry	Agastyamalai hills, Tamil Nadu	Symplocaceae		2.3
407.	*Pyrenaria cherrapunjeana* Mir	Khasi Hills (Mawmluh, Sohrarim and Mawsynram), Meghalaya	Theaceae	CR	3.1
408.	*Aquilaria khasiana* Hallier f.	Khasi Hills (Mawkasain), Meghalaya	Thymelaeaceae	A2c; B1ab(i,ii)+2ab(i,ii); D	3.1
409.	*Aquilaria malaccensis* Lam.	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura	Thymelaeaceae	A2cd	3.1
410.	*Ulmus wallichiana* Planch.	Jammu-Kashmir	Ulmaceae	A1c	2.3
411.	*Cayratia pedata* Gagnep.	Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Karnataka, Kerala, Maharashtra, Meghalaya, Orissa, Tamil Nadu, West Bengal	Vitaceae	A2cd	3.1
412.	*Cayratia pedata* var. *glabra* Gamble	Kerala and Tamil Nadu particularly in Silent Valley and adjoining Tamil Nadu Border	Vitaceae	B2ab(ii,iii,v)	3.1
413.	*Curcuma caulina* J. Graham	Pune and Satara, Maharashtra	Zingiberaceae	B1ab(iii)	3.1
414.	*Curcuma coriacea* Mangaly & M. Sabu	Idukki, Palakkad and Pathanamthitta, Kerala	Zingiberaceae	B1ab(iii)	3.1
415.	*Curcuma pseudomontana* J. Graham	Andhra Pradesh, Karnataka, Kerala	Zingiberaceae	A2cd	3.1
416.	*Tribulus rajasthanensis* Bhandari & V.S. Sharma	Gujarat, Rajasthan	Zygophyllaceae	A2cd	
	GYMNOSPERMS				
1.	*Amentotaxus assamica* D.K. Ferguson	Turoo and Dafla hills, Arunachal Pradesh	Taxaceae	B1ab(iii)+2ab(iii)	
2.	*Cephalotaxus mannii* Hook.f.	Arunachal Pradesh, Meghalaya (Khasi, Jaintia, Mishmi hills and Naga hills), Assam (Manipur, Nagaland)	Taxaceae	A2cd	

S. No.	Scientific name	Geographic rangein India	Family	Red list category	Red list criteria	Criteria version
3.	*Cycas annaikalensis* Rita Singh & P. Radha	Palaghat, Kerala	Cycadaceae	CR	B1ab (iii,v)+2ab (iii,v)	3.1
4.	*Cycas beddomei* Dyer	Tirupati-Kadapa hills, Andhra Pradesh, northwest of Madras, eastern Peninsular India	Cycadaceae	EN	B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v)	3.1
5.	*Cycas circinalis* L.	Karnataka, Kerala, Tamil Nadu	Cycadaceae	EN	A2acd	3.1
6.	*Cycas nathorstii* J. Schust.	Tamil Nadu	Cycadaceae	VU	A2cd; C1	3.1
7.	*Cycas pectinata* Buch.-Ham.	North-Eastern states (Assam, Manipur, Meghalaya, Sikkim, Darjeeling)	Cycadaceae	VU	A2c	3.1
8.	*Cycas zeylanica* (J. Schust.) A. Lindstr. & K.D. Hill	Andaman and Nicobar Islands	Cycadaceae	VU	A2bc	3.1
9.	*Gnetum contractum* Markgr.	Kerala, Tamil Nadu	Gnetaceae	VU	B1ab(iii)	3.1
10.	*Picea brachytyla* (Franch.) E.Pritz.	Arunachal Pradesh (Kameng, Mago)	Pinaceae	VU	A2cd	3.1
11.	*Taxus contorta* Griff.	Himachal Pradesh, Jammu and Kashmir and Uttarakhnad	Taxaceae	EN	A2acd	3.1
12.	*Taxus wallichiana* Zucc.	Arunachal Pradesh, Assam	Taxaceae	EN	A2acd	3.1
	PTERIDOPHYTES					
1.	*Cyathea crinita* Copel.	Idukki, Wayanad, Palakkad, Kerala; Avalanche (Nilgiris), Palni Hills (Dindigul), Tamil Nadu	Cyatheaceae	EN	B1ab(iii)+2ab(iii)	3.1
2.	*Isoetes panchganiensis* G.K. Srivast. & D.D. Pant & P.K.Shukla	Panchgani tableland, Maharashtra and Kemmangundi hills, Karnataka.	Isoetaceae	EN	B1ab(iii)+2ab(iii)	3.1
	BRYOPHYTES					
1.	*Aitchisoniella himalayensis* Kashyap	Kumaon (northwest Himalaya: Mussoorie, Simla, Kuku, Dulchi Pass)	Exormothecaceae	EN	C2a(i)	3.1
2.	*Diplocolea sikkimensis* Amakawa	Sikkim	Solenostomataceae	EN	B1+2c	2.3
3.	*Mitrobryum koelzii* H. Rob.	Uttar Pradesh	Dicranaceae	EN	B1+2cd	2.3
4.	*Pinnatella limbata* Dixon	Uttar Kanad, Karnataka	Neckeraceae	CR	B1+2c	2.3
5.	*Sewardiella tuberifera* Kashyap	Himachal Pradesh, Uttarakhand	Petalophyllaceae	VU	A1ac+2bc	2.3
6.	*Stephensoniella brevipedunculata* Kashyap	Himachal Pradesh, Uttarakhand	Exormothecaceae	EN	B1+2cd	2.3
7.	*Takakia ceratophylla* (Mitt.) Grolle	Sikkim	Takakiaceae	VU	B1+2cd	2.3
	FUNGI					
8.	*Squamanita schreieri* Imbach	India locality doubtfull (Kautmanova, 2019)	Tricholomataceae	EN	C2a(i)	3.1
	ALGAE					
	Nil					

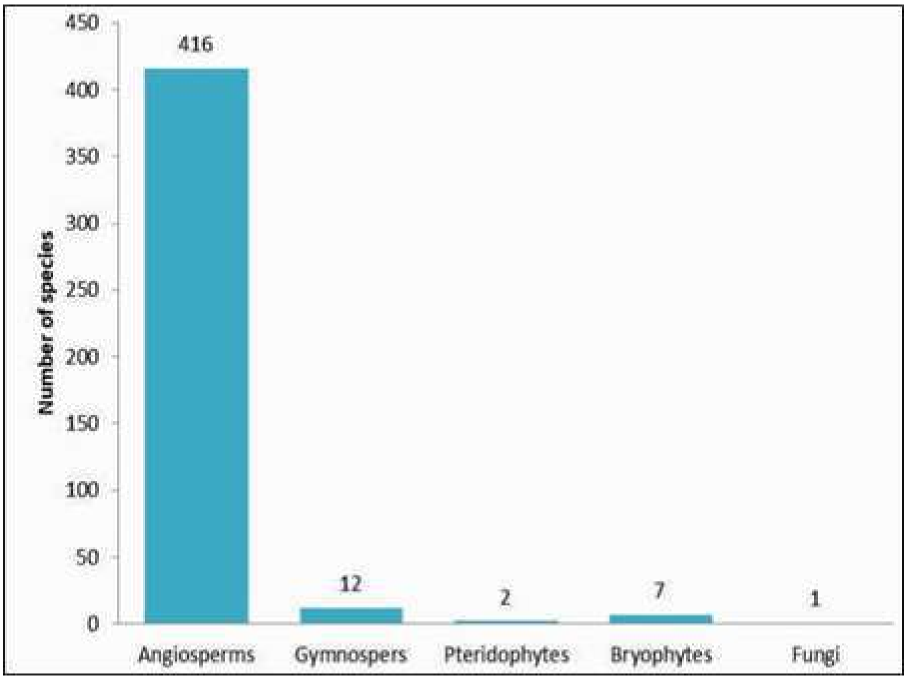

Fig. 11: Number of Red listed species in India under different groups of plants.

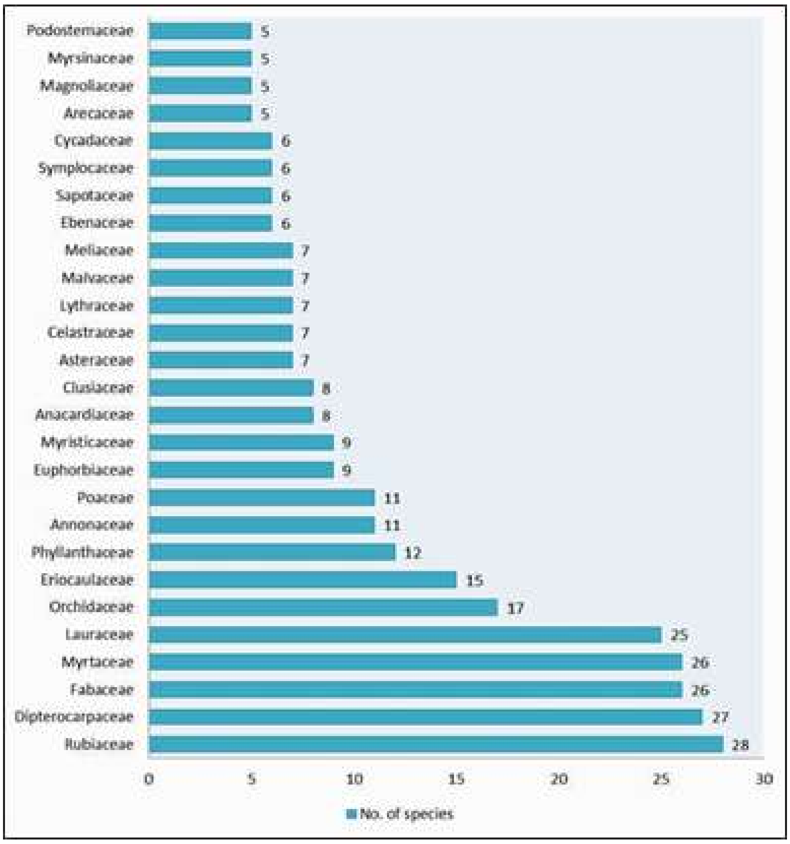

Fig. 12: Families of angiospermic threatened plants in India having five or more species under various categories of threat.

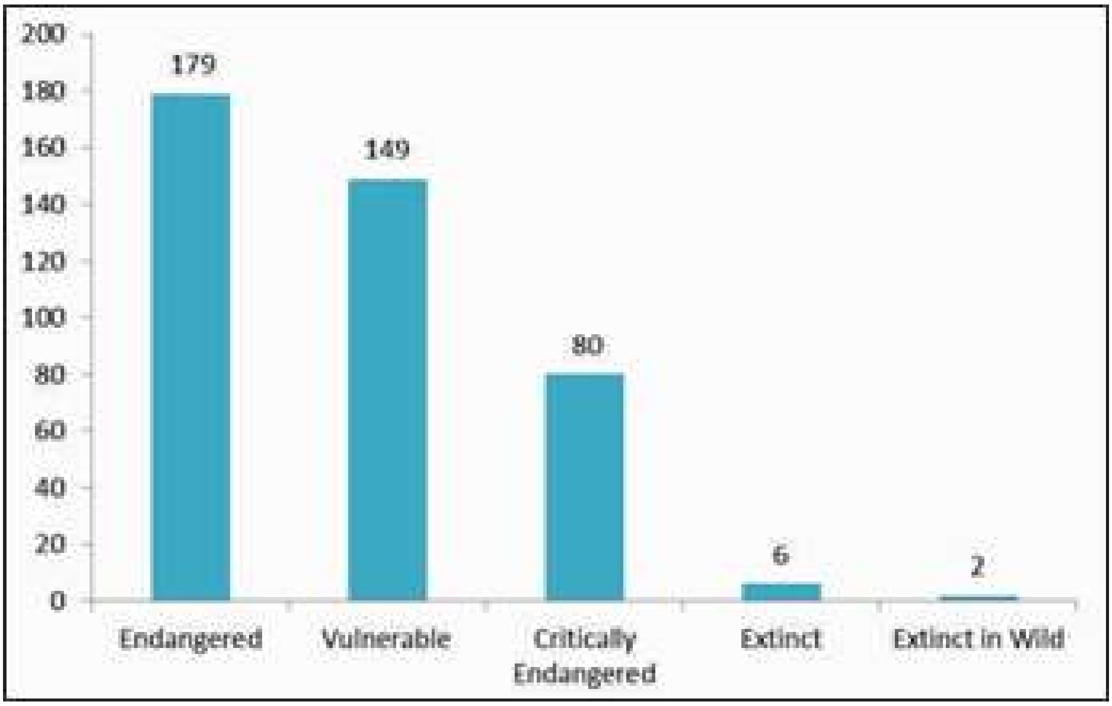

Fig. 13: Analysis of number of angiospermic threatened plants in India under various categories of threat.

Red List Committee (Gärdenfors et al., 2001; IUCN 2003, 2012). When applied at national or regional levels it must be recognized that a global category may not be the same as a national or regional category for a particular taxon. Other means of listing threatened taxa at regional/national level is through Conservation Assessment and Management Plans (CAMPs). CAMPs are intended to offer strategic leadership for data collection techniques and application of intensive management of threatened taxa. CAMPs provide a rational and comprehensive means of assessing main concern for exhaustive management within the framework of the wider conservation requirements of threatened taxa.

Several notable documents on rare, endemic and threatened plants of India had been published by Botanical Survey of India such as Threatened Plants of India by Jain and Sastry (1980, 1983, 1984) and "Red Data Book of Indian Plants" by Nayar and Sastry (1987, 1988, 1990).

Though above mentioned means of listing of threatened plants sound relatively simple but there are difficulties to implement them to realistic situations. Moreover, most of the species on worldwide basis have not been the subjects of much scientific study, making it difficult to evaluate their status based on evidence. There has been ample discussion as to whether researchers should take up the worst-or best-case scenario when scientific data are inadequate. Even for well-studied species it has proven very problematic for biologists to visualize extinction risk as there are innumerable factors that can add to the decline of a species. In the endeavour to calculate the risk of extinction encountered by distinct species, biologists have recognized a new field of ecology intended on identifying smallest viable populations and performing population viability study (Akçakaya and Sjögren-Gulve, 2000).

Conserving biodiversity without further delay is the need of hour to meet the ever-increasing needs of countries. Regardless of crucial importance for Himalayan ecosystems, most plant species of Indian Himalayan Region (IHR) are lacking for the proper extinction risk assessments and consequently restraining our ability to identify conservation priorities. Across the IHR, small and remote populations of threatened and economically important plants can be found. Measuring the impact of threats, identification, prioritising and envisaging conservation pockets are crucial for the conservation and management of threatened species. There are various threats that affect a species and add on to their risk of extinction. Threats can be anthropogenic such as clearing of habitat, pollution, overharvesting, invasive alien species, or random natural events such as cyclones, floods, droughts, fire, etc.

Though considerable amount of work has been done in the area of conservation in the country still we have to achieve the realistic goal of actual preservation of threatened plant species. Akin to species specific conservation programmes for threatened animal species like project tiger, project elephant and so on, similar importance should be given to plant species and similar systematic and prioritized efforts needs to be put forth for conserving them. Red List preparation is one of the first strides to achieve the goal of species conservation. Again, species protection is not a standalone effort; it needs the concerted efforts from all for realizing the challenging task and managing biodiversity. Nonetheless a renewed, well-designed, systematic, specialised approach needs to be taken for actual red listing of plants of India.

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CASE STUDY 3:

Diversity and regeneration pattern along altitudinal gradient. Regeneration pattern of 17 *Rhododendron* species in Dzongri Gocha La trekking corridor, Sikkim was studied.

The genus *Rhododendron* L. (Ericaceae) is represented by about 132 taxa in India and distributed in mostly sub-tropical to alpine regions of Himalaya with few speceis in Western Ghats (Mao et al. 2017). It is the largest genus of the family Ericaceae as well as among one of the largest flowering plant genera in Asia (Cullen & Chamberlain 1978). Most *Rhododendrons* are found in fragile habitat of eastern Himalaya. In Sikkim, Rhododendron speceis distributed in higher altitudes preferable within protected areas. Members of this genus play a considerable role in maintaining ecological stability in higher ecosystems and known for their phenological sensitivity. Therefore, a suitable number of *Rhododendron* species have been recognized as indicators species of forest health as well as for climatic change (Chettri et al. 2018). Rhododendron species also act as a keystone species in the fragile ecosystem of Himalayas since they provide niche for several plant and animal speceis (Menon et al. 2012). J.D Hooker's was reported the occurrence of Rhododendrons rom Sikkim during his visit on 1849 and he described thirty-four new species of Rhododendrons from the Sikkim Himalaya in his monograph 'The Rhododendrons of Sikkim-Himalaya'.He described 34 new species of Rhododendrons from the Sikkim Himalaya in his monograph 'The Rhododendrons of Sikkim-Himalaya'. Subsequent publications (Clarke 1882; Pradhan & Lachunga 1990; Long & Rae 1991; Mao et al. 2001, 2027; Badola & Pradhan 2010; Mao 2010, 2018; Pradhan 2010; Chettri et al. 2018; Pandey & Badola 2018) reveal a comprehensive account on Rhododendrons of Sikkim Himalaya. Altogether forty-six taxa of Rhododendrons have been reported from Sikkim state (Mao et al. 2017).

Besides aesthetic and sacredness, the members of Rhododendron have ethnomedicinal, commercial and social importance in Sikkim. Due to heavy anthropogenic disturbance, deforestation, over-exploitation and unscientific expansion of agricultural fields, roads the natural habit of Rhododendrons are dwindling; as a result, many species have become vulnerable and threatened. Therefore, record of distinct species of Rhododendrons and understanding of their habitat, associated species in remote area like Dzongri-Goecha La region is need of the hour. Unless exact distributions of distinct species of *Rhododendrons*.

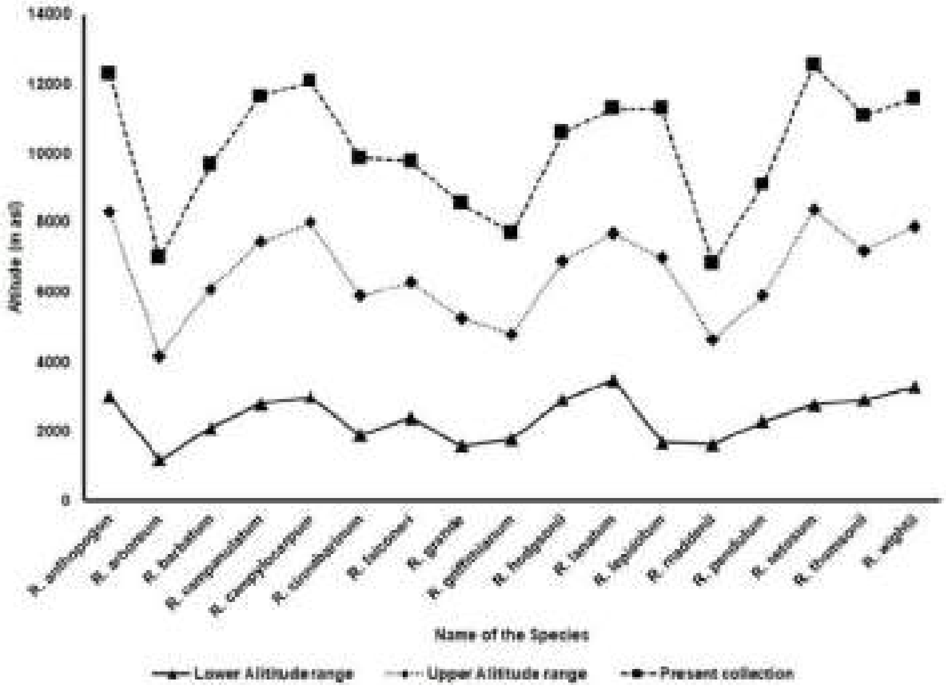


Fig. 14: Altitudinal distribution of *Rhododendron* species at Dzongri Goecha La trekking trail.

Data collection

The study was carried out during April 2016 to May 2019. The region was visited in every season in connection with setting up permanent plots under the project "Biodiversity Assessment through Long–term Monitoring Plots in Indian Himalayan Landscape" for monitoring of plant diversity change in the Dzongri– Gocha La area (Figure.1). Plant specimens were collected as per standard procedures (Jain & Rao 1977); photographs were taken in field with Sony-DSCHX400V camera. The flowers were dissected and observed under Olympus light microscope (SZ61) to identify and study the macro-morphological characters. All the species were identified with the help of available literature (Hooker 1849; Clarke 1882; Long & Rae1991; Mao 2010, 2018; Mao et al. 2017; Maity et al. 2018) and consultation with the herbaria (ARUN, ASSAM, BSHC, CAL). All these species of Rhododendrons, so collected, are enumerated here alphabetically according to the accepted name followed by a brief description based on the field characters, data on phenology, details of specimens collected, a note on altitudinal distribution (Figure 1) and ecology. An artificial key based on the field characters is provided here to facilitate easy identification of these species.

Fig.15: A. *Rhododendron campanulatum* D. Don; **B.** *Rhododendron wightii* Hook.f.; **C.** *Rhododendron falconeri* Hook.f.; **D.** *Rhododendron hodgsonii* Hook. f.; **E.** *Rhododendron lanatum* Hook. f.; **F.** *Rhododendron lepidotum* Wall. ex G. Don **G.** *Rhododendron pendulum* Hook.f.; **H.** *Rhododendron thomsonii* Hook.f.

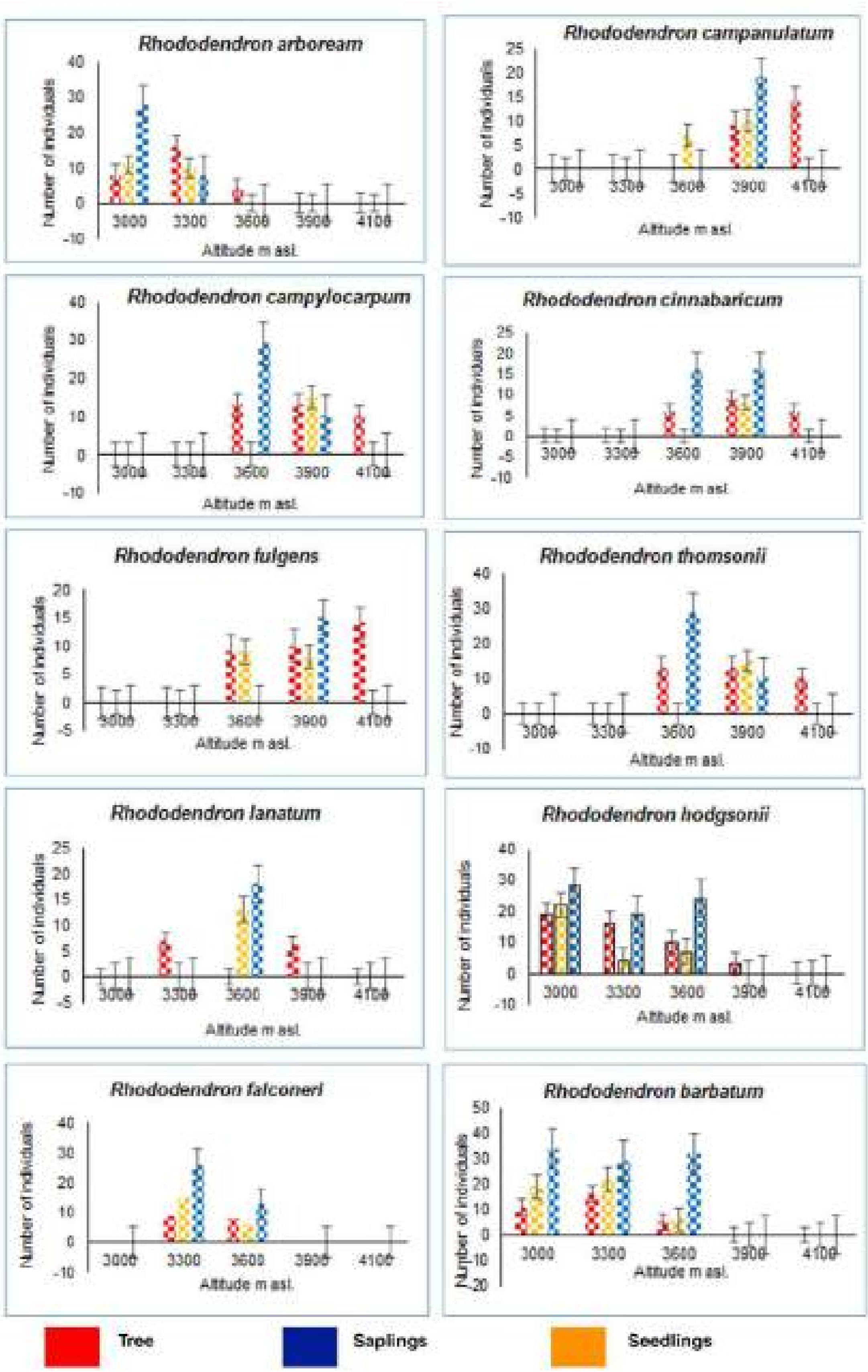


Fig.16: Regeneration pattern of *Rhododendron* species in different altitude of Dzongri Gochela Trekking corridor.

TREE

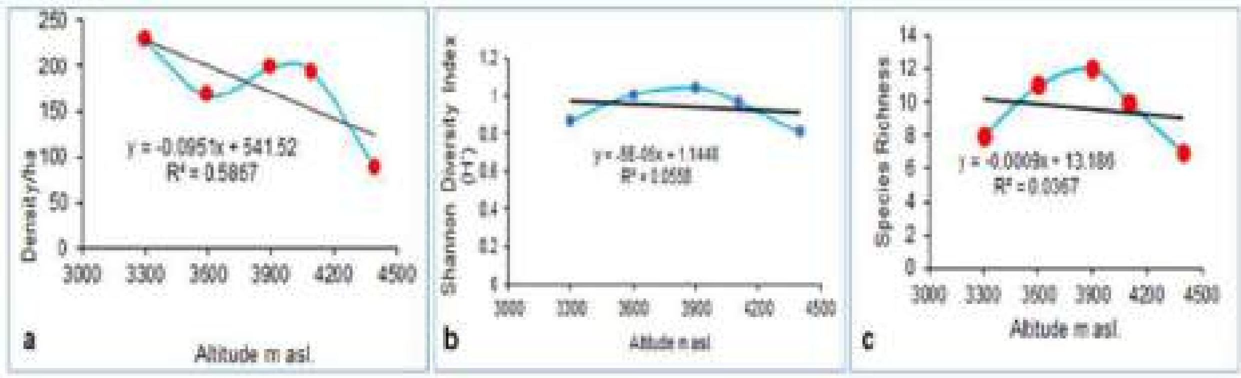


Fig.17: Correlation between Rhododendron tree Density/ha (a), species diversity (b) and species richness (c) along with altitudinal gradient of Dzongri Gocha La trekking corridor, Sikkim.

SAPLINGS

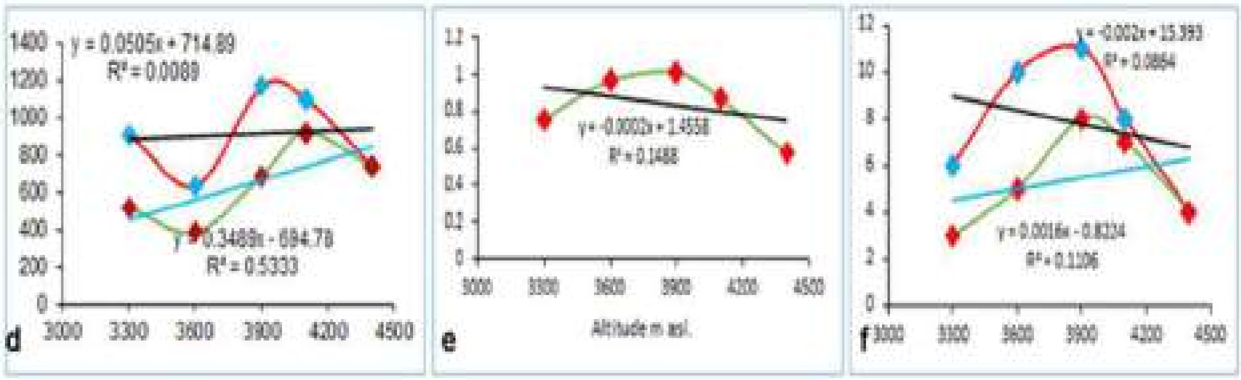


Fig.18: Correlation between Rhododendron saplings Density/ha (d), species diversity (e) and species richness (f) along with altitudinal gradient of Dzongri Gocha La trekking corridor, Sikkim.

SEEDLINGS

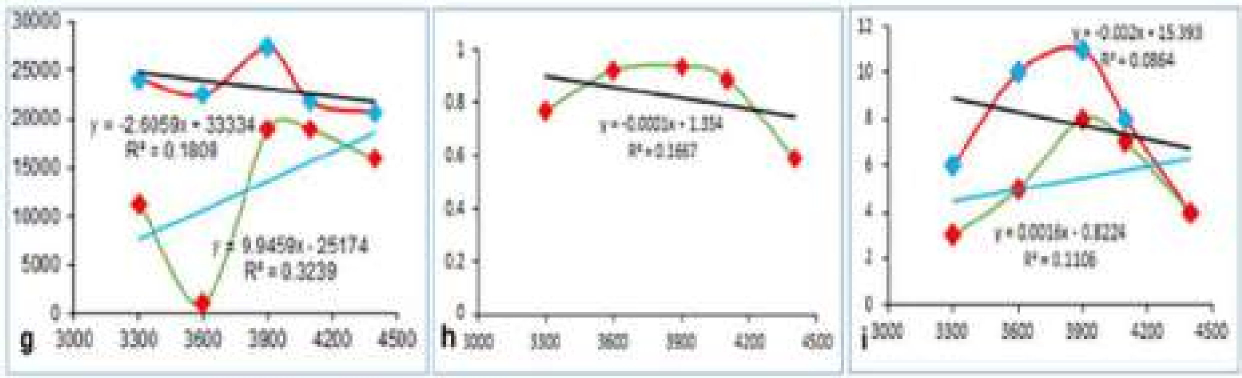


Fig.19: Correlation between Rhododendron seedlings Density/ha (g), species diversity (h) and species richness (i) along with altitudinal gradient of Dzongri Gocha La trekking corridor, Sikkim.

CASE STUDY 4:

COMMUNITY STRUCTURE AND REGENERATION STATUS OF TREE SPECIES IN KYONGNOSLA ALPINE SANCTUARY, EASTERN HIMALAYA, INDIA

Data Analysis

All collected plant specimens were identified with the help of available literature (Bhattacharyya & Sanjappa, 2014; Panda & Sanjappa, 2014; Mao, Dash, & Singh, 2017; Maity, Maiti, & Chauhan, 2018) and also by consulting different herbaria (ARUN, ASSAM, BSHC and CAL). Voucher specimen were prepared following standard procedure (Jain & Rao, 1977) and deposited at Central National Herbarium (CAL). The phytosociological parameters i.e., frequency, density, abundance, total basal area, and their relative values were calculated from pooled quadrate data (Misra, 1968). Importance value index (IVI) was calculated by summing up the relative values of density (RD), frequency (RF), and total basal (TBA) area (Misra, 1968). If a species contributed ≥50% of the total IVI in a particular site/ habitat that site was considered a single species dominated community and if <50% of the total IVI, a mixed community. Species richness was determined as the number of species per unit area (Whittaker, 1972). The distribution patternwas determined by the ratio of abundance to frequency. This ratio indicates regular (<0.025), random (0.025 to 0.05) and contagious (>0.05) distributions (Odum, 1971). Regeneration status of species was totally based on population size of seedlings and saplings (Malik & Bhatt, 2016; Sharma, Mishra, Tiwari, Krishan, & Rana, 2018). Good regeneration is when a species is present in seedlings > saplings > mature stages; fair regeneration, when species is present in seedlings > saplings < mature stage; poor regeneration, when the species is present only in sapling stage, but not as seedlings. When a species is present only in mature stage it is considered as not regenerating. Species is considered as new if the species has no adults but only seedlings or saplings.

The diversity (H') was determined by using Shannon-Wiener information index (Shannon & Weaver, 1963) as: H' = - Σni /n log2 ni /n where, ni was the IVI value of a species and n was the sum of total IVI values of all species in that forest type. Simpson's diversity index (Simpson, 1949) was calculated as: D = 1–Cd, where, D = Simpson's diversity and Cd = Simpson's concentration of dominance = (Σni /n)2. Species evenness was calculated using the Shannon evenness index: J′= H′/ln (S) where H′ is the Shannon– Wiener diversity index and S is the number of species (Pielou, 1966). The Shannon evenness index ranges from 0(when one species is dominant) to 1 (when all species are equally abundant). Beta diversity (Whittaker, 1972) was calculated using the formula: β–diversity =(S1-c) / (S2 - c) where S1 is the total number of species in site 1 and S2 total number of species in site 2, c is the total number of species occurring in both sites. Species area curve were calculated using PCCORD V. 7 (McCune & Mefford, 2016). Species area curve was used to evaluate the adequacy of sample size in the plant community.

The species richness and regeneration status of a temperate mixed forest dominated with Rhododensrons and Abis densa was investigated in the Kyangnosla Alpine Sanctuary, Sikkim. The study sites were located between 2800-3800 m asl. and grouped into two altitudinal zones viz., lower (2800-3200 m asl.) and upper (between 3400-3800 m asl.). Three functional groups seedlings, saplings and adult trees were sampled to study the regeneration status. The average species richness of trees and saplings was 13.5± 0.7 while in seedlings it was 12.5 ± 0.07. The mean density of seedlings 3609.77 ± 494.39 was maximum followed by saplings (1540 ± 113.13 ha^{-1}) and trees (548.75 ± 8.83 ha^{-1}). Total basal cover ranged from 38.48 ± 2.64 m2 ha-1 for trees, 1.62 ± 0.12 m2 ha-1 for saplings and from 0.86 ± 0.04 m^2 ha^{-1} for seedlings. Fair regeneration was observed in 64.72 % of total species, good regeneration observed in 17.64 % species, while 11.76 % species exhibited poor regeneration and 5.88 % showed no regeneration. Density-diameter distribution exhibited decrease in tree densities towards higher DBH classes. Due to the high anthropogenic pressure in the sanctuary, the regeneration status of the trees in the sanctuary was inadequate, which may result into the decline of tree population.

Result

A total of 17 species belongs to 9 genera and 8 families were recorded from two sampling sites RA [Site-1] and GR [Site-2]. Rhododendron with 9 species was the most dominant genus. Species richness of trees varied from 13-14 (13.5 ± 0.70), saplings 13-14 (13.5 ± 0.70) and seedlings 13-12 (12.5 ± 0.70) at different sites. Total tree density in study sites varied from 542.5-555 ha-1 (548.75 ± 8.83), saplings 1460-1620 ha-1 (1540 ± 113.13) and seedlings 3115.38-4104.16 ha-1 (3609.77 ± 494.39). Tree basal area recorded maximum (40.35 m2 ha-1) at site 1 (RA) and minimum (36.61 m2 ha-1) at site 2 (GR). Average basal area per site for trees, saplings and seedlings found 38.48 ± 2. 64 m^2 ha^{-1}, 1.62 ± 0.12 m^2 ha^{-1} and 0.86 ± 0.04 m^2 ha^{-1} respectively.

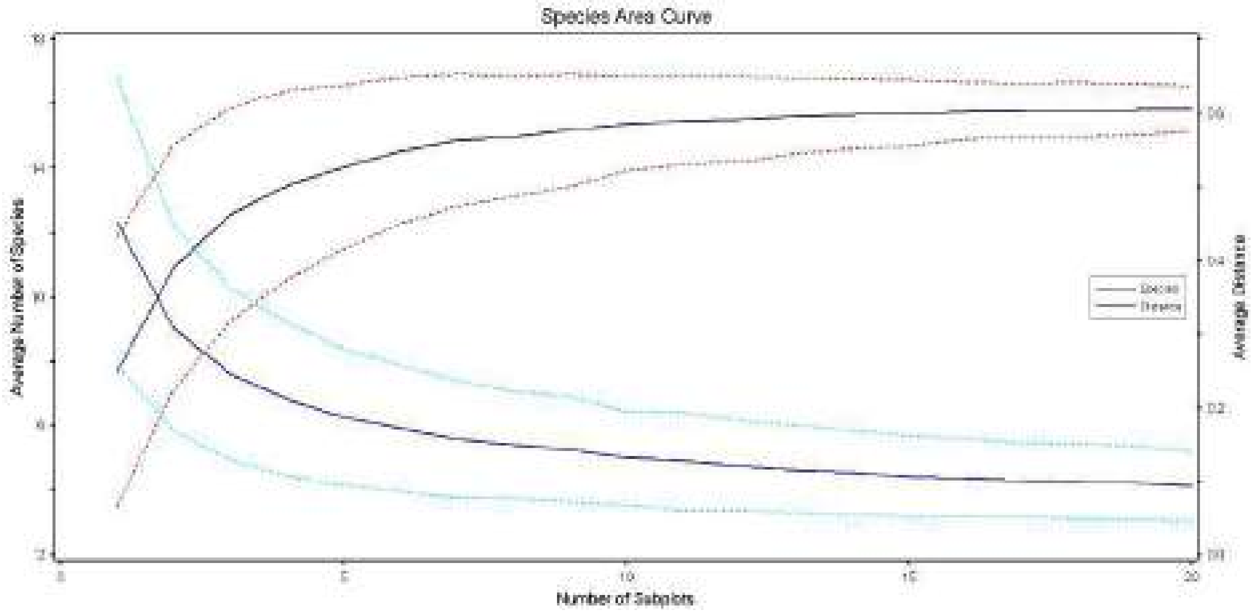
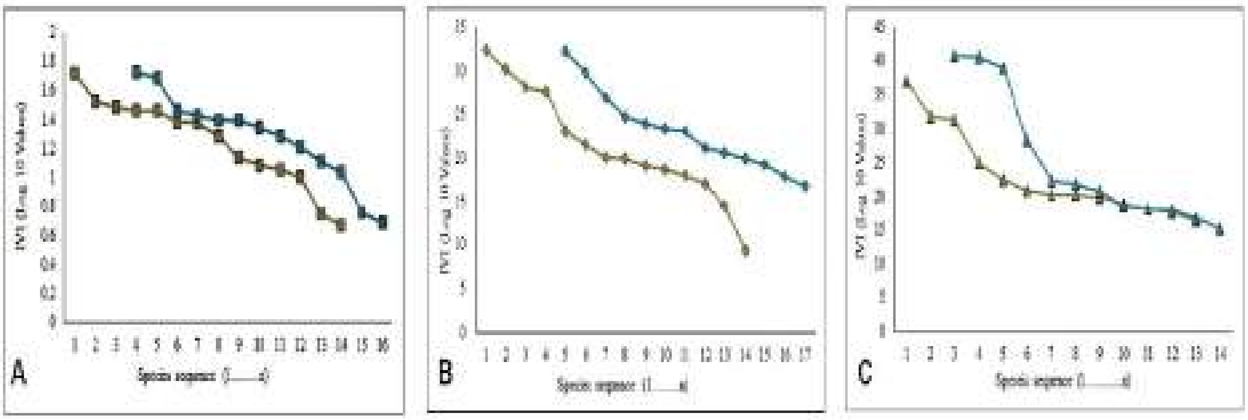


Fig.20: Species area curve based on repeated sub-sampling of a fixed sample (20 sample unit and 17 species)



Remarks: A. Trees B. Saplings and C. Seedlings

Fig.21: Dominance-diversity curves (d-d curve)

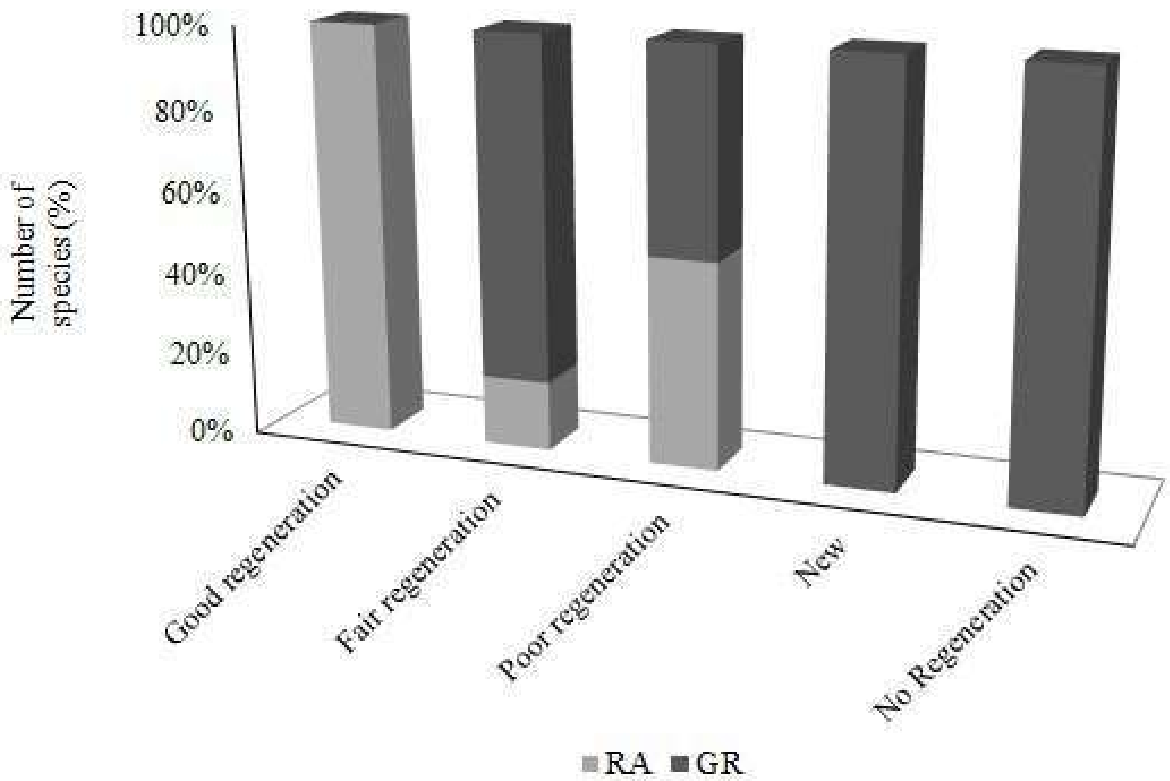


Fig.22: Regeneration status of tree species at various study sites

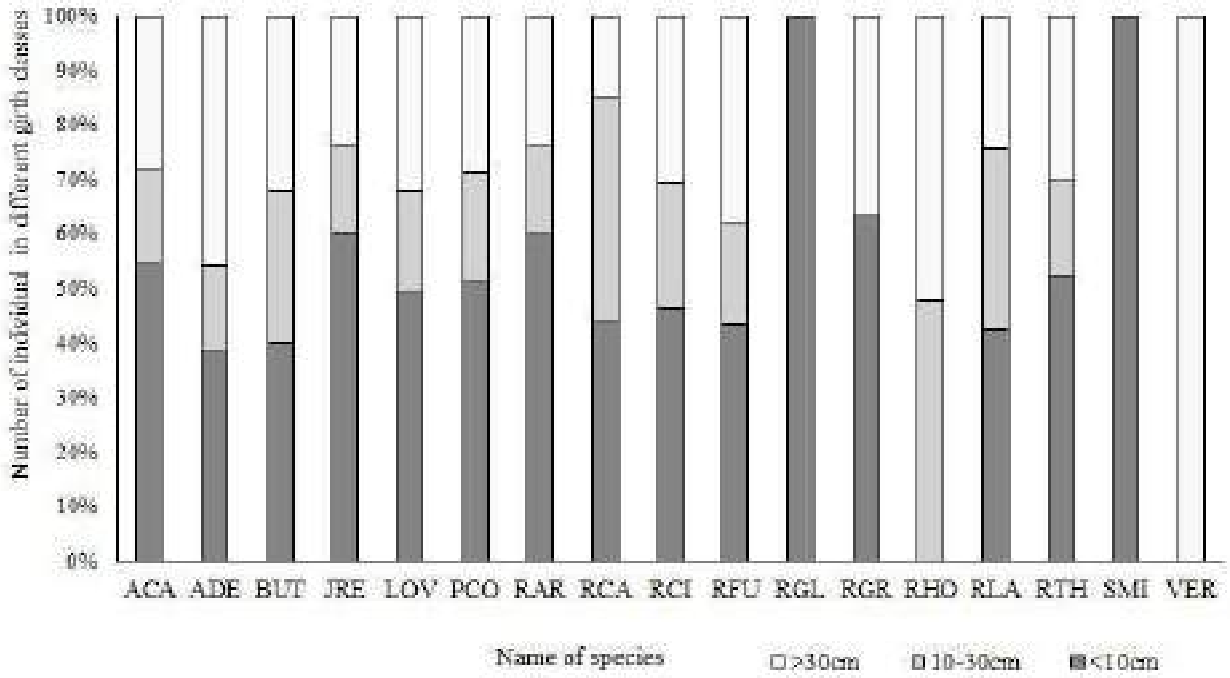


Fig.23: Distributions of tree individuals in different diameter classes

CASE STUDY 5:

Reassessment of Threat Status of *Allium carolinianum* Redouté (Amaryllidaceae)

The present work reassessed the threat status of Allium carolinianum Redouté (Amaryllidaceae) as its population is continuously declining due to different natural and anthropogenic pressures. Geocat online tool was used for the study of the geographical distribution of the species. The species is known to be distributed from Central Asia to Mongolia, and Trans Himalayan countries including India, which is less than five locations of occurrence all around the world (criteria B2(a), IUCN Red list,). Present study revealed the Area of occupancy (AOO) to be 284 Km2 and, hence, the threat status of the species has been upgraded to Endangered (EN) category from Vulnerable (VU) (<500 km2, B2 criteria) following IUCN recommendations. Additional measures such as land use land cover changes (LULC) were recorded as the studied land at many places have been converted to the agricultural land destroying the original habitat of the species (Criteria B2(b3)). Our survey of the literature indicated the distribution of *Allium carolinianum* in several countries of Central Asia (Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Tibet, Uzbekistan, and Xinjiang), Himalayas (Nepal, Pakistan, India) and Mongolia (Nasir 1975; Hara et al. 1978; Zhengyi and Raven 2000; Singh & Sanjappa 2006).

The population of *A. carolinianum* occurs in patches approximately up to 200 m2 and number of individuals in the mentioned area varies from 2 to148. (Sharma et. al., unpublished data). It can survive dry stony slopes, where bulbs of Allium spp. provide anchorage that helps them to withstand in the extreme environment. Our results showed that EOO area exceeds the area designated for the, threatened categories (<20,000 Km2 for vulnerable taxon) and fits within the category of Least concern with an area of 3,413,054.059 km2. The AOO comes under the category ‘Endangered’ (EN) with an area of 284 km2. *Allium carolinianum* is found to be endangered as it follows the criteria B of the IUCN red list. We found that out of criteria B1 and B2, our results indicated this taxon fitting under the B2 criteria as the AOO is less than 500 km2 (IUCN, 2012 criteria B). IUCN listed three more criteria for any species to be declared as endangered, for which our results showed subsistence for criteria B2 (a) and B2 (b3), as Figure 2 shows the occurrence of the taxon in Central Asia to Mongolia and Trans Himalayan countries including India which is less than five locations of occurrence all around the world (supports criteria B2 (a); Jain and Bhownik 2016).

We also found a continuing decline of A. carolinianum population due to natural and anthropogenic interventions (Verma et al. 2008; supports B2(b3)). The extreme harsh climatic conditions with constantly blowing dry wind and heavy snowfall for over six months challenge the survival of the plant. Moreover, poor seedling vigour in this taxon also leads to low adaptability in new habitat (Verma et al. 2008). Our field investigation also noted that migratory livestock of cows, sheep, yaks, goats, donkeys, mules and other wild animals like wild ass and boars damage the vegetation by overgrazing.

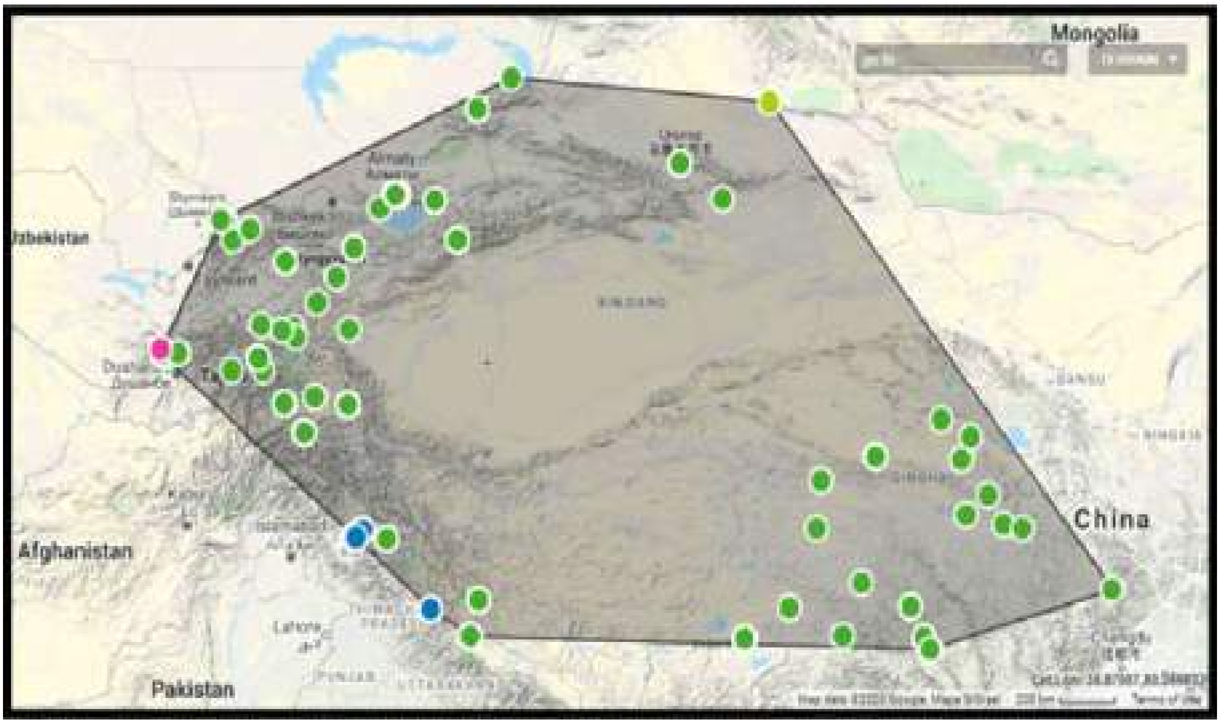


Fig.24: Geo co-ordinates developed from the herbarium study and field data showing Area of occupancy (AOO) and Extent of occurrence (EOO)

CASE STUDY 6:

Threat Assessment of Two Himalayan Endemic Alpine Plant Species and Conservation Implications

Aconitum novoluridum Munz (Ranunculaceae) and *Bistorta longispicata* Yonek. & H. Ohashi (Polygonaceae), a narrow endemic plant species confined to the Himalayas. The present study assesses the threat status of these species using the criteria of the IUCN Red List of Threatened Species based on the available occurrence records, and both species currently categorized as the "Endangered". As the species is simultaneously experiencing various threats and the known distribution range is relatively narrower, it is the right time to develop conservation strategies for the sustainable utilization of these narrow endemic alpine plant species of the Himalayas.

Experimental methods

During the survey, the geographic coordinates of each population of the chosen alpine plant species were noted. Additionally, using Google Earth Pro software, the latitude and longitude information of previously collected plant specimens found in the herbariums of the Central National Herbarium (CAL), Sikkim Himalaya Regional Centre, Gangtok (BSHC), Eastern Regional Centre, Shillong (ASSAM), and Arunachal Pradesh regional center, Itanagar (ARUN) was extracted. In addition to the above-mentioned, the herbarium sheets that were deposited in the international herbarium were accessed through the global plant database management systems Global Plants JSTOR (https://plants.jstor.org), Global Biodiversity Information Facility (GBIF, https://www.gbif.org), Kew Herbarium Catalogue (https://apps.kew.org), etc. The Geospatial Conservation Assessment Tool (GeoCAT) was used to assess the worldwide range of a species using the geographic coordinates of all the acquired localities and herbarium data. IUCN Categories (2019) and Criteria B1 and B2 were used to calculate the extent of occurrence (EOO) and area of occupancy (AOO) using the GeoCAT as an extension for ArcView 3.x, version 1.2. There are three main criteria that were categorized, i.e., Critically Endangered, Endangered, and Vulnerable.
During our studies, we were able to locate eight subpopulations of *Aconitum novoluridum* in Kyongnosla Alpine Sanctuary, Sikkim and its surrounding areas like Tsongmo lake, Memencho lake (GPS coordinates: N 27°.379, E 88°.863; N 27°.422, E 88°.801; N 27°.421, E 88°.805; N 27°.378, E 88°.725; N 27°.408, E 88°.776; N 27°.404, E 88°.759; N 27°.377, E 88°.723; N 27°.348, E 88°.818). According to the GPS coordinates, the extent of occurrence (EOO) of the species *Aconitum novoluridum* was calculated to be 60.46 km^2, and the area of occupancy (AOO) 24 km^2. With the currently available information, the threat status for *Aconitum novoluridum* in Indian perspective can be assessed as 'Endangered' [EN B1ab(iii)+2ab(iii)] in Indian perspective. *Bistorta longispicata* Yonek. & H. Ohashi was first reported from India by Lahiri et al., (2019) from West Sikkim near Samiti Lake area at the altitude 4300 m. This is the only known location of this species during the present study reported in 6 fragmented small location belonging to 2–7 individuals each. The species is dwindling in its natural habitat due to several anthropogenic threat's heavy tourist influx and local grazing. However, Gogoi et al., reported another location near Gurudongmar lake of north Sikkim. Here we consider two sub population of *B. longispicata* spread over seven occurrence points (GPS coordinates: N 27°.541, E 88°.186; N 27°.560, E 88°.188; N 27°.560, E 88°.187; N 27°.560, E 88°.188; N 27°.552, E 88°.187; N 27°.551, E 88°.187; N 28°.018, E 88°.70). According to the GPS coordinates, the extent of occurrence (EOO) of the species *Bistorta longispicata* was calculated to be 51.484 km^2, and the area of occupancy (AOO) 12.000 km^2. With the information presently available, the threat status of *Bistorta longispicata* Yonek. & H. Ohashi in India could be classified as 'Endangered' [EN B1ab (iii) + 2ab (iii)]. The findings of the current study have broad significance in developing effective conservation strategies for this unique species in high-altitude ecosystems of the Himalaya in an era of fast land-use change and climate crises. This study highlights the value of conducting conservation assessments using the most recent regional IUCN Red List recommendations. Following these criteria, our findings reveal the conservation status of all the two evaluated species to be "Endangered."

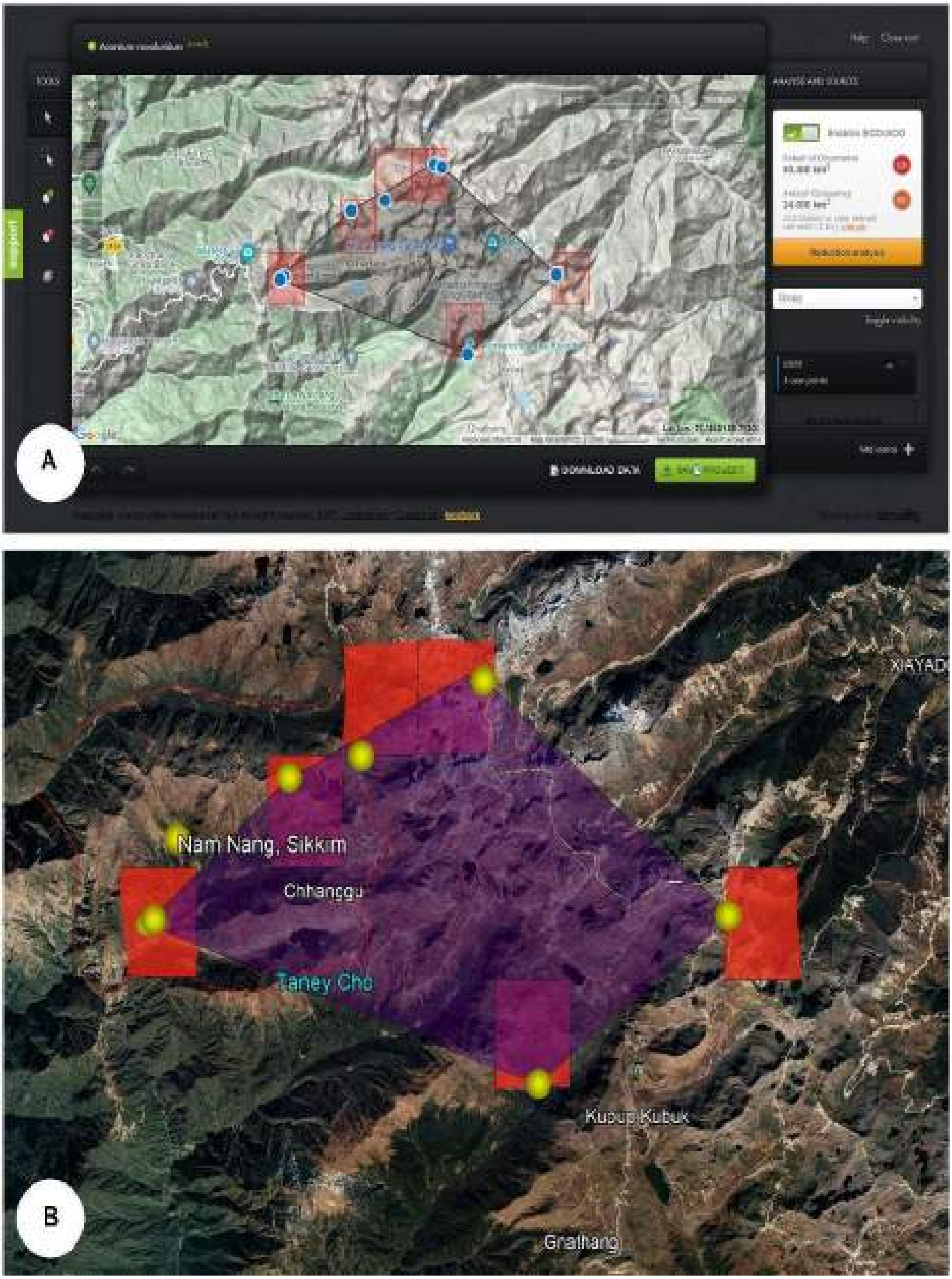


Fig.25: Map showing the geographic range of *A. novoluridum* Munz (a) View in GeoCAT (b) View in Google Earth

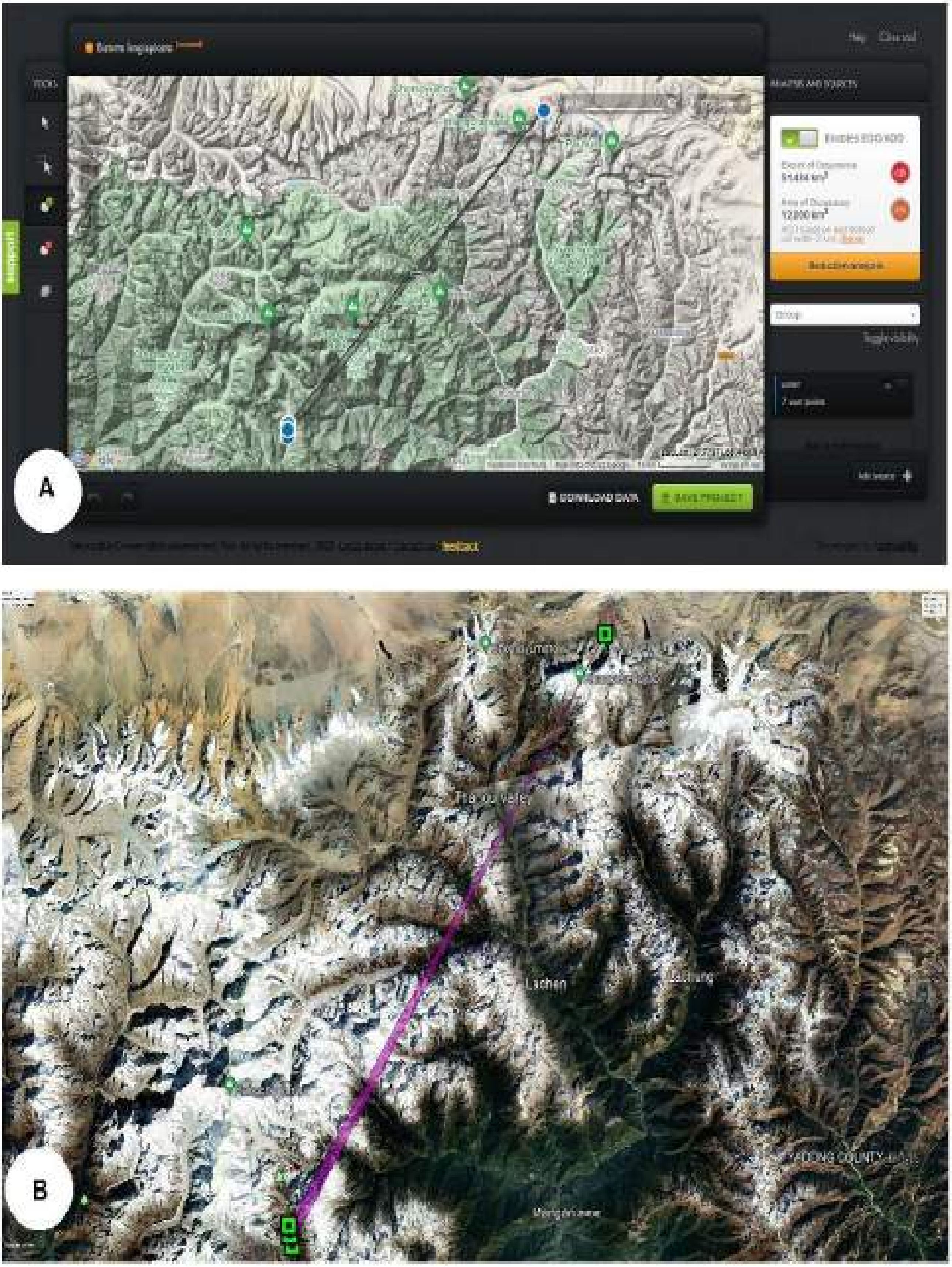


Fig.26: Map showing the geographic range of *B. longispicata* Yonek. & H. Ohashi (a) View in GeoCAT (b) View in Google Earth Map

CASE STUDY 7

Ecological Niche Modelling and habitat suitability prediction: *Gentiana kurroo, Aconitum heterophyllum*, *Jasminum parkeri*, *Phlomoides superba* and *Pittosporum eriocarpum*

Ecological Niche Modelling (ENM) is an effective tool for habitat suitability prediction and analysis of species-specific requirements in its wild habitat. To perform the habitat rehabilitation and species recovery program for the successful recruitment of the selected species in their natural habitats it is necessary to mark the suitable habitat for their plantation. For this purpose, ENM study was conducted for the *Gentiana kurroo, Aconitum heterophyllum, Jasminum parkeri, Phlomoides superba* and *Pittosporum eriocarpum.*

The principle of Species distribution modelling is to relate known locations of a species with the environmental characteristics of these locations in order to estimate the response function and contribution of environmental variables, and predict the potential geographical range of a species. These models estimate the fundamental ecological niche in the environmental space (*i.e.* species response to abiotic environmental factors) and project it onto the geographical space to derive the probability of presence for any given area or, depending on the method, the likelihood that specific environmental conditions are suitable for the target species. Distribution models are used by conservation practitioners to estimate the most suitable areas for a species and infer probability of presence in regions where no systematic surveys are available. They can also assess the potential expansion of introduced species in newly colonized areas estimate the future range of a species under climate change or assist in reserve planning.

MAXENT modelling, is now commonly implemented in conservation-oriented studies. Regional or continent-wide studies are facilitated by the recent availability of global datasets. Environmental layers, such as the global climate variables developed in the WorldClim project, offer continuous description of very large areas. Similarly, the development of open biodiversity databases (see for example the Global Biodiversity Information Facility, GBIF, http://www.gbif.org) increases manifolds the spatial coverage of fieldwork observations that could have been collected by a single project. Such databases usually provide presence-only data that can be handled by modelling methods like MAXENT.

Maxtent software for modelling species niches and distributions by applying a machine-learning technique called maximum entropy modelling. From a set of environmental (e.g., climatic) grids and georeferenced occurance localities, the model expresses a probability distribution where each cell has a predicted suitability of conditions for the species. Under particular assumptions about the input data and biological sampling efforts that led to occurance records, the output can be interpreted as predicted probability of presence (cloglog transform), or as predicted local abundance (raw exponential output).

Species models are determined from a set of environmental or climate layers (or “coverages”) for a set of grid cells in a landscape, together with a set of sample locations where the species has been observed. The model expresses the suitability of each grid cell as a function of the environmental variables at that grid cell. A high value of the function at a particular grid cell indicates that the grid cell is predicted to have suitable conditions for that species. The computed model is a probability distribution over all the grid cells. The distribution chosen is the one that has maximum entropy subject to some constraints: it must have the same expectation for each feature (derived from the environmental layers) as the average over sample locations.

1. Pre-processing of satellite image

a. **Layer stacking:** Based on the work we are going to do we choose the bands of the satellite image and layer stack them. Layers of the same resolution are stack together. We use layer stacking for the formation of the LULC map.

b. **Mosaicking:** Mosaic tool is used to join the different tiles together to form a single image.

c. **Sub setting:** Subset tool is used to cut out the study area from the satellite image and also it is used to avoid the disturbances in the edges of the image.

2. **Image Enhancement:** This process is used to alter the visual impact that the image has on the interpreter in a fashion that improves the information content.

e.g., Contrast Enhancement

7. Image classification: Image classification is the process of assigning land cover classes to pixels. For example, classes include water, urban, forest, agriculture, and grassland.

There are two type of classification we generally use in remote sensing.

1. Supervised classification: In supervised classification, you select representative samples for each land cover class. The software then uses these "training sites" and applies them to the entire image.
2. Unsupervised classification: In unsupervised classification, it first groups pixels into "clusters" based on their properties. Then, you classify each cluster with a land cover class.

<u>Ecological niche modelling results for *Gentiana kurroo*</u>:

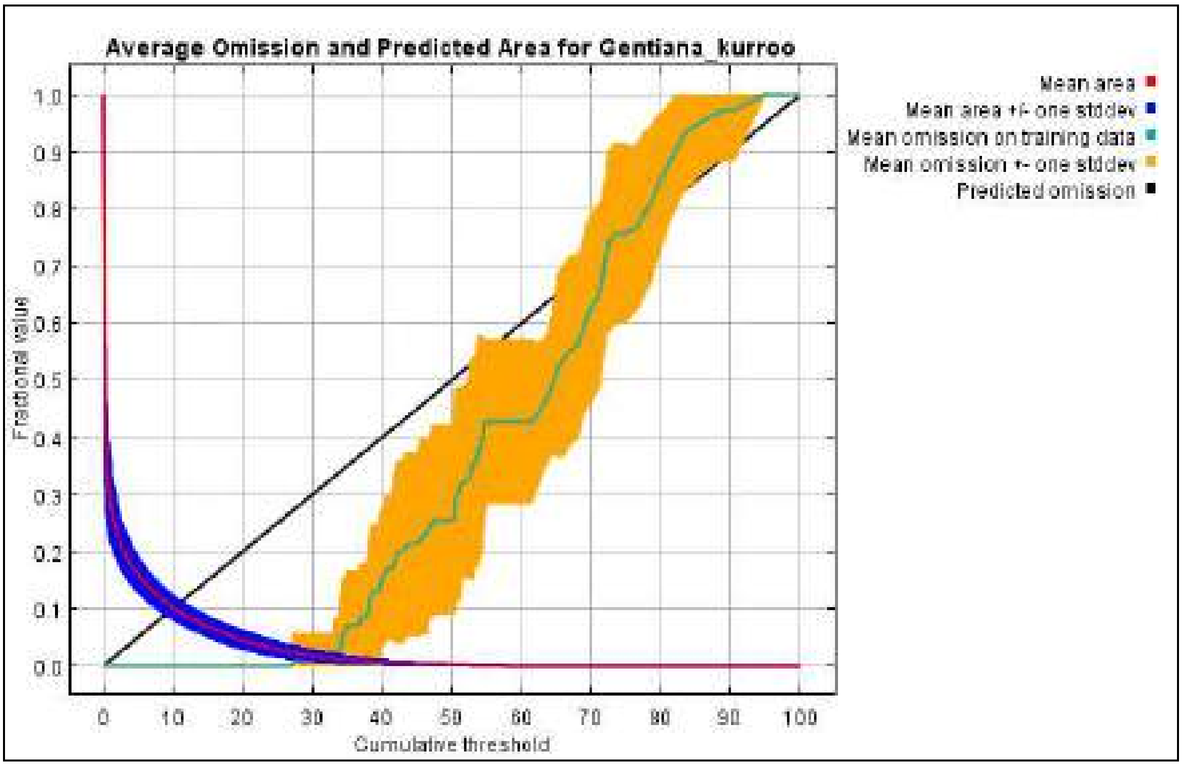


Fig. 27. Average omission and predicted area for *Gentiana Kurroo*

Analysis of omission/commission

The following picture shows the training omission rate and predicted area as a function of the cumulative threshold, averaged over the replicate runs. The next picture is the receiver operating characteristic (ROC) curve for the same data, again averaged over the replicate runs. Note that the specificity is defined using predicted area, rather than true commission (see the paper by Phillips, Anderson and Schapire cited on the help page for discussion of what this means). The average training AUC for the replicate runs is 0.997, and the standard deviation is 0.000.

Analysis of variable contributions

The following table gives estimates of relative contributions of the environmental variables to the Maxent model. To determine the first estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. For the second estimate, for each environmental variable in turn, the values of that variable on training presence and background data are randomly permuted. The model is reevaluated on the permuted data, and the resulting drop in

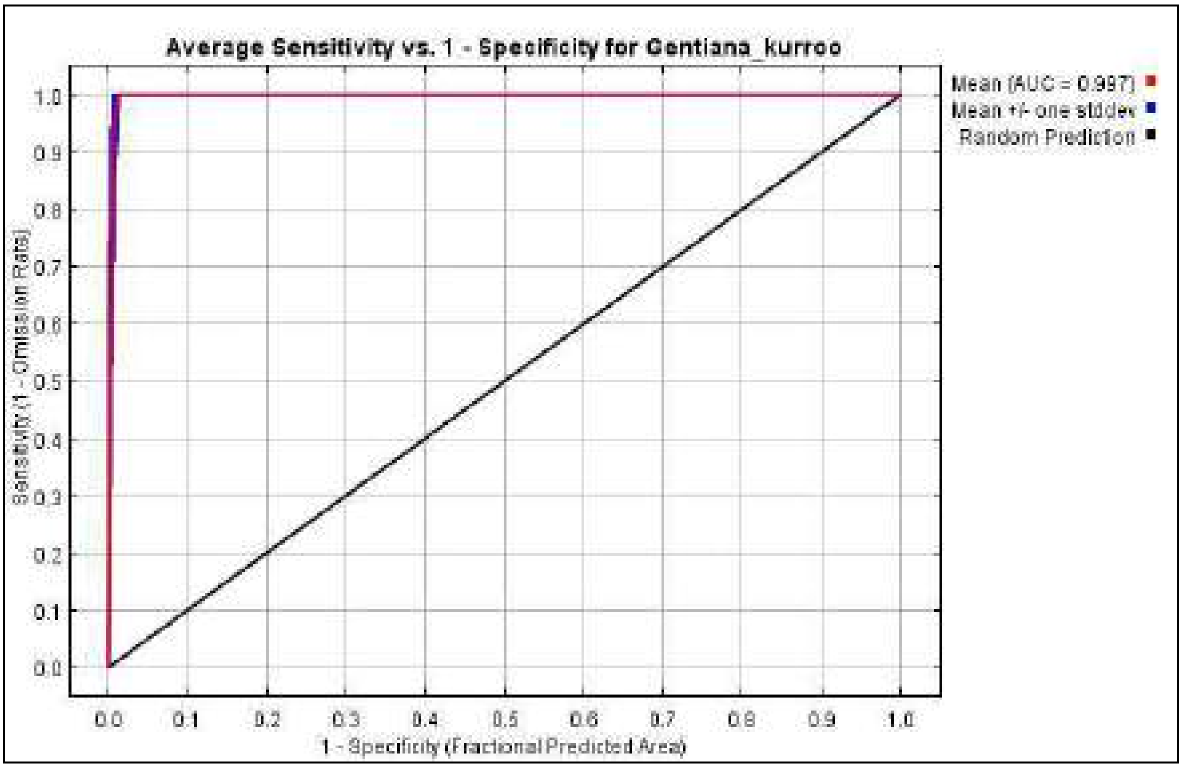


Fig. 28. Average sensivity vs. 1- specificity for *Gentiana Kurroo*

training AUC is shown in the table, normalized to percentages. As with the variable jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

Table. 3: Relative contributions of the environmental variables to the Maxent model

Variable	Percent contribution	Permutation importance
bio_3	37.4	24
bio_17	18.7	27.6
bio_8	16.7	20.9
bio_5	9.1	5.9
bio_13	8.9	0.6
bio_4	4.4	4.6
bio_14	1.3	0.6
bio_7	0.9	0
bio_16	0.7	0.2
bio_19	0.5	0.2
bio_9	0.4	1.6
bio_15	0.4	0.1
bio_6	0.2	10.9
bio_2	0.1	0
bio_11	0	2.3
bio_1	0	0
bio_12	0	0
bio_10	0	0.5
bio_18	0	0

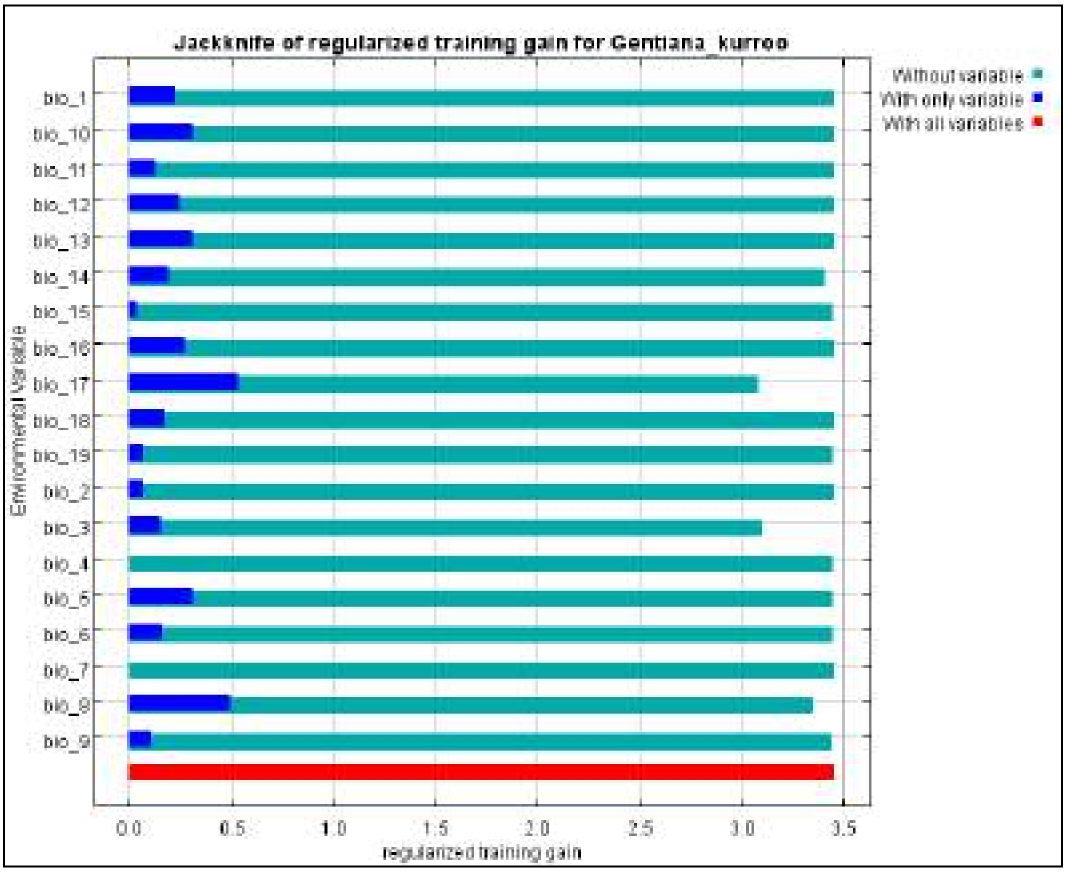


Fig 29. Jackknife of regularized training for *Gentiana kurroo*

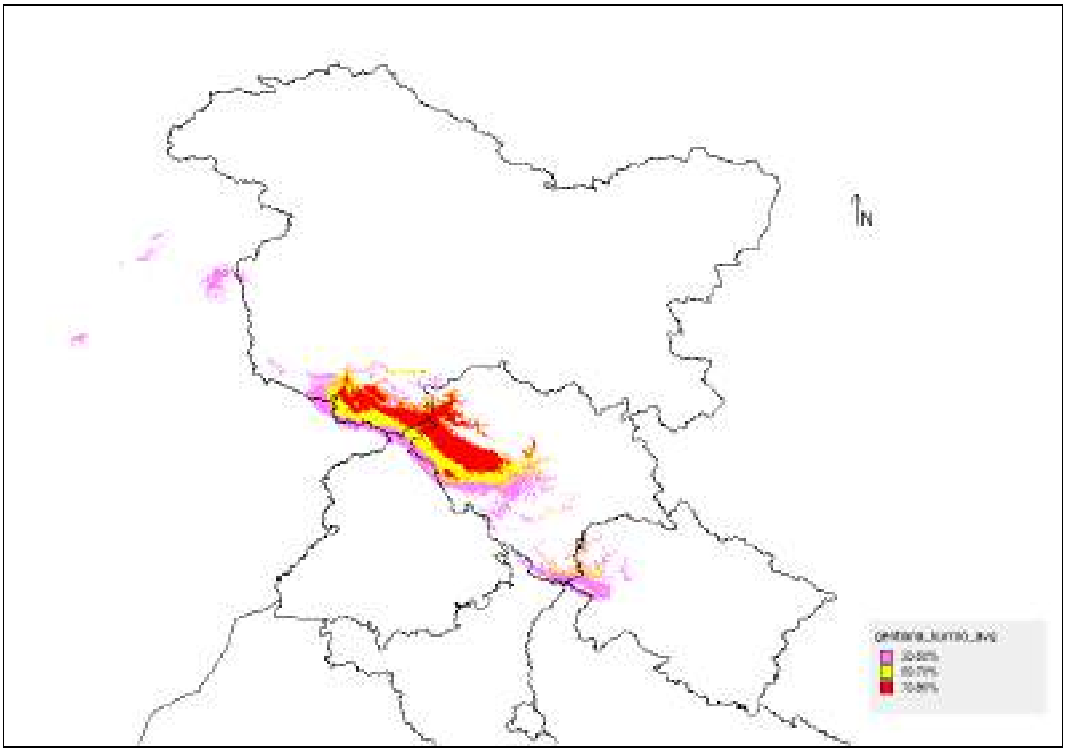


Fig 30. Showing habitat suitability regions for *Gentiana kurroo*

The following picture shows the results of the jackknife test of variable importance. The environmental variable with highest gain when used in isolation is bio_17, which therefore appears to have the most useful information by itself. The environmental variable that decreases

Ecological niche modelling results for *Aconitum heterophyllum*:

Analysis of omission/commission

The following picture shows the training omission rate and predicted area as a function of the cumulative threshold, averaged over the replicate runs.

The next picture is the receiver operating characteristic (ROC) curve for the same data, again averaged over the replicate runs. Note that the specificity is defined using predicted area, rather than true commission (see the paper by Phillips, Anderson and Schapire cited on the help page for discussion of what this means). The average training AUC for the replicate runs is 0.995, and the standard deviation is 0.003.

Analysis of variable contributions

The following table gives estimates of relative contributions of the environmental variables to the Maxent model. To determine the first estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. For the second estimate, for each environmental variable in turn, the values of that variable on training presence and background data are randomly permuted. The model is reevaluated on the permuted data, and the resulting drop in training AUC is shown in the table, normalized to percentages. As with the variable jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

Table. 4: Relative contributions of the environmental variables to the Maxent model

Variable	Percent contribution	Permutation importance
bio_17	34.1	26.2
bio_5	19	10.2
bio_3	13.6	19.6
bio_2	12.9	3.6
bio_7	8	32
bio_15	6.6	0.2
bio_14	2.9	0.1
bio_18	1.1	1
bio_9	0.8	4.8
bio_12	0.4	1.3
bio_8	0.3	0.7
bio_19	0.3	0.3
bio_10	0	0
bio_4	0	0
bio_13	0	0
bio_1	0	0
bio_11	0	0
bio_6	0	0
bio_16	0	0

The following picture shows the results of the jackknife test of variable importance. The environmental variable with highest gain when used in isolation is bio_2, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is bio_3, which therefore appears to have the most information that isn't present in the other variables. Values shown are averages over replicate runs.

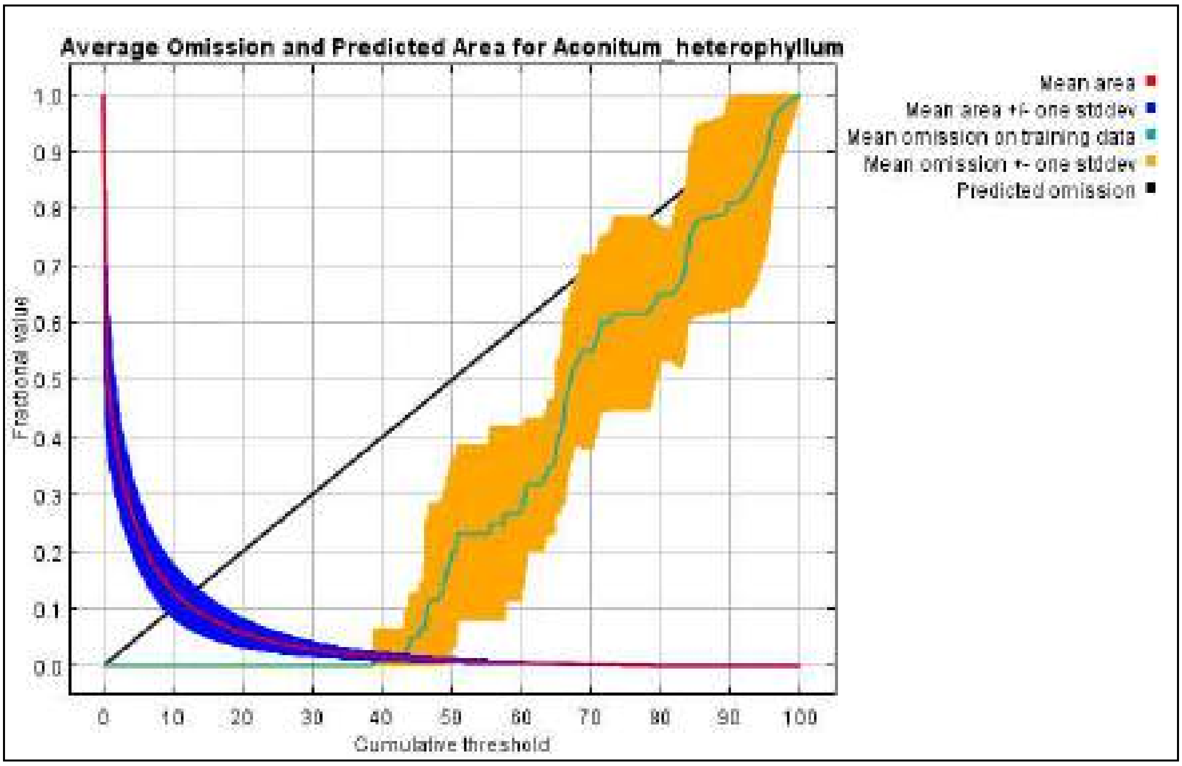


Fig. 31. Average omission and predicted area for *Aconitum heterophyllum*

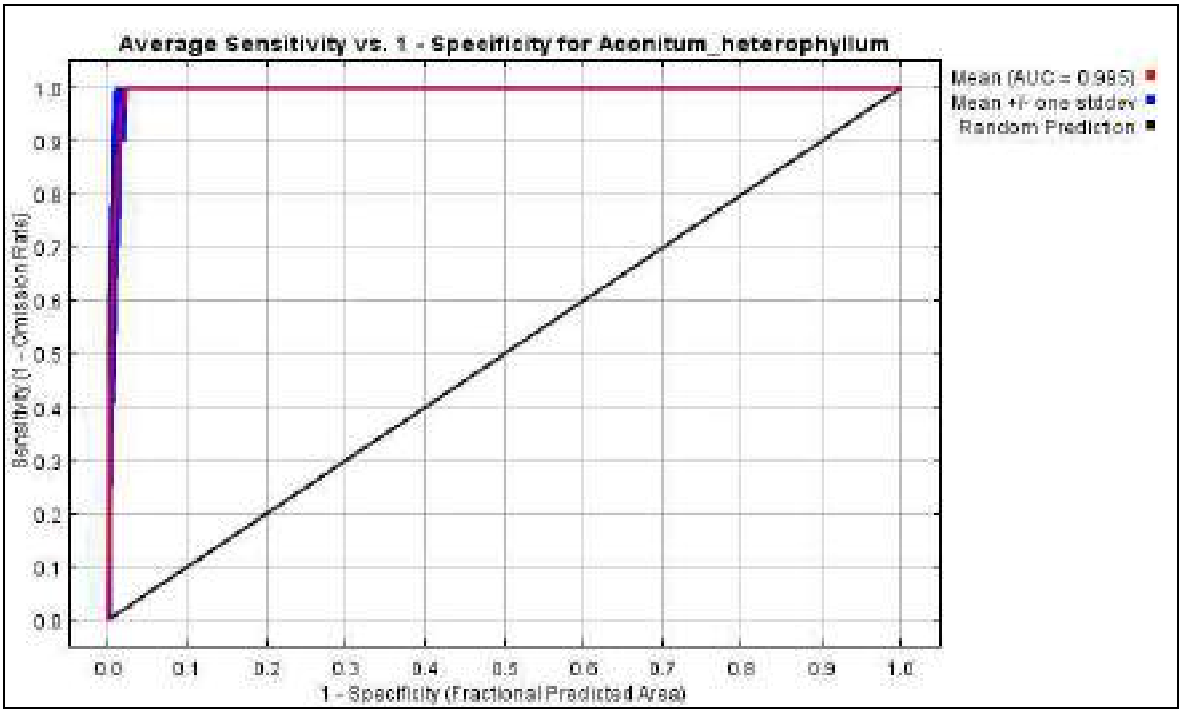


Fig. 32. Average sensivity vs. 1- specificity for *Aconitum heterophyllum*

Fig 33. Jackknife of regularized training for *Aconitum heterophyllum*.

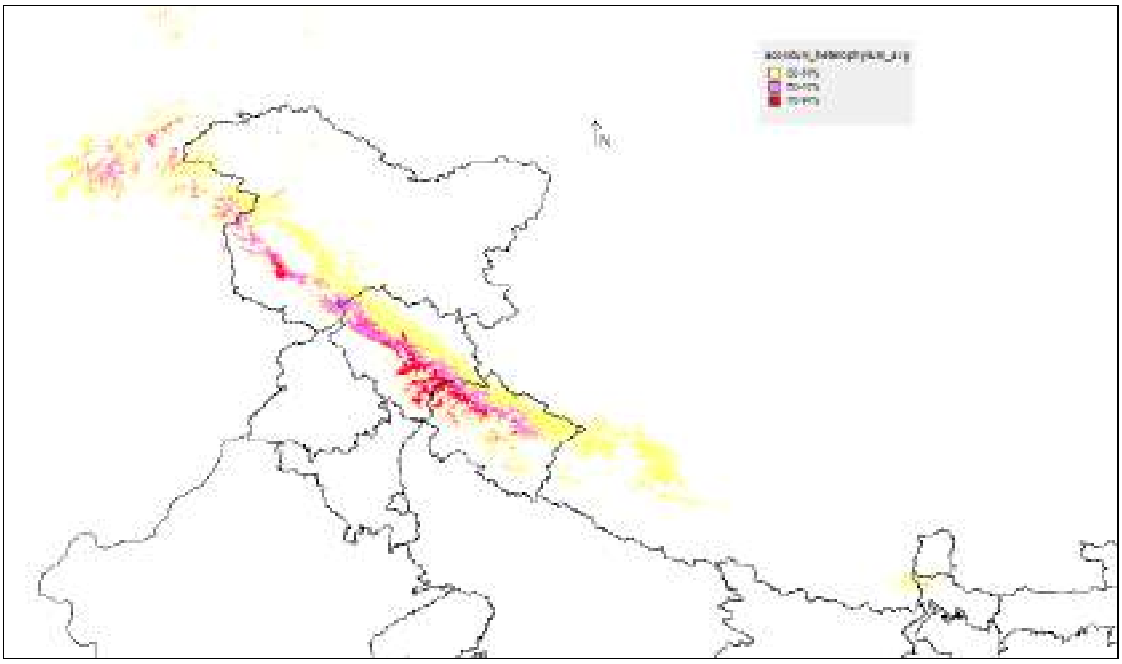


Fig. 34. Showing habitat suitability regions for *Aconitum heterophyllum* predicted through Maxent modeling.

<u>Ecological niche modelling results for *Jasminum parkeri*:</u>

Analysis of omission/commission

The following picture shows the training omission rate and predicted area as a function of the cumulative threshold, averaged over the replicate runs. The next picture is the receiver operating characteristic (ROC) curve for the same data, again averaged over the replicate runs. Note that the specificity is defined using predicted area, rather than true commission (see the paper by Phillips, Anderson and Schapire cited on the help page for discussion of what this means). The average training AUC for the replicate runs is 0.999, and the standard deviation is 0.001.

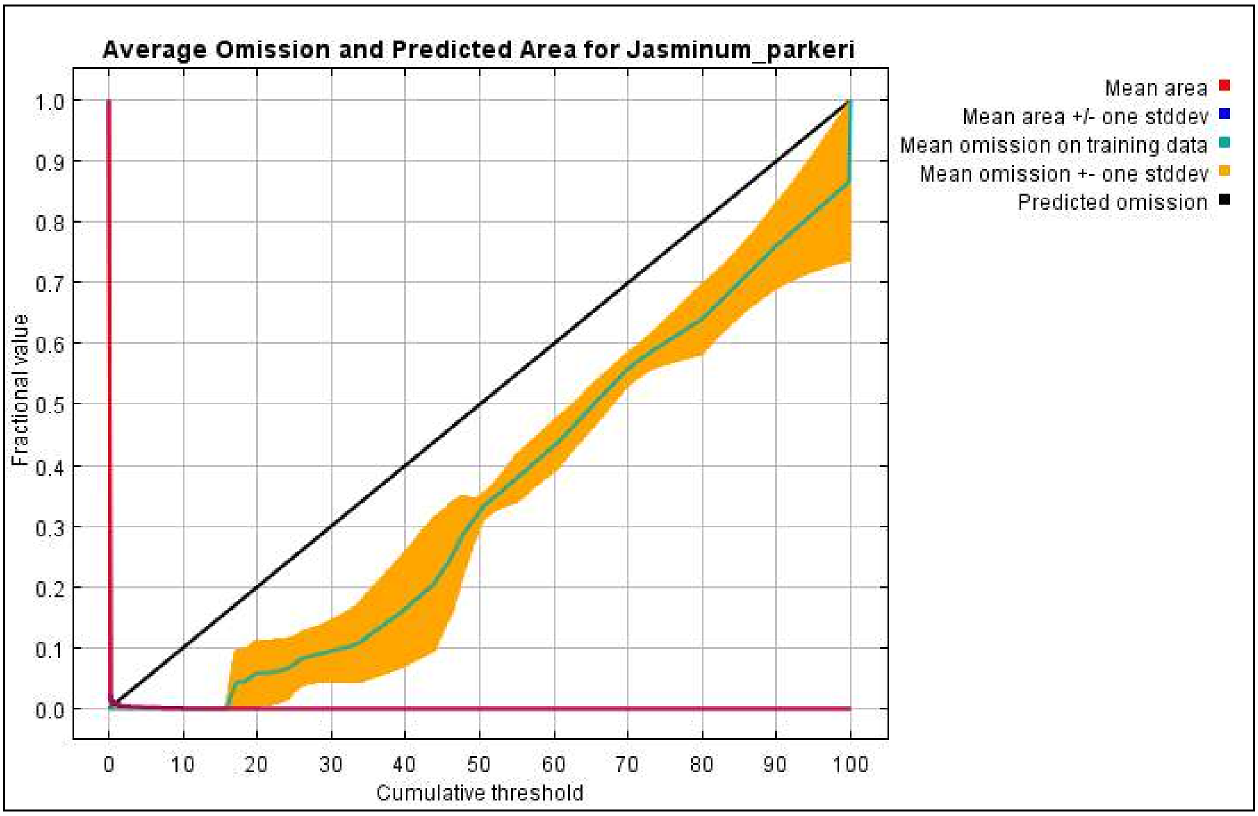


Fig. 35. Average omission and predicted area for *Jasminum parkeri*.

Analysis of variable contributions

The following table gives estimates of relative contributions of the environmental variables to the Maxent model. To determine the first estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. For the second estimate, for each environmental variable in turn, the values of that variable on training presence and background data are randomly permuted. The model is reevaluated on the permuted data, and the resulting drop in training AUC is shown in the table, normalized to percentages. As with the variable jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

The following picture shows the results of the jackknife test of variable importance. The environmental variable with highest gain when used in isolation is bio_2, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is bio_3, which therefore appears to have the most information that is not present in the other variables. Values shown are averages over replicate runs.

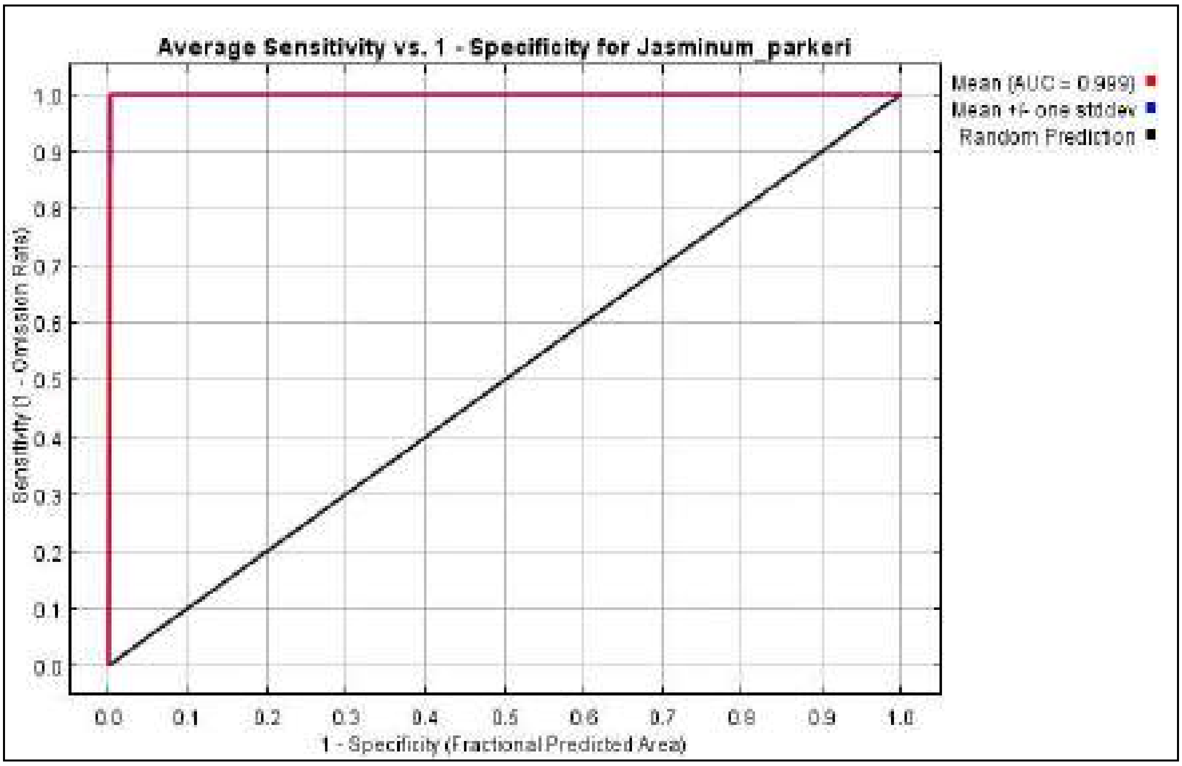


Fig. 36. Average sensivity vs. 1- specificity for *Jasminum parkeri*.

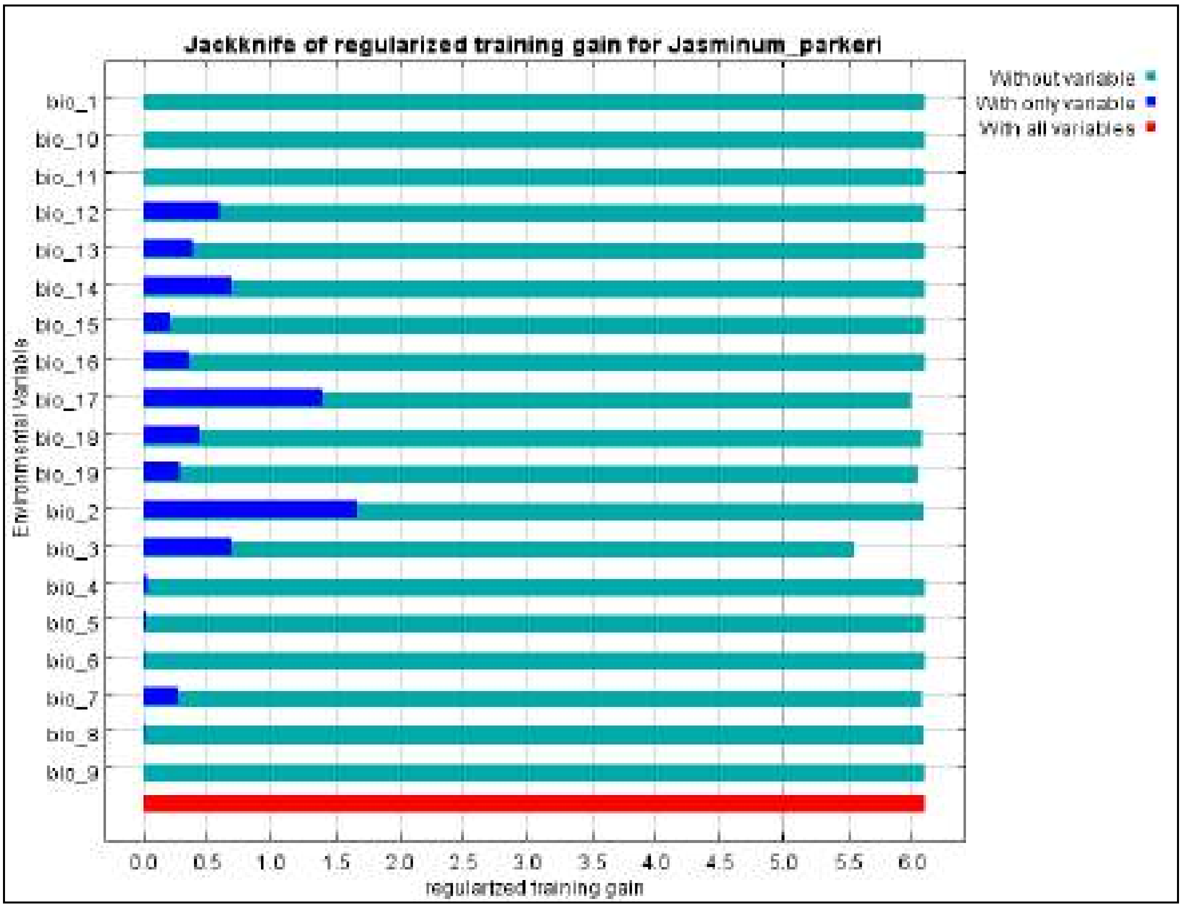


Fig 37. Jackknife of regularized training for *Jasminum parkeri*.

Table. 5: Relative contributions of the environmental variables to the Maxent model

Variable	Percent contribution	Permutation importance
bio_3	39.1	64
bio_17	32	6.3
bio_2	14.8	1
bio_8	7.4	1.3
bio_13	4.8	0
bio_14	0.5	0
bio_18	0.4	0.1
bio_19	0.3	0.8
bio_7	0.2	25.6
bio_4	0.1	0.8
bio_15	0.1	0
bio_1	0.1	0
bio_6	0	0
bio_5	0	0
bio_9	0	0
bio_12	0	0
bio_11	0	0
bio_10	0	0
bio_16	0	0

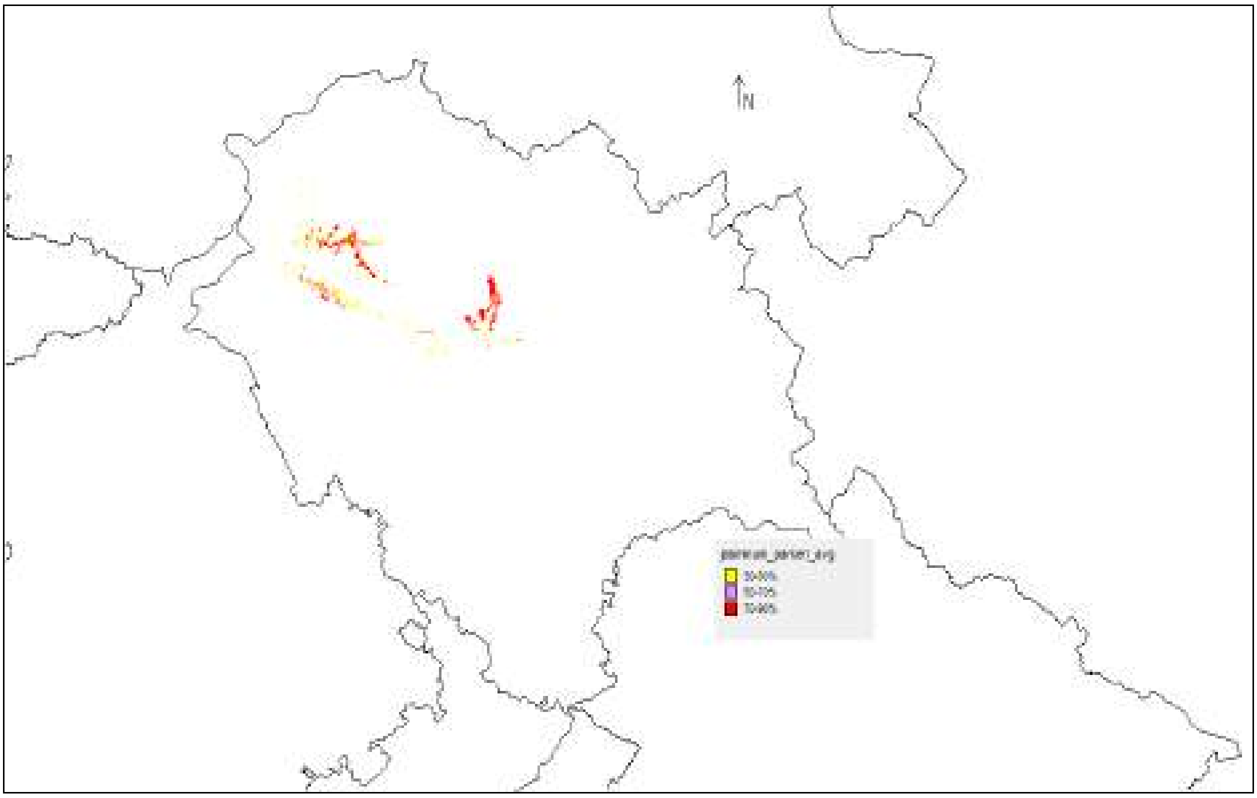


Fig.38. Showing habitat suitability regions for *Jasminum parkeri* predicted through Maxent modeling

Ecological niche modelling results for *Phlomoides superba*:

Analysis of omission/commission

The following picture shows the training omission rate and predicted area as a function of the cumulative threshold, averaged over the replicate runs. The next picture is the receiver operating characteristic (ROC) curve for the same data, again averaged over the replicate runs. Note that the specificity is defined using predicted arearather than true commission (see the paper by Phillips, Anderson and Schapire cited on the help page for discussion of what this means). The average training AUC for the replicate runs is 0.998, and the standard deviation is 0.000.

The following table gives estimates of relative contributions of the environmental variables to the Maxent model. To determine the first estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. For the second estimate, for each environmental variable in turn, the values of that variable on training presence and background data are randomly permuted. The model is reevaluated on the permuted data, and the resulting drop in training AUC is shown in the table, normalized to percentages. As with the variable jackknife, variable contributions should be interpreted with caution when the predictor variables are correlated. Values shown are averages over replicate runs.

The following picture shows the results of the jackknife test of variable importance. The environmental variable with highest gain when used in isolation is bio_17, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is bio_17, which therefore appears to have the most information that isn't present in the other variables. Values shown are averages over replicate runs.

Table. 6. Analysis of variable contributions

Variable	Percent contribution	Permutation importance
bio_17	27.2	5.5
bio_3	23.7	20
bio_6	10.9	21.9
bio_14	9.1	0
h_dem	8.3	33.4
bio_8	8.1	2.1
bio_5	7.2	1.4
canopy_ht	4.6	0.1
bio_10	0.6	0
bio_11	0.3	15.5

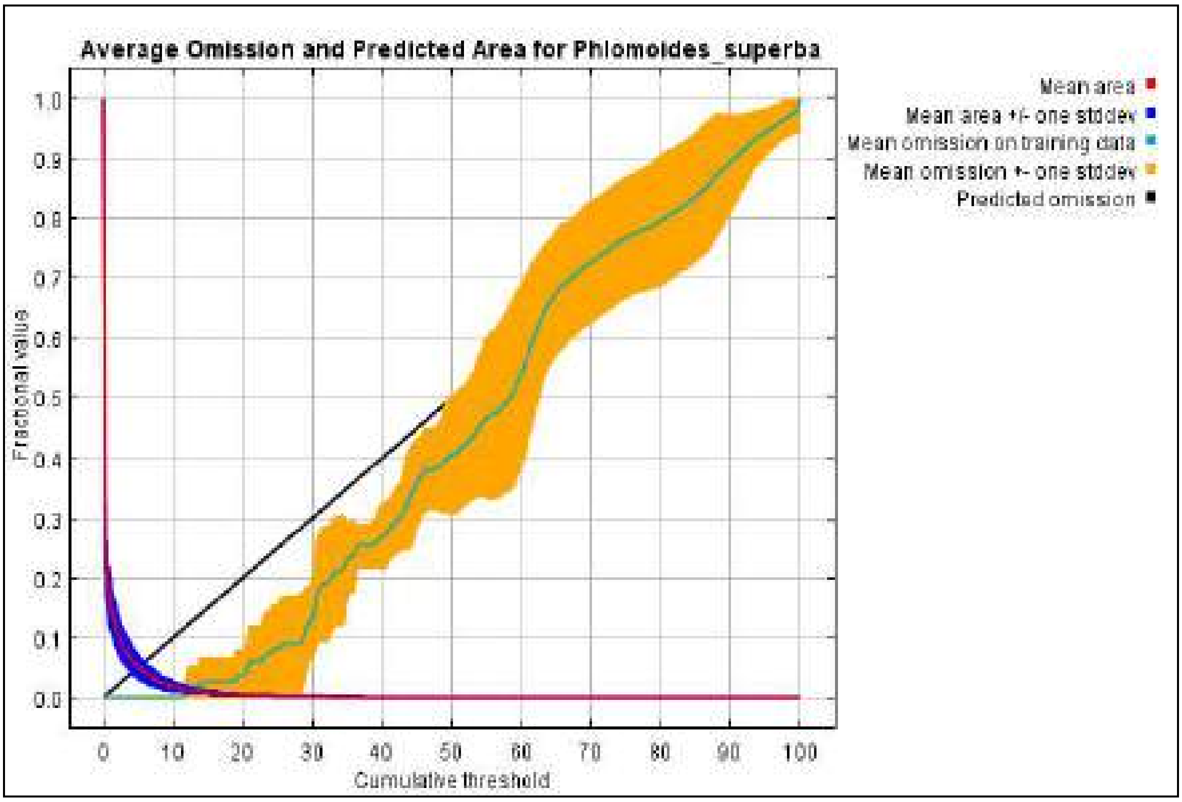


Fig. 39. Average omission and predicted area for *Phlomoides superba*

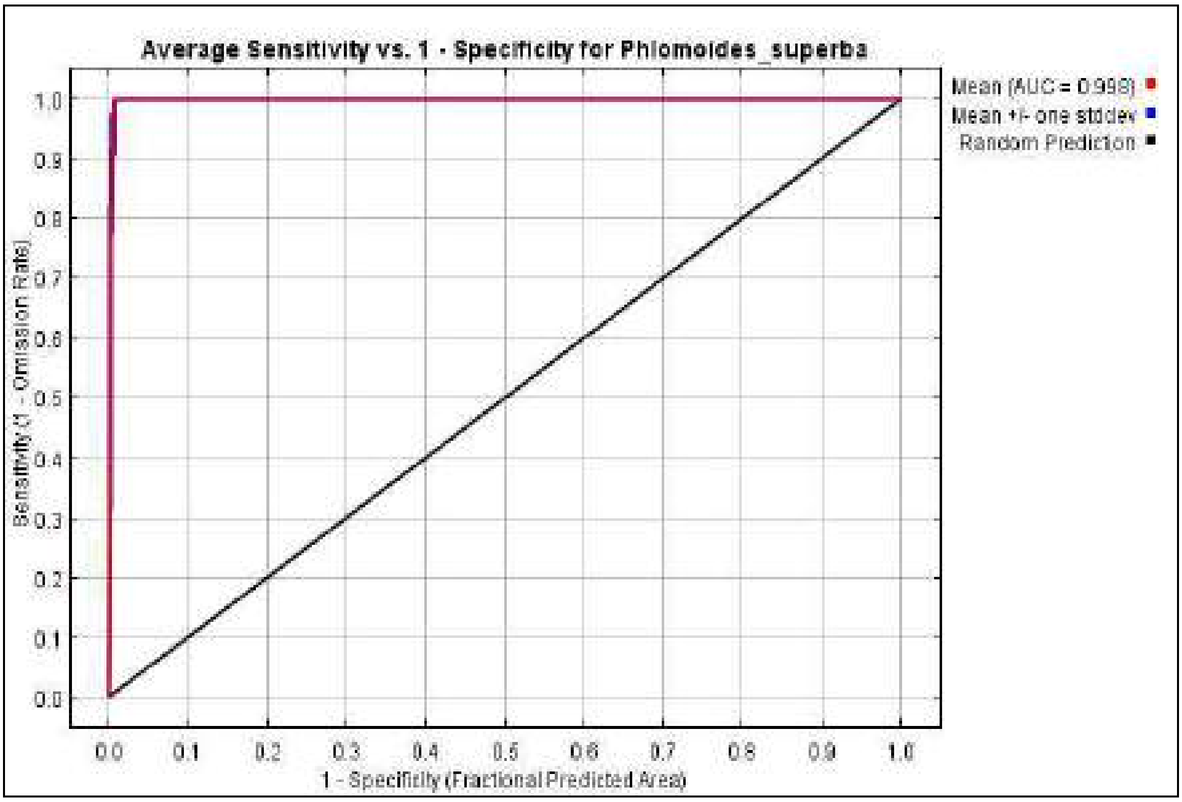


Fig. 40. Average sensivity vs. 1- specificity for *Phlomoides superba*

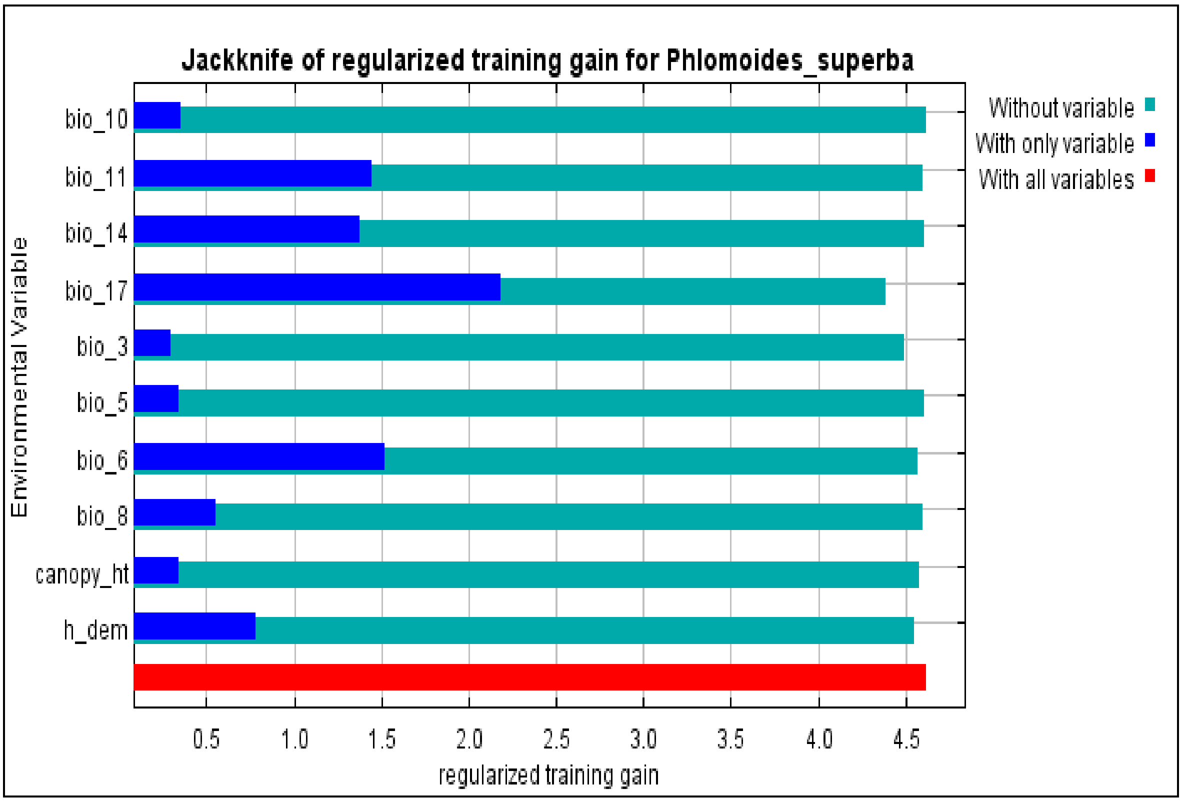


Fig 41. Jackknife of regularized training for *Phlomoides superba*

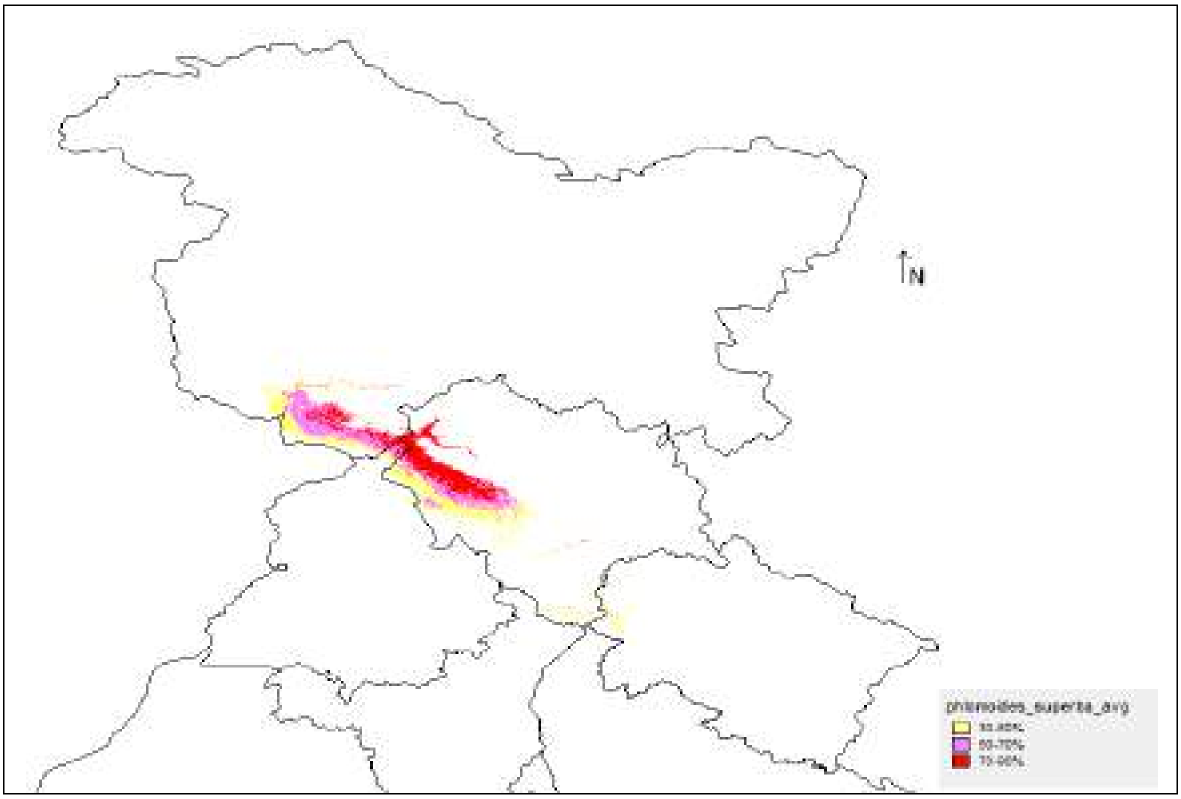


Fig. 42. Showing habitat suitability regions for *Phlomoides superba*

Ecological niche modelling results for *Pittosporum eriocarpum*:

Analysis of omission/commission

The following picture shows the training omission rate and predicted area as a function of the cumulative threshold, averaged over the replicate runs. The next picture is the receiver operating characteristic (ROC) curve for the same data, again averaged over the replicate runs. Note that the specificity is defined using predicted area, rather than true commission (see the paper by Phillips, Anderson and Schapire cited on the help page for discussion of what this means). The average training AUC for the replicate runs is 0.999, and the standard deviation is 0.000.

Analysis of variable contributions

The following table gives estimates of relative contributions of the environmental variables to the Maxent model. To determine the first estimate, in each iteration of the training algorithm, the increase in regularized gain is added to the contribution of the corresponding variable, or subtracted from it if the change to the absolute value of lambda is negative. For the second estimate, for each environmental variable in turn, the values of that variable on training presence and background data are randomly permuted. The model is reevaluated on the permuted data, and the resulting drop in training AUC is shown in the table, normalized to percentages.

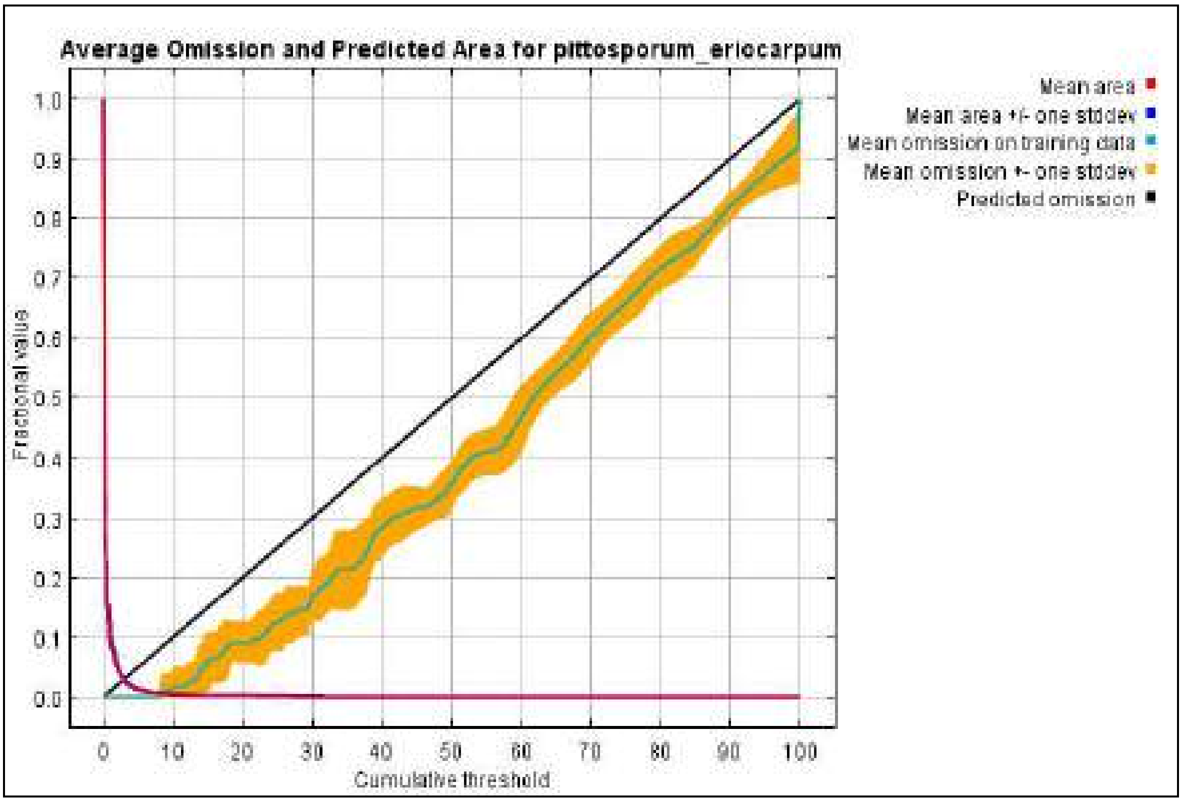


Fig. 42. Average omission and predicted area for *Pittosporum eriocarpum*

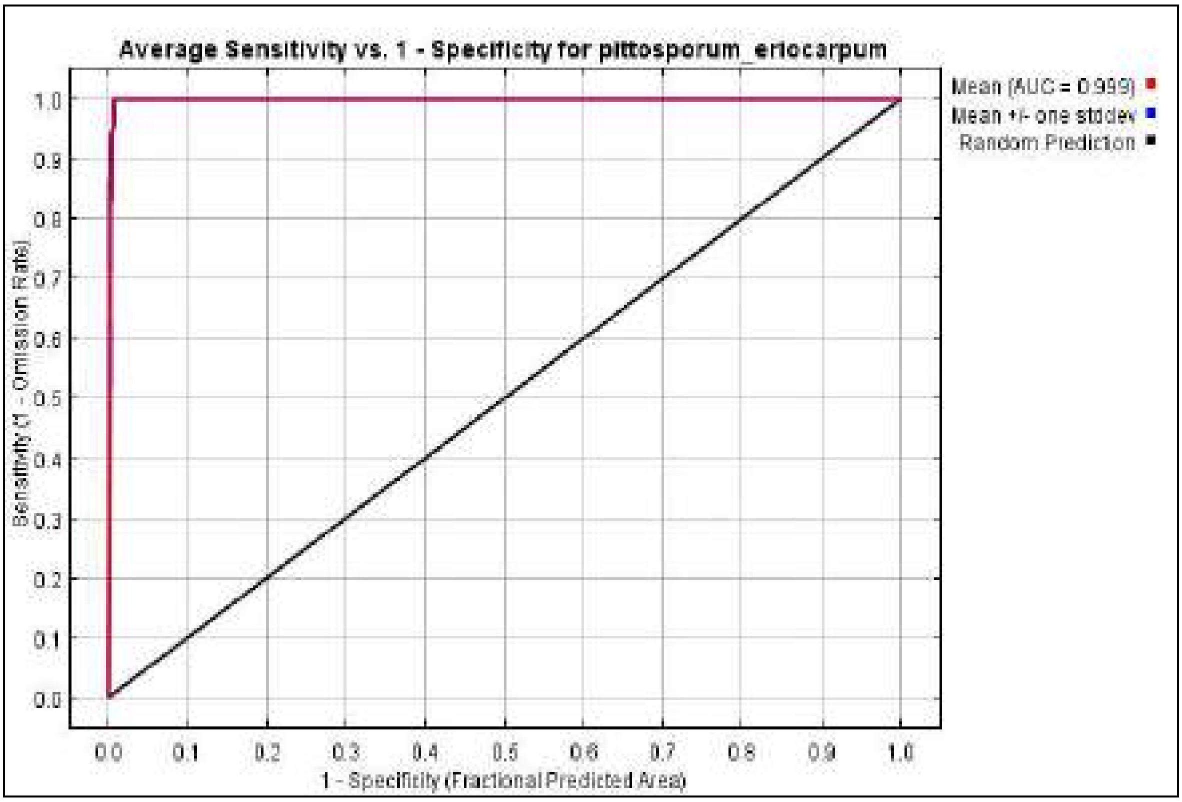


Fig. 43. Average sensivity vs. 1- specificity for *Pittosporum eriocarpum*

Table. 7. Analysis of variable contributions

Variable	Percent contribution	Permutation importance
bio_17	60.1	18.9
bio_15	17.6	2.7
h_dem	7.4	1.3
bio_18	6.9	0
bio_13	2.7	0
bio_19	2.3	0.1
bio_6	1.6	74.4
bio_14	1.2	0.5
bio_2	0.2	2.1
bio_11	0.1	0

The following picture shows the results of the jackknife test of variable importance. The environmental variable with highest gain when used in isolation is bio_17, which therefore appears to have the most useful information by itself. The environmental variable that decreases the gain the most when it is omitted is bio_17, which therefore appears to have the most information that isn't present in the other variables. Values shown are averages over replicate runs.

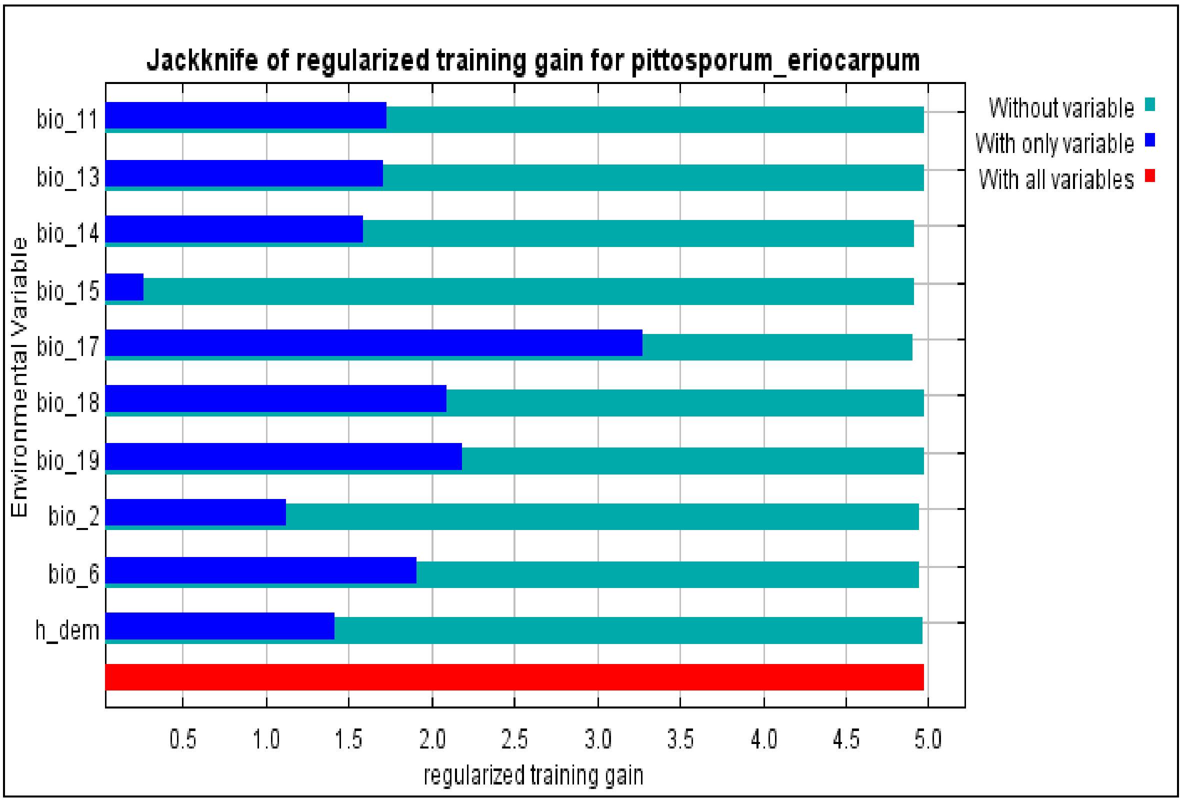


Fig 44. Jackknife of regularized training for

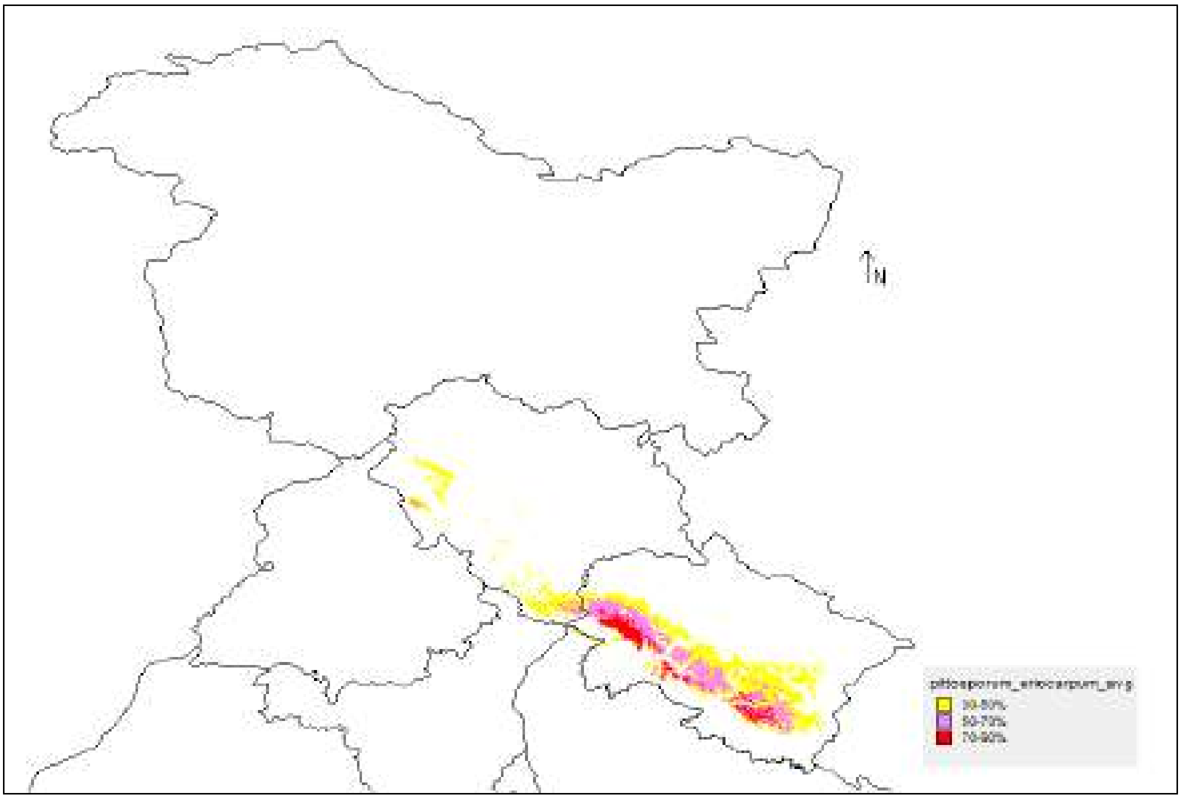


Fig.45. Showing habitat suitability regions for *Pittosporum eriocarpum* predicted through Maxent modeling

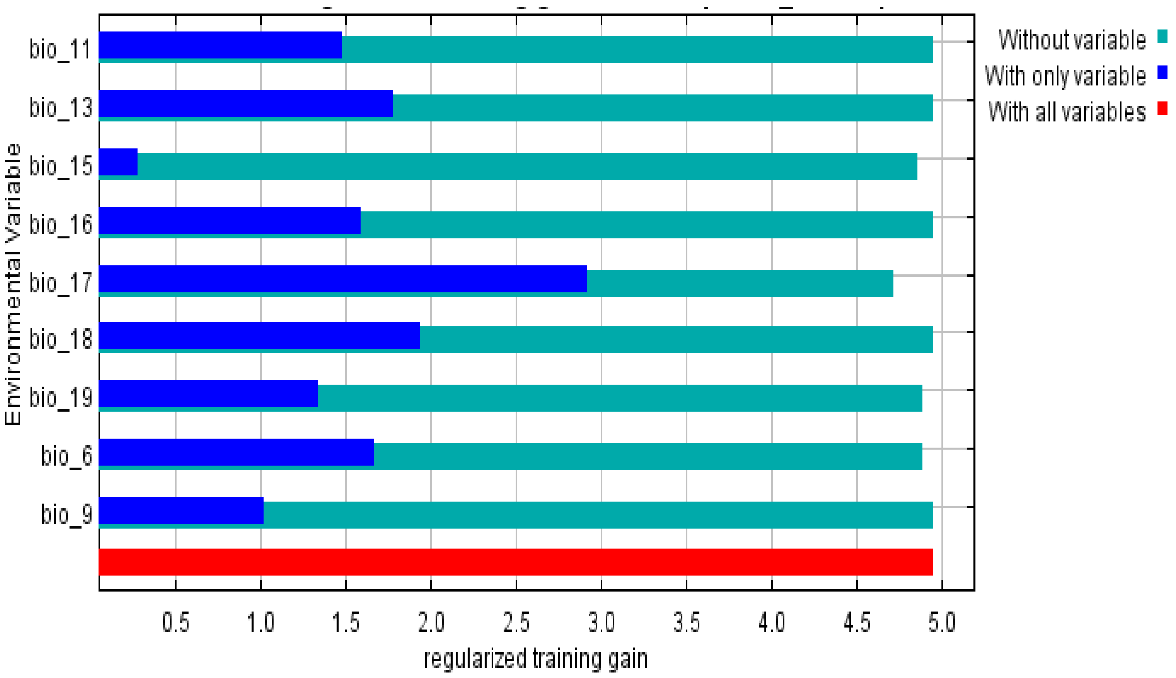


Fig.46. Relative predictive power of different bioclimatic variables based on the jackknife of regularized training gain in Maxent models

Table.8. Selected environmental variables and their percent contribution in Maxent model in India

Environment variable	Percent Contribution
Precipitation of Driest Quarter (bio-17)	40
Precipitation seasonality (bio-15)	15.4
Precipitation of wettest month (bio-13)	14
Minimum temperature of coldest month (bio-6)	12.5
Minimum temperature of coldest quarter (bio-11)	11.3
Precipitation of warmest quarter (bio-18)	4.6
Precipitation of coldest quarter (bio-19)	0.8
Precipitation of wettest quarter (bio-16)	0.8
Mean temperature of warmest quarter (bio-9)	0.7

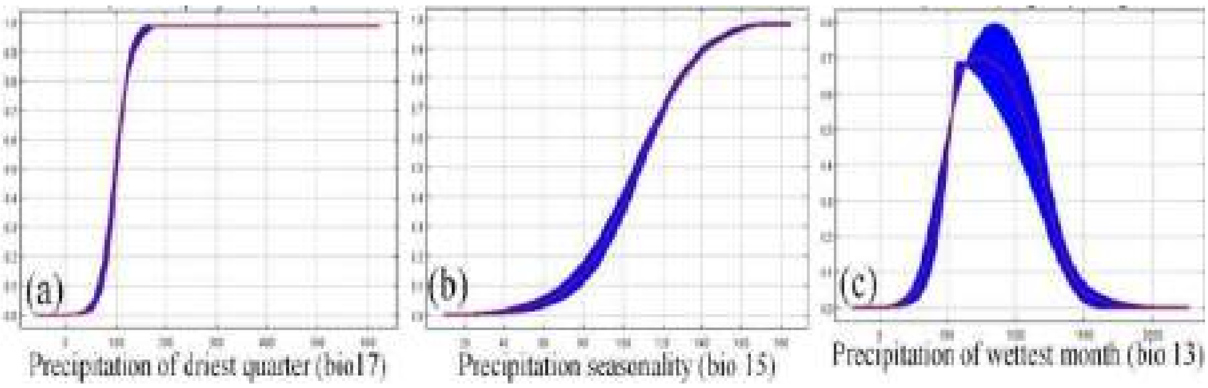


Fig. 47. Response curves showing the relationship between the probability of presence of a species and top three bioclimatic variables (a-c)

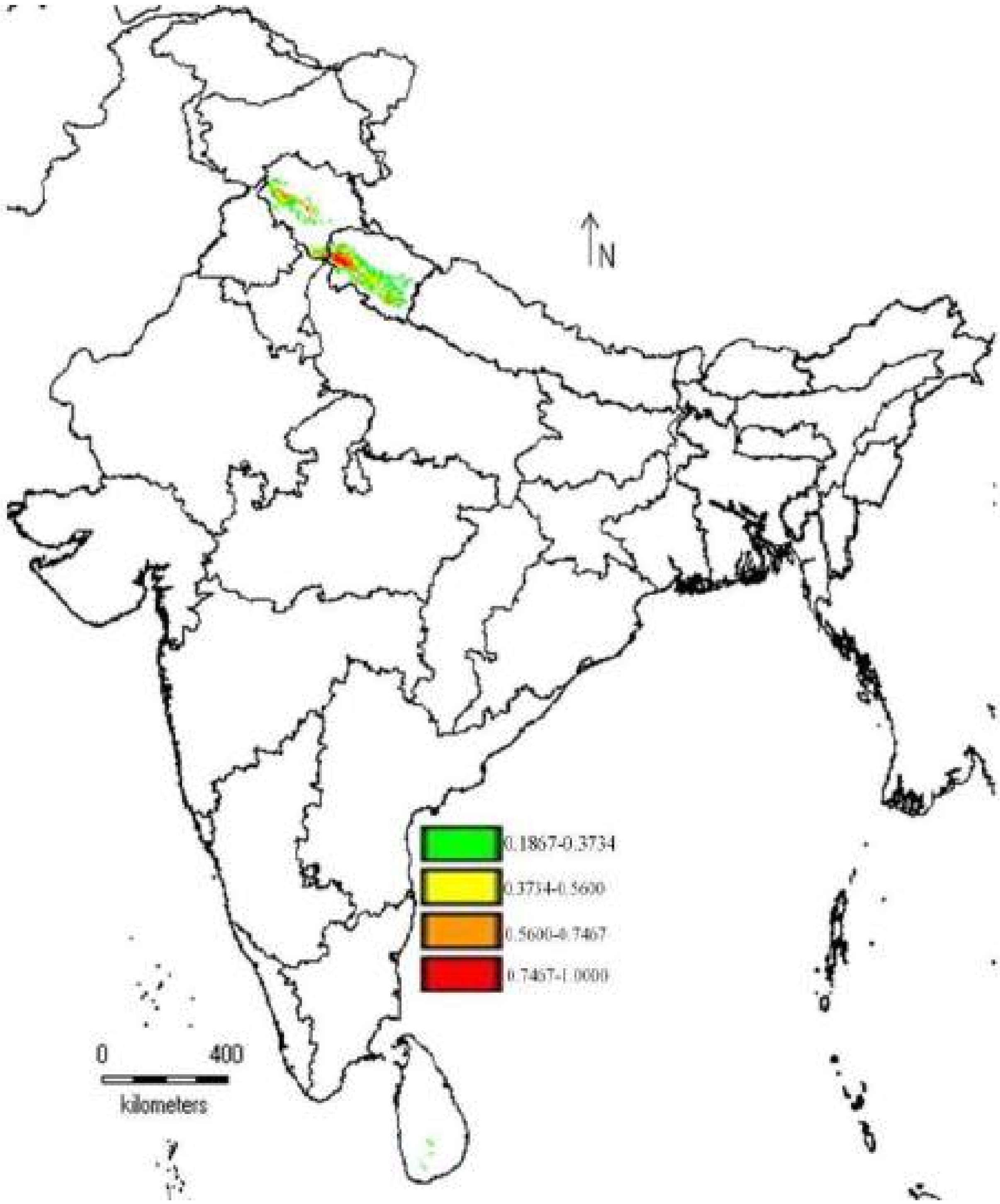


Fig.48. Maxent model AUC value: 0.998; Most suitable habitat predicted [Uttarakhand. Localities suitable for introduction: Shivalik ranges]

Ecological niche modelling results for *Lillium polyphyllum*:

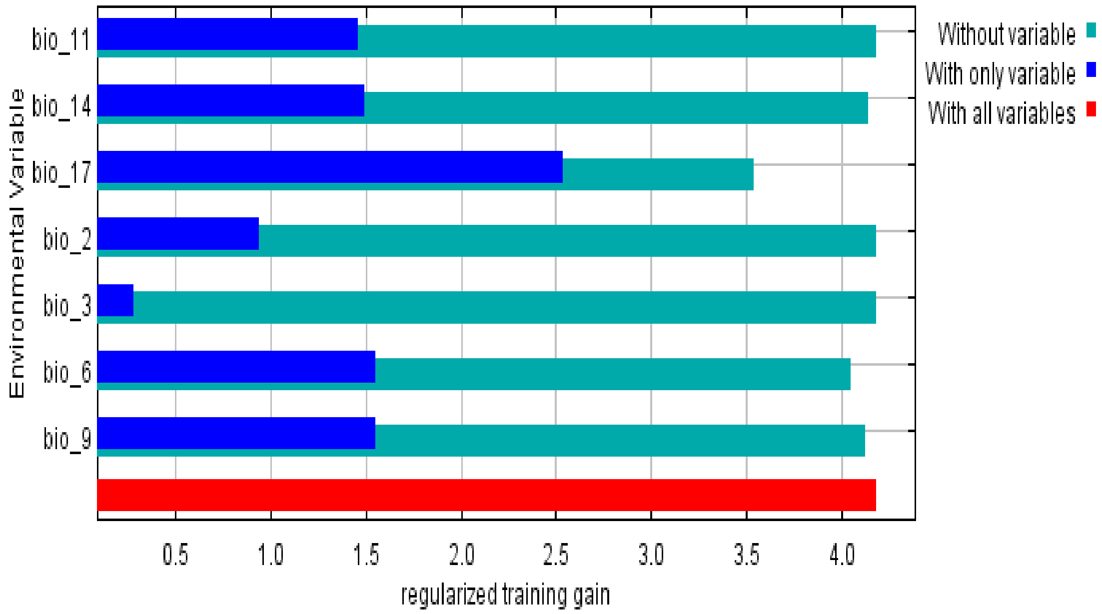


Fig.49. Relative predictive power of different bioclimatic variables based on the jackknife of regularized training gain in Maxent models.

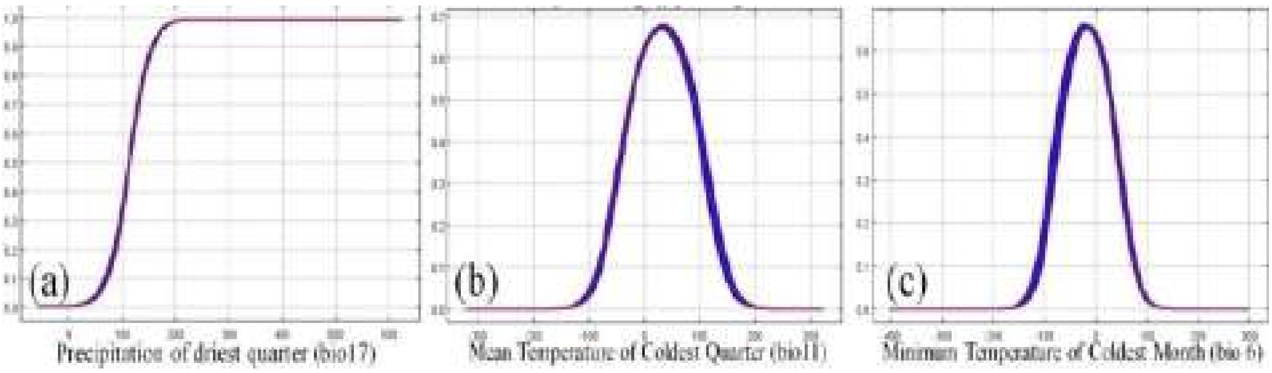


Fig.50. Response curves showing the relationship between the probability of presence of a species and top three bioclimatic variables (a-c)

Table.9. Selected environmental variables and their percent contribution in Maxent model in India

Environment variable	Percent Contribution
Precipitation of Driest Quarter (bio-17)	37.3
Mean Temperature of Coldest Quarter(bio-11)	29.3
Minimum Temperature of Coldest Month(bio-6)	17.7
Mean Diurnal Change (bio-2)	12.5
Precipitation of Driest Month (bio_14)	1.9
Annual Mean Temperature (bio_9)	1.3
Isothermality (bio-3)	0.1

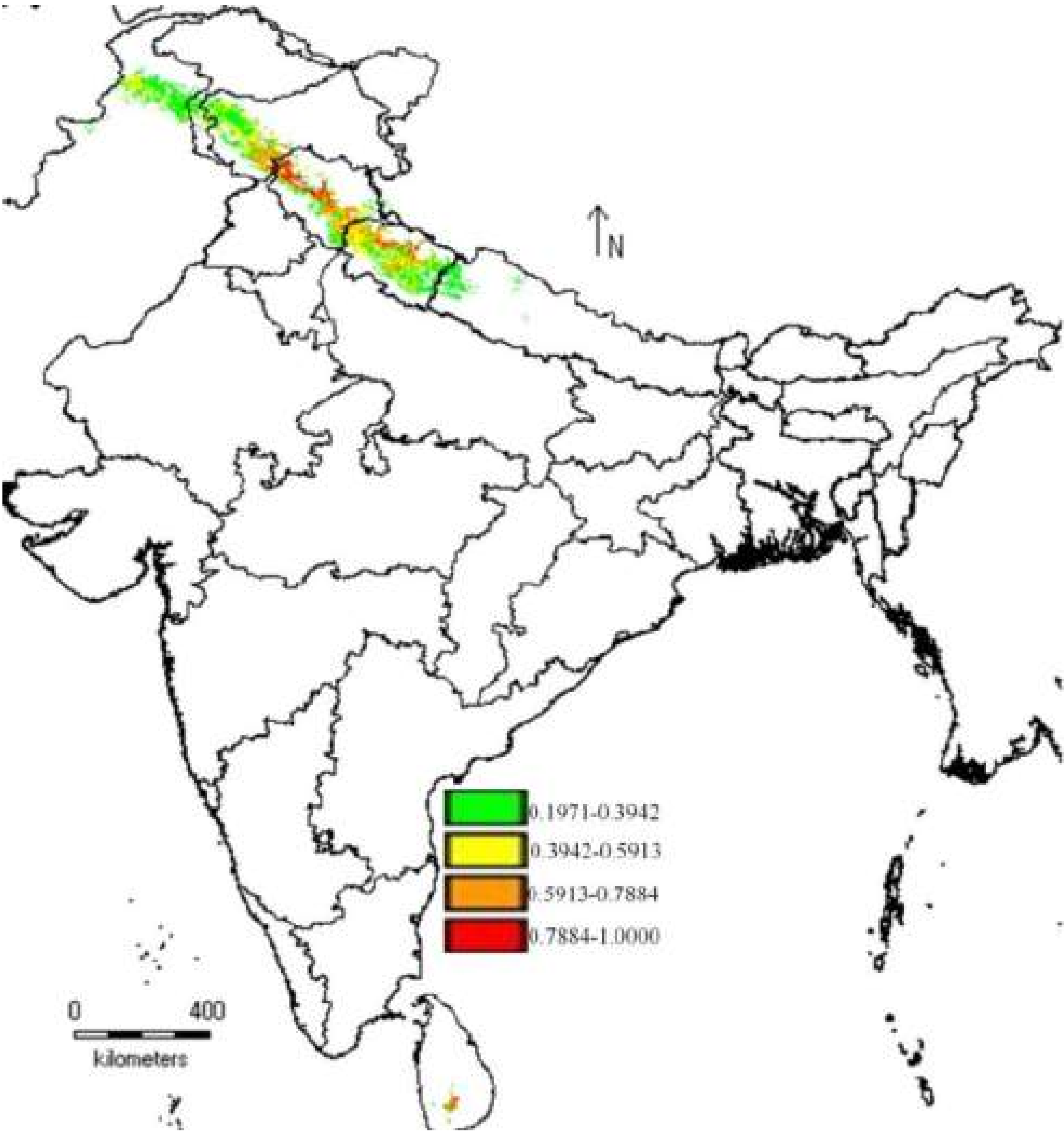


Fig.51. Predicted distribution of *Lillium polyphyllum*

Ecological niche modelling results for *Ephedra gerardiana*:

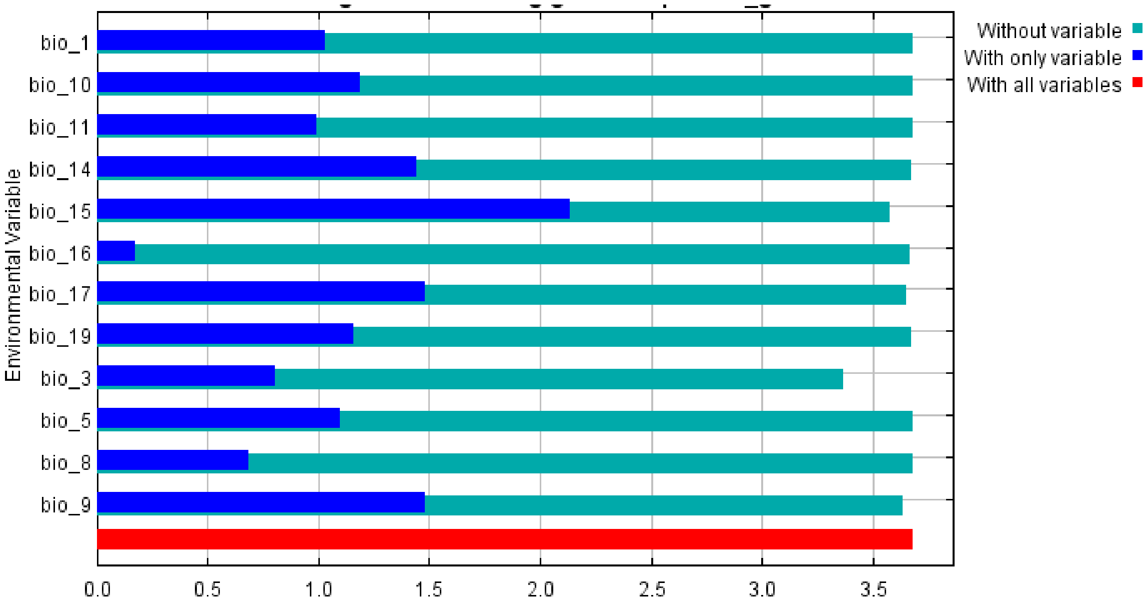


Fig.52. Relative predictive power of different bioclimatic variables based on the jackknife of regularized training gain in Maxent models.

Table.10. Selected environmental variables and their percent contribution in Maxent model in India

Environment variable	Percent Contribution
Precipitation seasonality (bio-15)	37.6
Precipitation of Driest Month (bio-14)	18.5
Isothermality (bio-3)	9.8
Mean Temperature of Coldest Quarter(bio-11)	9.7
Precipitation of Driest Quarter (bio-17)	7.9
Annual Mean Temperature (bio-1)	7.4
Annual Mean Temperature (bio-9)	3.2
Precipitation of coldest quarter (bio-19)	3
Mean Temperature of Warmest Quarter (bio-10)	1.3
Precipitation of wettest quarter (bio-16)	1
Mean Temperature of Wettest Quarter (bio-8)	0.4
Maximum Temperature of Warmest Month (bio-5)	0.1

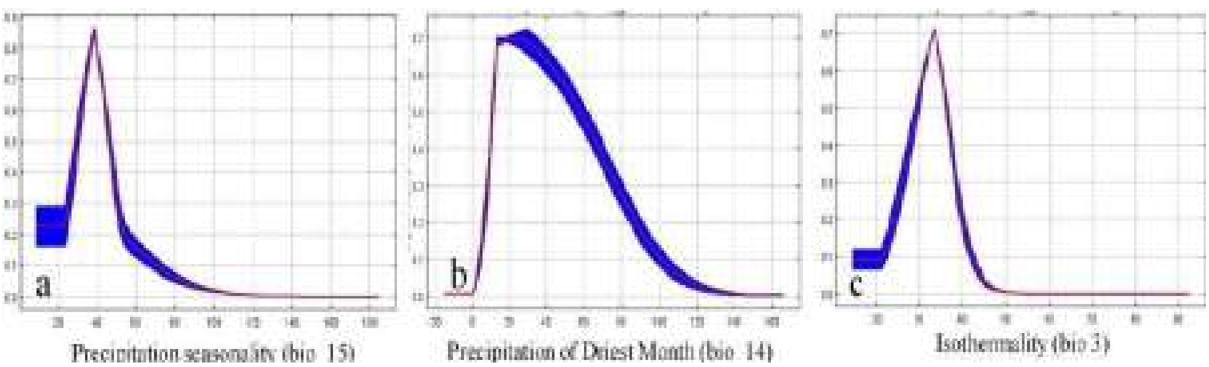


Fig.53. Response curves showing the relationships between the probability of presence of a species and top three bioclimatic variables (a-c)

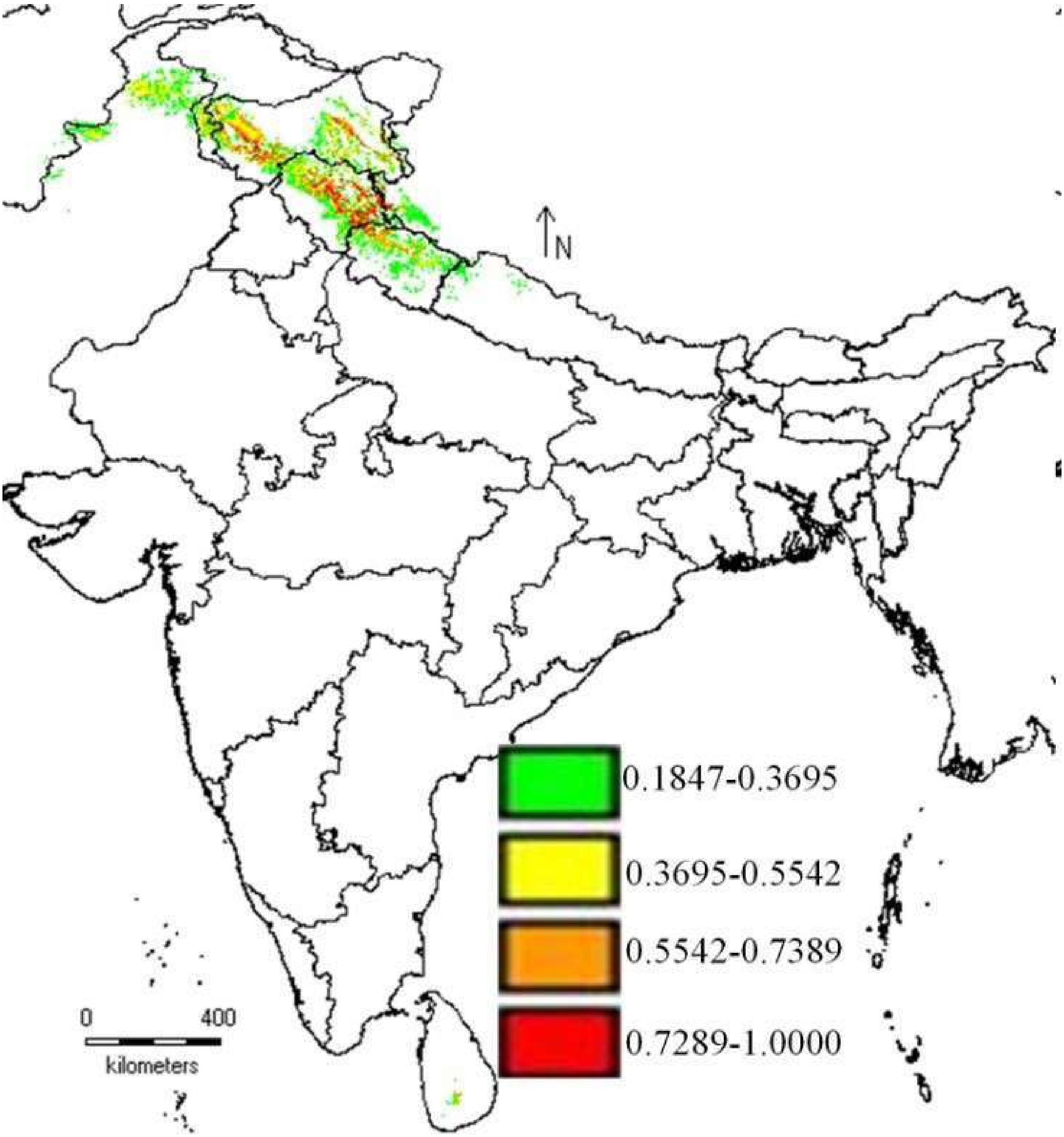


Fig.54. Predicted distribution of *Ephedra gerardiana*

Ecological niche modelling results for *Malaxis acuminata*:

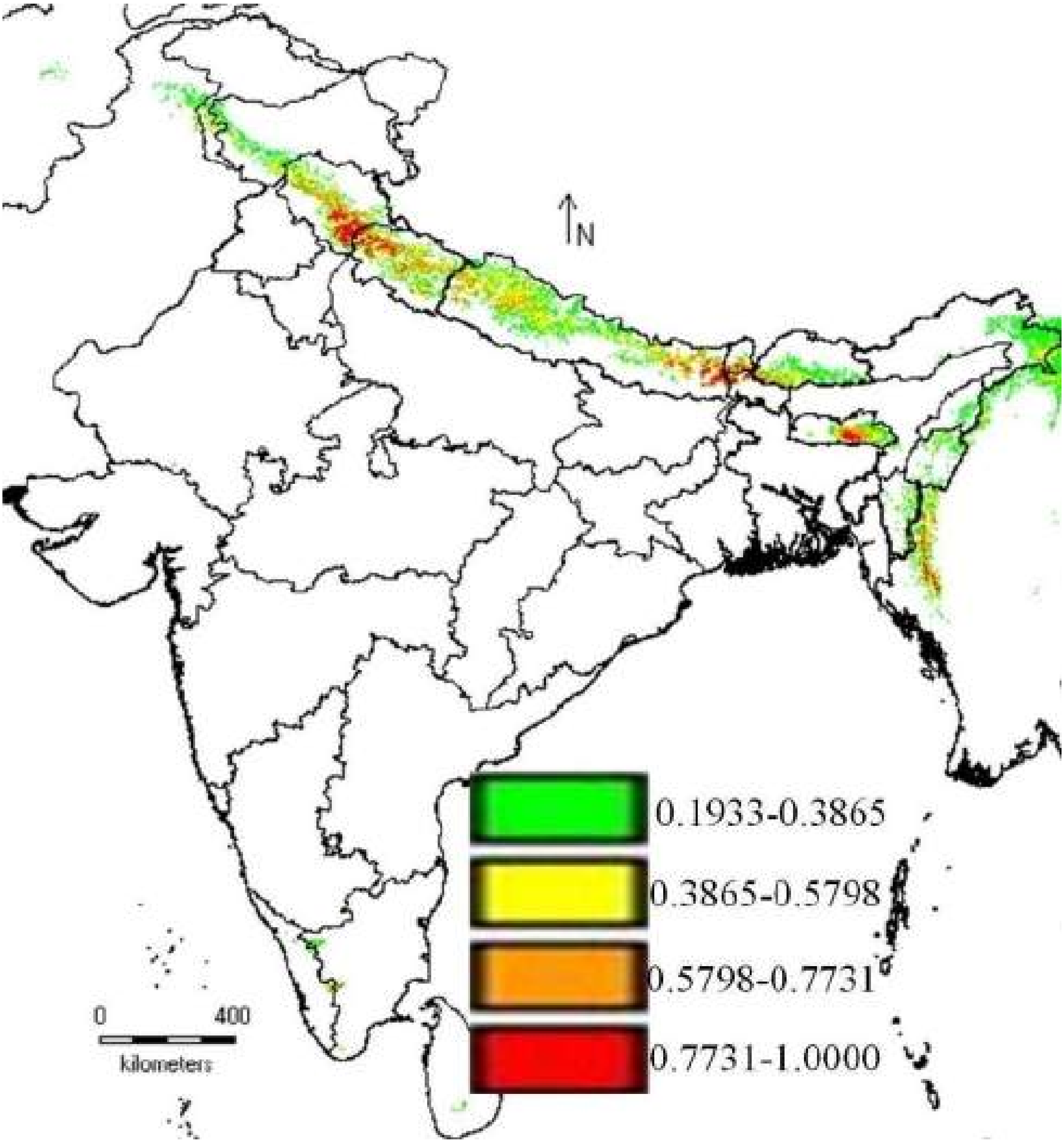


Fig.55. Predicted distribution of *Malaxis acuminata*

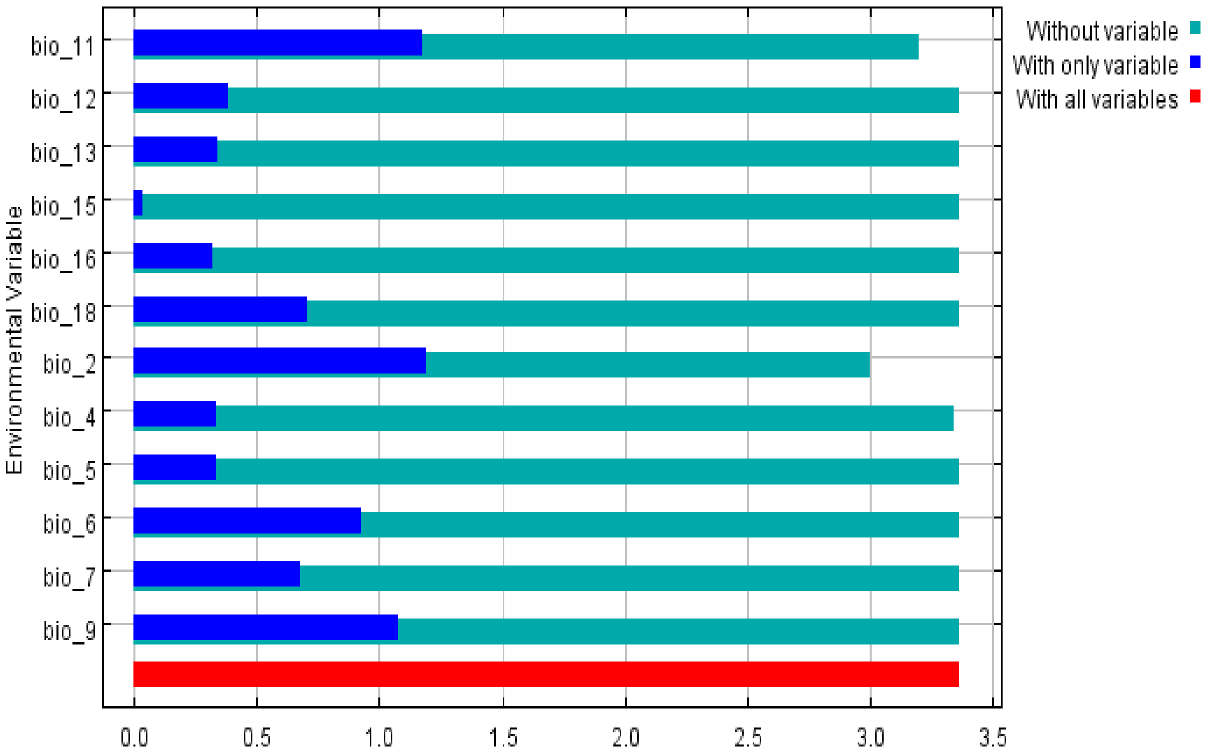


Fig.56. Relative predictive power of different bioclimatic variables based on the jackknife of regularized training gain in Maxent models.

Table.11. Selected environmental variables and their percent contribution in Maxent model in India

Environment variable	Percent Contribution
Annual Temperature (bio-2)	45.1
Mean Temperature of Coldest Quarter(bio-11)	33.3
Temperature Annual Range (bio-7)	11.5
Minimum Temperature of Coldest Month (bio-6)	4.3
Temperature Seasonality (bio-4)	2.4
Precipitation of Warmest Quarter (bio-18)	1.9
Annual Precipitation (bio-12)	0.5
Annual Mean Temperature (bio_9)	0.3
Precipitation of wettest quarter (bio-16)	0.1
Precipitation seasonality (bio-15)	0.1

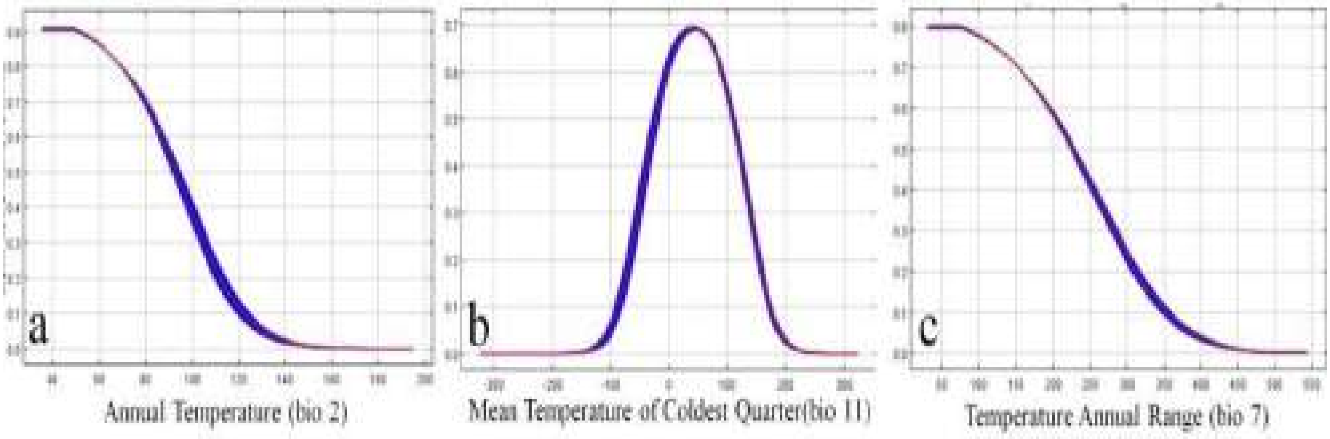


Fig.57. Response curves showing the relationship between the probability of presence of a species and top three bioclimatic variables (a-c)

<u>Ecological niche modelling results for *Allium carolinianum*</u>

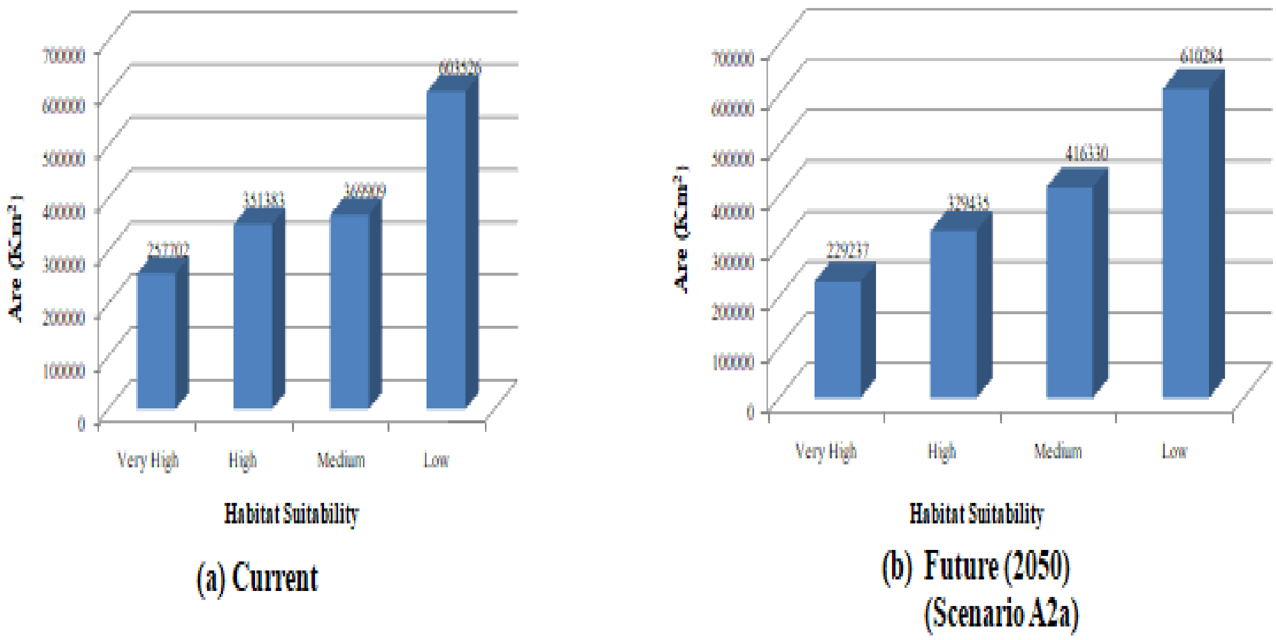


Fig.58. Area under different suitability grades for current and future potential suitable habitat of *A. carolinianum* in India. Figures at the top of each bar represent the area

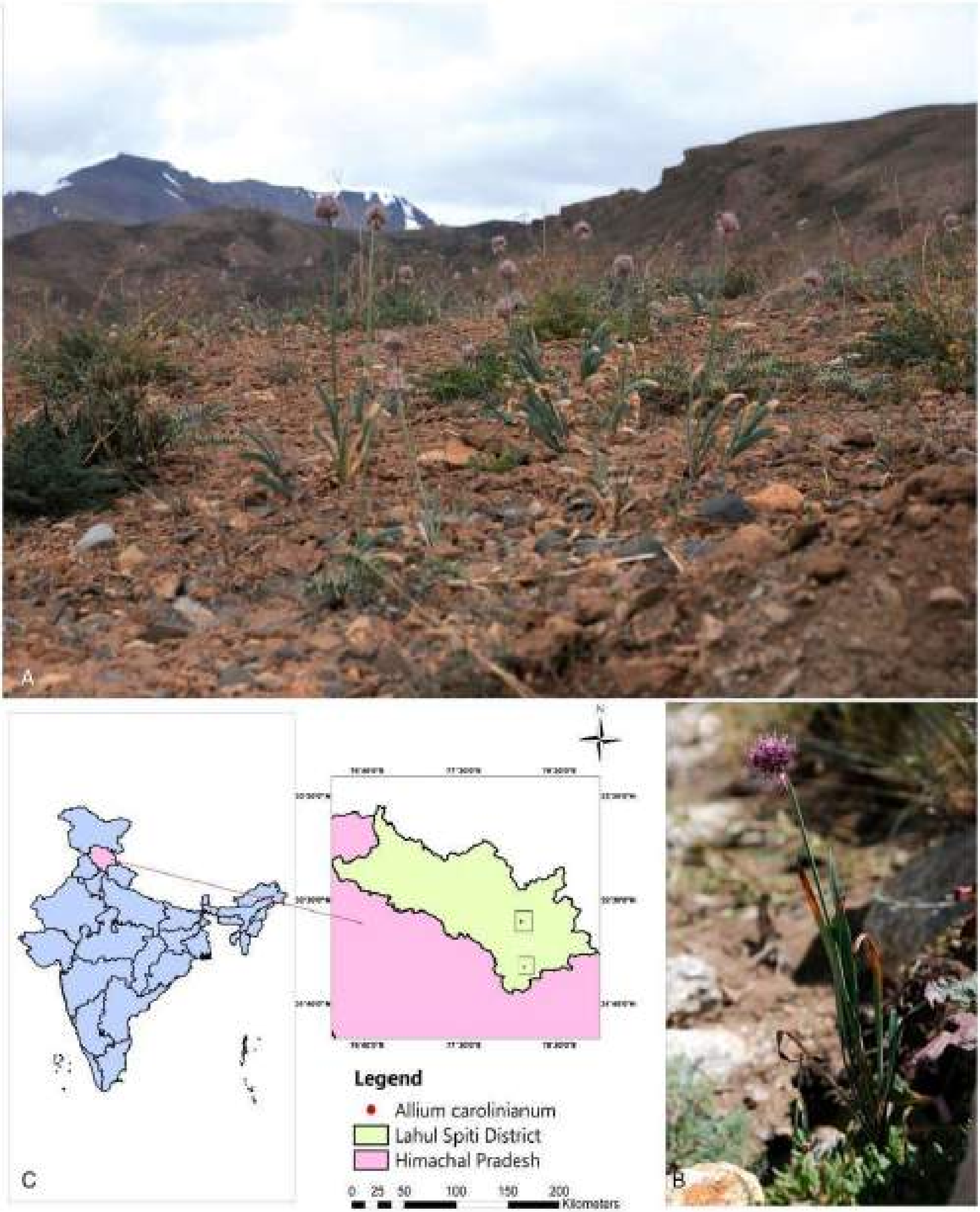


Fig.59. *Allium carolinianum*. **A** habitat, Lahaul Spiti, Himachal Pradesh, India; **B.** habit; **C**. map of collection locality.

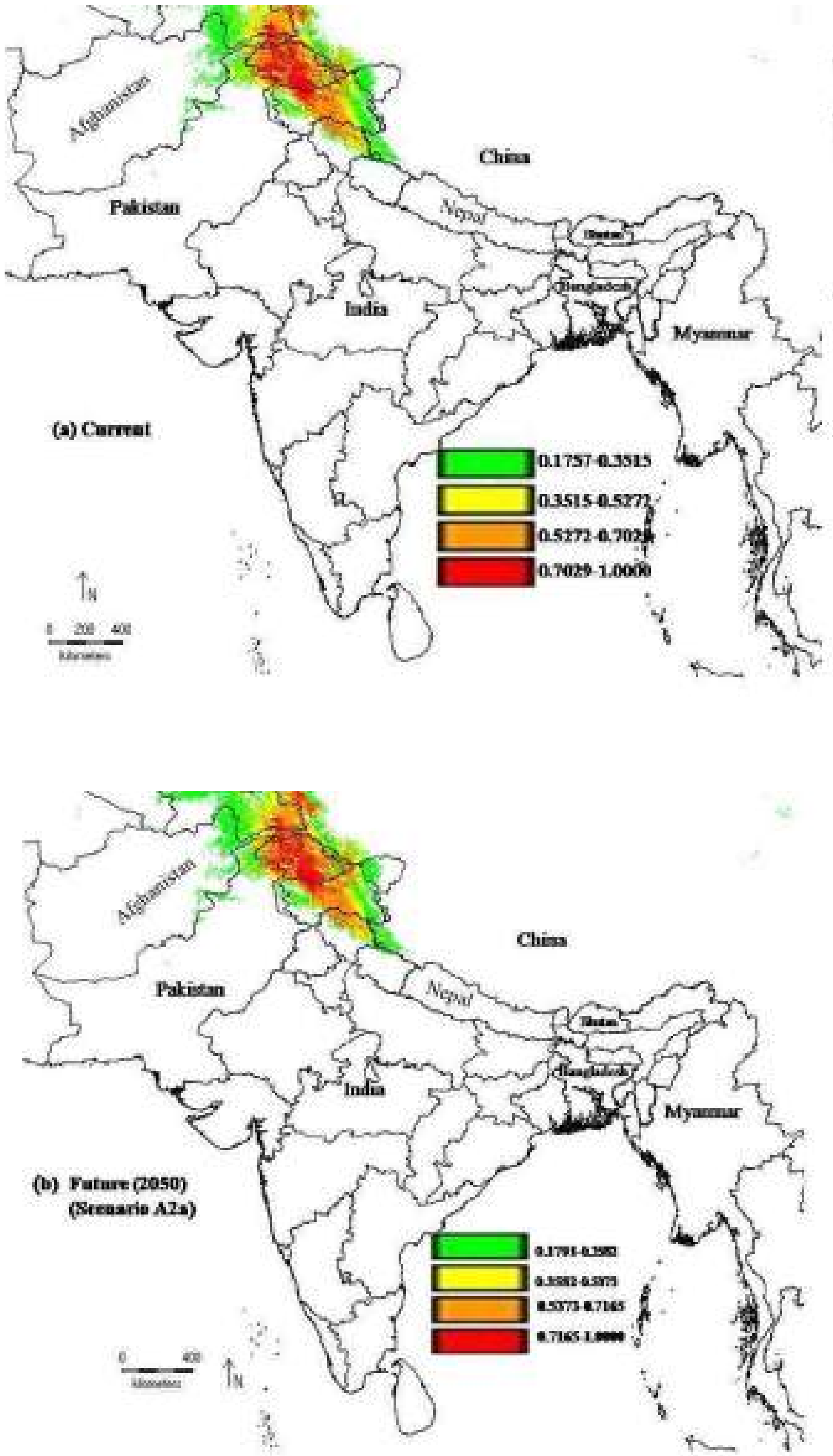


Fig.60. Predicted current (a) and future (b) potential suitable habitat of *A. carolinianum* in Himalayas

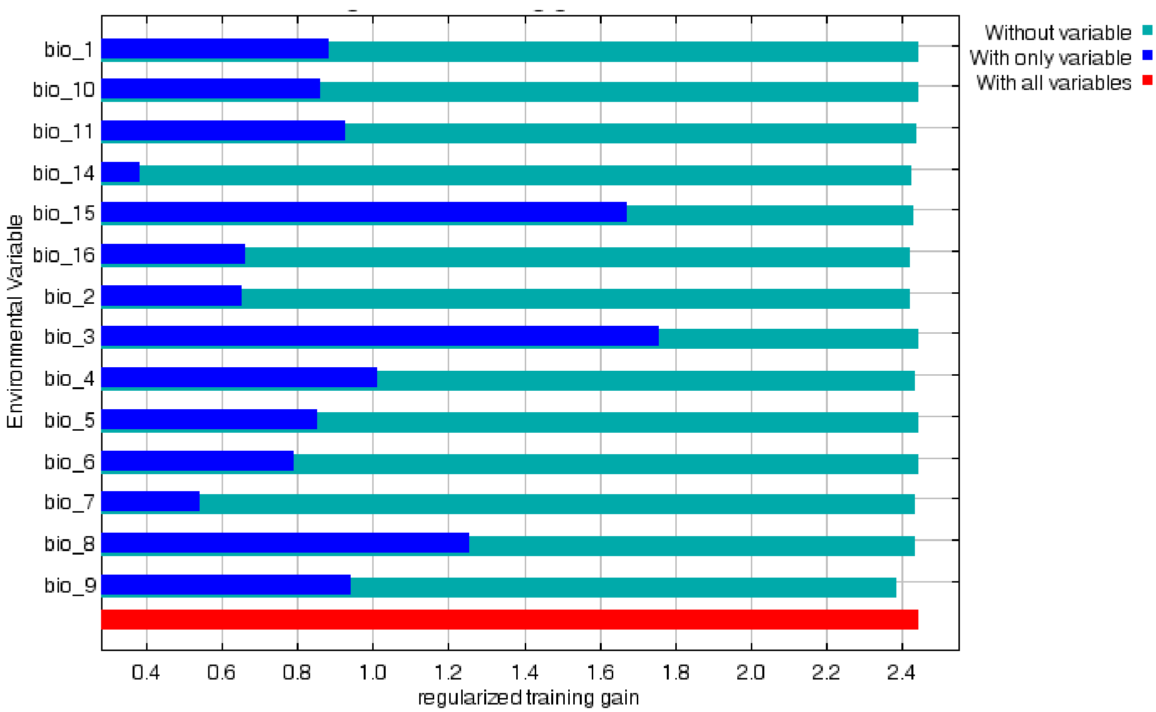


Fig.61. Relative predictive power of different bioclimatic variable based on the jackknife of regularized training gain in maxent model for *A. carolinianum*

<u>Ecological niche modelling results for *Cymbidium tigrinium*:</u>

Table.12. Selected environmental variables and their percent contribution in maxent model for *Cymbidium tigrinum*

Environment Variables	Percent Contribution
Min Temperature of Coldest Month (Bio_6)	34.7
Temperature Annual Range (Bio_7)	21.6
Max Temperature of Warmest Month (Bio_5)	15.3
Precipitation of Warmest Quarter (Bio_18)	10.8
Precipitation of Wettest Month (Bio_13)	7.2
Temperature Seasonality (Bio_4)	5.7
Mean Temperature of Driest Quarter (Bio_9)	3
Precipitation Seasonality (Bio_15)	0.9
Mean Diurnal Range (Bio_2)	0.4
Precipitation of Driest Month (Bio_14)	0.3
Precipitation of Driest Quarter (Bio_17)	0.2

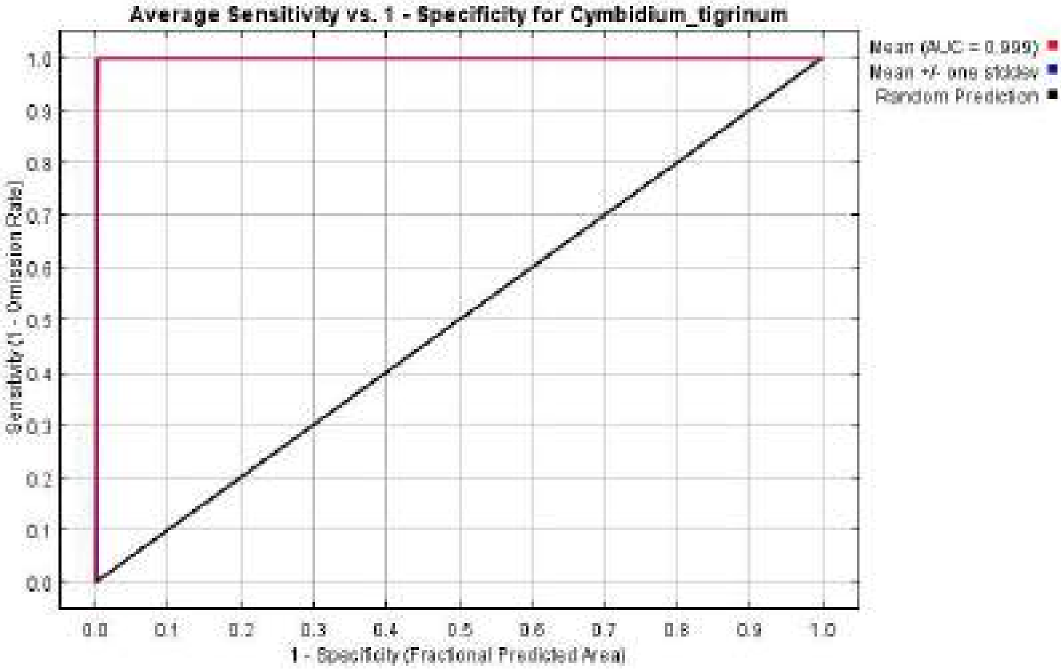


Fig.62. Result of AUC in developing habitat suitability model for *Cymbidium tigrinum*

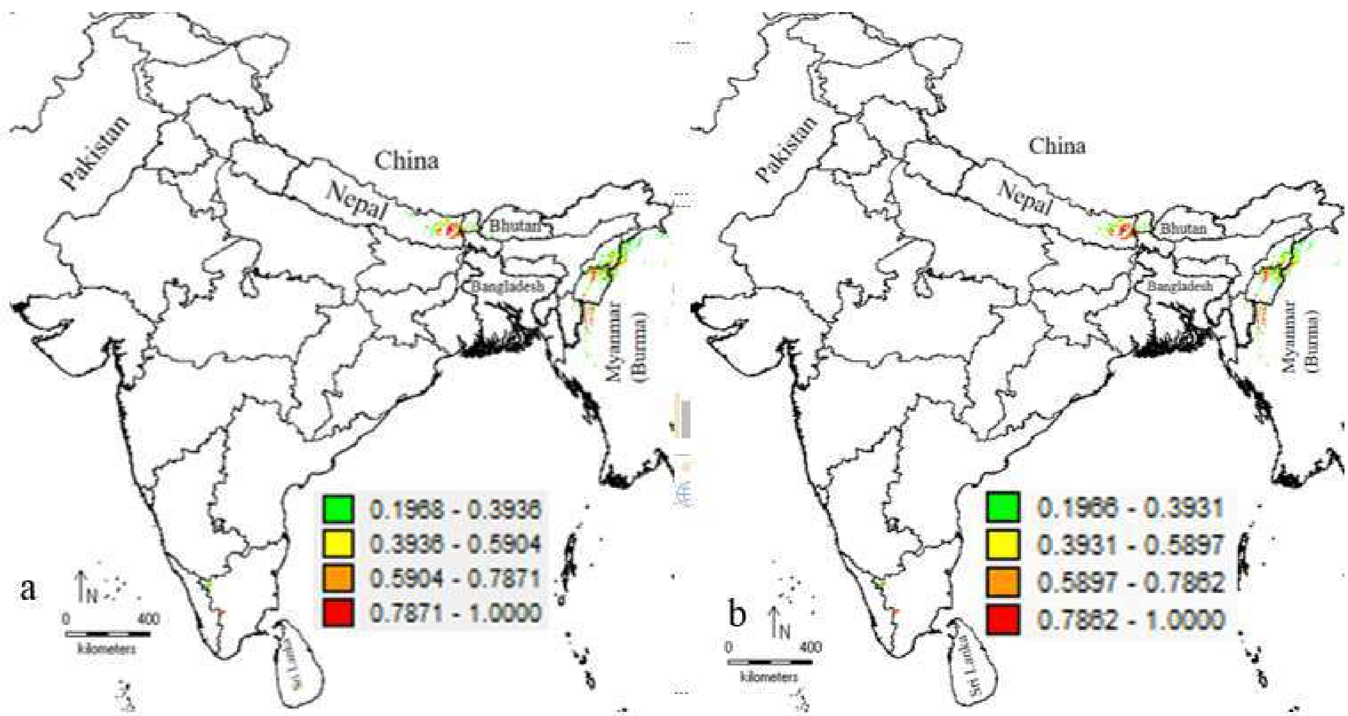


Fig.63. Predicted current (a) and future (b) potential suitable habitat of *Cymbidium tigrinum* (Shapefile republished from DIVA-GIS database (https://www.diva-gis.org/) under a CC BY license, with permission from Global Administrative Areas (GADM), original copyright 2018.).

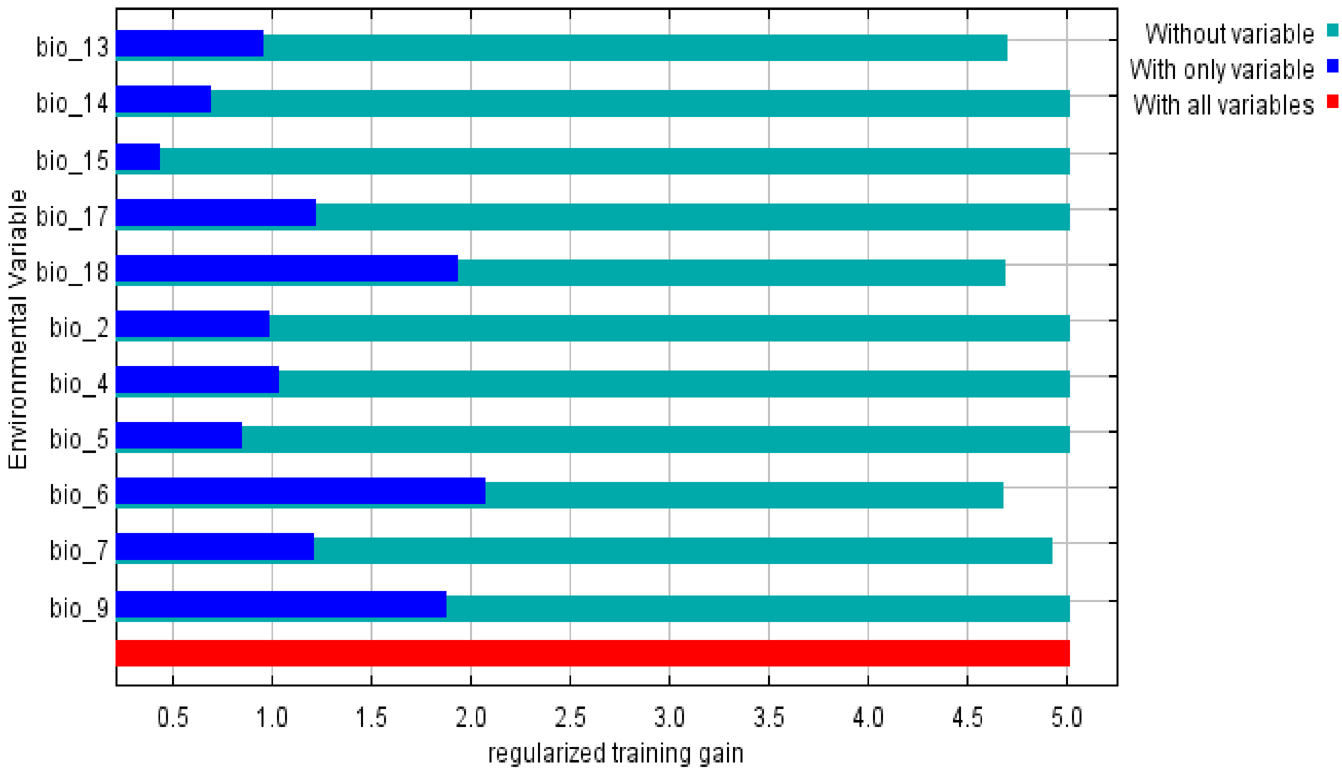


Fig.64. Relative predictive power of different bioclimatic variables based on the jackknife of regularized training gain in maxent model for *Cymbidium tigrinum*

Propagation and Mass Multiplication

Mass scale multiplication of the selected species was performed through the collected propagating materials from different localities and from the planted specimens as well. Different types of propagating material *viz.*, seeds, stem cutting, bulbs, rhizome etc. were collected for propagation trials at Arunachal Pradesh regional centre, Itanagar (ARUN); Eastern Regional Centre, Shillong (ASSAM); Botanic Garden of Indian Republic, Noida (BGIR); Sikkim Himalaya Regional Centre, Gangtok (BSHC); Northern Regional Centre, Dehradun (DD). The selected plant species were propagated through different propagation techniques including both micro and macro propagation methods to develop a stock for reintroduction, distribution, and *ex-situ* conservation.

Macropropagation:

There are numerous wild fruit plants which are used by rural and tribal populations and contributing significantly to their livelihood and food security especially for the North-Eastern region of India and eastern and western Himalaya. Despite of the immense diversity in wild edible fruits, only a few have been grown commercially for their economic, social, and religious importance. And many such fruit plants remain largely unknown to the rest of the country. Through the project, certain underutilised fruit species were taken up for mass propagation and subsequent transfer to local stakeholders. These will not only ensure commercial utilisation of the species, but also play in significant role in livelihood and income generation as well as serve the dual purpose of increasing the green cover of the region.

Table. 13. Response of different treatments on seed germination and cuttings of the plants

S. No.	Species	Propagating material	Treatment	Response	Total plants propagated	Reintroduced in wild
1.	*Acer oblongum* var. *membranaceum*	Seeds Stem cuttings	Hot scarification	30%	600	-
			Cold scarification	75%	1500	
			IBA treatment	No response	-	
2.	*Aconitum heterophyllum*	Seeds Tubers	Cold scarification	65%	1900	200
			No treatment	80%	100	
3.	*Gentiana kurroo*	Seeds	Cold scarification	45%	2000	150
		Suckers	No treatment	95%	150	
4.	*Stereospermum suaveolens*	Seeds	Hot scarification	50%	100	-
5.	*Indopiptadenia oudhensis*	Seeds	No treatment	98%	5000	500
6.	*Jasminum parkeri*	Seeds	Cold scarification	45%	200	-
		Stem cuttings		80%	800	
7.	*Eremostachys superba*	Seeds	Cold scarification	85%	1275	200
			Hot scarification	48%	720	
8.	*Sophora mollis*	Seeds Stem cuttings	Hot scarification	65%	500	-
9.	*Prunus cerasoides*	Seeds Stem cuttings	Normal water soaking	90%	1000	200
10.	*Mahonia jaunsarensis*	Seeds	Cold scarification	25%	275	-
			Hot scarification	8%	225	

a. ***Stereospermum suaveolens*:** Mature fruits of the species were collected from Rajaji National Park area near Mohand, Uttarakhand in the month of May. The pods were dried and seeds were separated. Further, seeds were sown directly in seed beds consisting of mixture of soil and sand in 1:1 ratio. The seeds germinated within 7-15 days showing a germination rate of 45-50%. However, seedling mortality was observed to be very high in the species due to fungal infection and other unknown causes.

b. ***Sophora mollis*:** Seeds were collected from the planted specimen at BSI, Dehradun campus and from Sahastradhara. The seeds were given pre-sowing hot water treatment for 24 hours. These pre-treated seeds were then treated with Bavistin and sown in germination trays. The seeds started germination after 15 days of sowing but the germination was not uniform and continued for nearly 25–30 days having 65% germination rate. A total number of 500 saplings were produced thorough this method. A trial was also set for the vegetative propagation of *S. mollis* through stem cuttings. Cuttings were treated with rooting hormones and were planted in sand medium, but planted stem cuttings did not show any response and eventually died after 2 months. The saplings raised through seeds were shifted in polybags for further growth and development.

c. ***Gentiana kurroo*****:** The seeds were collected from Sangrah, Himachal Pradesh, Suwakholi, Uttarakhand and were sown in germination tray in polyhouse at BSI, NRC Dehradun as well as at Deoban Nursery, Chakrata for germination. The seeds successfully germinated at Deoban nursery with nearly 45% germination rate. The raised seedlings were shifted in polybags after 6 months of growth for further development and reintroduction purpose. Nearly 2200 saplings raised from seeds in the Deoban nursery were then shifted to BSI, Dehradun for the further reintroduction and conservation.

d. ***Aconitum heterophyllum*****:** Seeds were collected in the month of October from Neelkanth valley, Badrinath. The collected seeds were given cold treatment by keeping them in refrigerator at -4^{o}C for 25 days. The treated seeds were also treated with Bavistin solution and were sown in Deoban forest nursery, Chakrata for further germination and development. The germination started after 15 days of sowing and continued for nearly 30 days. 65% seed germination was observed and total number of 2000 saplings was propagated through this method.

e. ***Jasminum parkeri*****:** Seeds and stem cuttings were collected during the field survey to Holi village, Chamba. The stem cuttings of 3-5 inches were prepared and then treated with market grade rooting hormone for root initiation. These cuttings were planted in pure sand medium in earthen pots and plastic trays. The stem cuttings showed nearly 80% rooting but the post rooting viability was observed 55% and 1000 saplings were raised.

f. ***Mahonia jaunsarensis*****:** The seeds of *Mahonia jaunsarensis* were collected from wild (Chakrata). The fleshy pulp of the fruit was removed and seeds were separated and dried properly. A trial with different pretreatments was setup for seed sowing. i) Hot water treatment for 24 hours, ii) Cold treatment for 24 hours, iii) Control i.e., soaked in normal water for 24 hours. 150 seeds in each trial were sown in coco-peat medium. The seeds germinated after 20 days with a very low germination rate. The seeds soaked in normal water showed maximum germination whereas least germination rate was observed in cold treatment.

g. ***Acer oblongum* var. *membranaceum*****:** Seeds were collected from the plant growing in the botanical garden and were sown in different medium after giving hot and cold treatment. The seed germination was initiated after 25 days of sowing and continued for nearly 60 days. The cold scarification treatment showed nearly 75% germination which is much higher than the hot scarification that showed only 30% seed germination. Total 2100 saplings were raised through this method.

h. ***Phlomoides superba*****:** The seeds were collected from the wild habitats and plans growing in the experimental Botanical Garden of BSI, Dehradun. The collected seeds were dried and given different treatment *viz.*, cold stratification, hot stratification, and control for enhancing the germination rate. However, the maximum germination percentage was observed in cold stratification, seeds which germinate after 15 days with 85% germination. Nearly 2000 saplings were raised through seeds in the nursery.

i. ***Magnolia kisopa*****:** Mature fruits were collected from Pandukeshwar, Joshimath, Chamoli region from wild growing trees. The seeds were separated from pulp and after pre-germination treatment were sown in cocopeat medium where they started germination.

Fig.65. Collection of propagating material of a. *Mahonia jaunsarensis*, b. *Indopiptadenia oudhensis*, c. *Pittosporum eriocarpum*, d. *Magnolia kisopa*, e. *Stereospermum suaveolens*, f. *Gentiana kurroo*, g. *Jasminum parkeri*, h. *Aconitum heterophyllum*.

Fig.66. Collected seeds of a. *Magnolia kisopa*, b. *Sophora mollis*, c. *Indopiptadenia oudhensis*, d. *Jasminum parkeri*, e. *Gentiana kurroo*, f. *Pittosporum eriocarpum*, g. *Phlomoides superba*, h. *Aconitum heterophyllum*.

Fig.67. Nursery activities: a-b. Preparation of seed bed and sowing of seeds, c-d. Preparation of polybags, e-f. Shifting of propagated seedlings, g. Preparation of stem cuttings, h. nursery maintenance.

Fig.68. Propagation of a. *Magnolia kisopa*, b. *Sophora mollis*, c. *Indopiptadenia oudhensis*, d. *Jasminum parkeri*, e. *Gentiana kurroo*, f. *Pittosporum eriocarpum*, g. *Phlomoides superba*, h. *Aconitum heterophyllum*.

Fig.69. Field station and nursery setup a-d. Species propagated in Polyhouse and Net house at BSI, NRC, e. Field station at Deoban, Chakrata, f. Propagation of *Gentiana kurroo* at Deoban, Chakrata, g. Nursery developed at Ghes village, h. Propagation of *Aconitum heterophyllum* at Ghes nursery.

Fig.70. Field station and nursery setup at BSI, ASSAM.

Fig.71. Field station and nursery setup at BSI, ASSAM.

Fig.72. In house production of jute seedling bags.

j. ***Indopiptadenia oudhensis*:** Fresh seeds were collected from Kukrail forest area, Lucknow in the month of May. These seeds were sown in polybags and earthen pots containing soil and sand in 1:2 ratio. The seeds started germination after 4–5 days and showed uniform germination of nearly 98%. A total number of 2000 saplings were raised in the nursery through seeds. The seeds remained viable only for a very short period and viability completely loses after 6 months of storage.

k. ***Prunus cerasoides*:** Seeds were collected from the natural population and planted trees in BSI, Dehradun. The seeds were given hot water scarification treatment for 12 hours before sowing and sown in sandy medium. The germination starts in 10 days and showed 90% germination. A total number of 500 saplings are produced for this species.

List of plants species propagated from Meghalaya, Nagaland, Manipur

There are numerous wild fruit plants which are used by rural and tribal populations and contributing significantly to their livelihood and food security especially for the North-Eastern region of India. Despite of the immense diversity in wild edible fruits, only a few have been grown commercially for their economic, social and religious importance. And many such fruit plants remain largely unknown to the rest of the country. Through the project, certain underutilised fruit species were taken up for mass propagation and subsequent transfer to local stakeholders. These will not only ensure commercial utilisation of the species, but also play in significant role in livelihood and income generation as well as serve the dual purpose of increasing the green cover of the region.

Carallia brachiata:

Fruits are edible. Bark is traditionally used in wound healing, treating itch, oral ulcer, inflammation of throat and stomatitis. Place of collection: Laitmawsiang, Meghalaya; Seed Germination (%): 37.5; Seedlings Mortality (%): 28.57; Number of seedlings distributed: 311; No. of seedlings in stock: 150

Fig.73. Seedling generation of *Carallia brachiata*

Castanopsis indica:

The nuts are edible. The wood is locally used in construction and the bark is used in tanning. The nuts have high economic value and are sold in the local market @ Rs. 300 - 400 per kg. Place of collection: Mylliem Village, Meghalaya; Seed Germination (%): 53.0; Seedlings Mortality (%): 14.91; Number of seedlings distributed: 2799; No. of seedlings in stock: 1711.

Fig.74. Seedling generation of *Castanopsis indica*

Castanopsis tribuloides:

The roasted or boiled nuts (like ground nuts) are sold in the market. The kernel is edible and rich in starch. The seeds have commercial value and are sold in the market @ Rs. 200-300 per kg. Place of collection: Ladmawphlang Village, Meghalaya; Seed Germination (%): 45.0; Seedlings Mortality (%): ten; Number of seedlings distributed: 280; No. of seedlings in stock: 440

C. tribuloides fruits | *C. tribuloides* seeds | Seedlings in tray

Fig.75. Seedling generation of *Castanopsis tribuloides*

C. roxburghii fruits | *C. roxburghii* seeds

C. roxburghii seedlings | Seedlings in polybags

Fig.76. Seedling generation of *Chrysophyllum roxburghii*

Chrysophyllum roxburghii:

C. roxburghii also known as the Indian star apple has a gummy taste and is harvested from December to March. It grows on evergreen trees which reach the height of more than 40m. The seeds are used in the treatment of pneumonia and traditionally use for the treatment of intestinal worm. Place of collection: Khatar Shnong village, Meghalaya; Seed Germination (%): 92.31; Seedlings Mortality (%): 53.33; Number of seedlings distributed: 520; No. of seedlings in stock: 378; Medicinal uses: A chemical analysis of the fruit reported that it could be a source of some important macro and micro nutrients, essential and non essential amino acids. Potasssium was the most highly concentrated macronutrient such that 38% of the RDA for adults could be met by consumption of 100g of the fresh fruit. It also contains high concentrations of B, Ca, Fe, Mn and P. The seeds are used in the treatment of pneumonia and traditionally use for the treatment of intestinal worm.

Syzygium cumini:

Syzygium cumini (S. cumini) (L.) Skeels (jambolan) is one of the widely used medicinal plants in the treatment of various diseases in particular diabetes. The plant has been viewed as an antidiabetic plant since it became commercially available. It has been reported to have antioxidant, anti-inflammatory, antibacterial properties. However, of all, the leaves and bark are regarded as most significant part. In Ayurveda, the bark is acrid, sweet, digestive and astringent to the bowels, anti-helminthes. Besides, it is used to cure sore throat, bronchitis, asthma, thirst, biliousness, dysentery, blood impurities and ulcer.
Place of collection: Laitmawsiang Village, Meghalaya; Seed Germination (%): 80.0; Seedlings Mortality (%): 11.54; Number of seedlings distributed: 452; No. of seedlings in stock: NIL

Fig.77. Seedling generation of *Syzygium cumini*

Syzygium tetragonum

It is used in Chinese folk medicine for the treatment of rheumatism, joint swelling and pain. The extracts from the twigs and leaves of the plant have been reported to effectively inhibit osteoclastogenesis and bone erosion by X-W Zhang (2014). This plant demonstrated great degree of anti-oxidant property. Place of collection: Laitryngew, Cherrapunjee, Meghalaya; Seed Germination (%): 78.33; Seedlings Mortality (%): 34.04; Number of seedlings distributed: 152; No. of seedlings in stock: NIL

Fig.78. Seedling generation of *Syzygium tetragonum*

Baccaurea ramiflora:

B. ramiflora commonly known as "Burmese grape'' is one of the important underutilized fruit as it is usually planted in homestead gardens or around agricultural fields. The plant is slow growing and native to Southeast Asia region. The fruits are edible and have commercial value, and sold in the local market @ Rs. 20-30 per bunch (around 15-20 pieces). The fruits are stewed or made into wine. The fruits have religious importance as people used to pay their homage to Lord Jagannath during the Holy Chariot Procession by offering the fruits along with other rituals. Young leaves of the plant used as vegetable or flavouring agent for curries and minced meat in Bangladesh. The seeds of the plant produce a valuable dye called "annatto" which is used for colouring silk, cotton and other textile materials in orange. Seed oil can also be extracted and commercially exploited, as it has shown presence of omega-9 fatty acids and other fatty acids of commercial importance in it. Medicinal importance: *Baccaurea ramiflora* has been mentioned in the Chinese Dai medicine. It is use as an anti-inflammatory and painkiller in treatment of injuries, rheumatoid arthritis, cellulitis, abscesses etc. The fruit has nutritional benefits because of its high content of vitamin C, protein and iron. The fresh bark of the plant chewed or juice taken orally for complaints of constipation in India. The seeds of the plant produce a valuable dye called "annatto" which is used for colouring silk, cotton and other textile materials in orange. Seed oil can also be extracted and commercially exploited, as it has shown presence of omega-9 fatty acids and other fatty acids of commercial importance in it. Place of collection: Nongpoh, Nongbah Mawshuit, Meghalaya; Seed Germination (%): 93.33; Seedlings Mortality (%): 28.57
Number of seedlings distributed: 732; No. of seedlings in stock: 30

Aphananthe cuspidata
A. cuspidata is deciduous or semi-deciduous tree usually growing 15 - 20 metres tall with some trees up to 33 metres. The fruits and seeds of the tree are edible. The fruits are used for making pickles. The bark is believed to have purifying and detoxifying effects. It is taken internally with lemon juice as a purifier of blood, for relieving itches and other cutaneous eruptions. Place of collection: Rymmai and Dewiong, Meghalaya; Seed Germination (%): 84.0; Seedlings Mortality (%): 40.48; Number of seedlings distributed: 2289; No. of seedlings in stock: NIL.

Fig.79. Seedling generation of *Baccaurea ramiflora*

Fig.80. Seedling generation of *Aphananthe cuspidata*

Gynocardia odorata

G. odorata is a medicinal plant growing wildly throughout India and tropical countries of the world. The seeds are sold in the local market @ Rs. 50 – 80 per kg. The fruit juice of *G. odorata* can be taken one time daily for 2 week as antipyretic agent. The leaves extract is used in the treatment of tooth decay. The seeds are showing anti-diabetic activity. The seeds also contain essential oil. It is known as Chaulmoogra (or Chaulmugra), powdered seeds are used in the treatment of scrofula, skin diseases, and rheumatism. Place of collection: Laitmawsiang village Meghalaya. Seed Germination (%): 30.23; Seedlings Mortality (%): 22.15; Number of seedlings distributed: 837; No. of seedlings in stock: 220

Fig.81. Seedling generation of *Gynocardia odorata*

Prunus nepaulensis

This seasonal fruit is edible and of high economic value. The sweet, tangy purple fruit is eaten raw commonly known as Sohiong in Khasi. Every year “Sohiong Festival” is being held in the state of Meghalaya to celebrate the unique taste and promote the indigenous practices of wine making. The fruit juice and pulp are used for preparation of processed products like jams, pickles, wine and ready-to-serve beverage. Its fruits are a potential source for antioxidants and its leaves acts as a diuretic. The market value of the fruit is Rs. 100 per kg. Place of collection: Diengsong village and Pynursla, Shillong, Meghalaya; Seed Germination (%): 70.31; Seedlings Mortality (%): 42.76; Number of seedlings distributed: 2556; No. of seedlings in stock: 100

Garcinia cowa

Fruits are edible and are also used for making pickles. Place of collection: Kongthong Village, Meghalaya; Seed Germination (%): 60.0; Seedlings Mortality (%): 22.75; Number of seedlings distributed: 365; No. of seedlings in stock: 80.

Fig.82. Seedling generation of *Prunus nepaulensis*

Fig.83. Seedling generation of *Garcinia cowa*

Fig.84. Seedling generation of *Myrica nagi*

Myrica nagi

Myrica nagi is an important medicinal tree, which is safely and effectively used to treat various disorders in Ayurvedic system of medicines since ancient times. Bioactive compounds of various parts of the plant have several pharmacological activities such as; anti-inflammatory, antioxidant, anthelmintic, anti-microbial, anxiolytic, chemopreventive, hypertension which itself speaks about the wide scope for the utilization of this species. Fruits are edible and sold in local market @ Rs. 200-300 per kg. There are strong prospects for the commercial utilization of the species.

Place of collection: Ladmawphlang Village, Meghalaya; Seed Germination (%): 21.35; Seedlings Mortality (%): 41.45; Number of seedlings distributed: 75; No. of seedlings in stock: NIL

Myrica esculenta

M. esculenta is known for its edible fruits and other by-products. Its fruits have been a potential income generating source for the local tribes of the Meghalaya and sub-Himalayan region. All the parts of the *M. esculenta* plant have huge nutritional and therapeutic importance. Fruits are used for syrups, jams, pickles, and preparation for refreshing drinks. *M. esculenta* fruits and roots are used as an active botanical ingredient in numerous ayurvedic formulations like Chwayanprash. Katphaladi Churna, Maha Vatagajankusa etc. The fresh fruits are sold in the market @ Rs. 100-200 per kg. The fruits are eaten to cure indigestion, diarrhoea, colic pain, fever, haemorrhage etc. Place of collection: Ladmawphlang village, Meghalaya; Seed Germination (%): 28.15 Seedlings Mortality (%): 24.51; Number of seedlings distributed: 428; No. of seedlings in stock: 73

Fig.85. Seedling generation of *Myrica esculenta*

Garcinia xanthochymus

Fruits are eaten raw or cooked. It is used for making jams, curries and vinegars, or as a flavouring agent in other foods. The fruit is a rich source of citric acid. Place of collection: Laitmawsiang village, Meghalaya; Seed Germination (%): 82.35; Seedlings Mortality (%): 7.14; Number of seedlings distributed: 1460; No. of seedlings in stock: 440

Garcinia macrophylla

Fruits are edible and can be used in making pickles and jam. Place of collection: Laitmawsiang Village, Meghalaya; Seeds under germination.

Bursera serrata

It is a wild edible fruit that is usually eaten raw. The bark of the tree is said to be used as medicine for treating microbial infection. Place of collection: Garo hills, Meghalaya; Seed Germination (%): 91.67; Seedlings Mortality (%): 30.91; Number of seedlings distributed: 250; No. of seedlings in stock: 200 preservatives. The fresh fruits are sold in the market @ Rs. 10-20 per 50g packet. The fruit extracts exhibited high antioxidant properties. HPLC studies found that the fruits contain Gallic acid, Catechin, Rutin and Ferulic acid. The tree is also used as timber. Place of collection: Shillong, Meghalaya; Seed Germination (%): 65.0; Seedlings Mortality (%): 49.92; Number of seedlings distributed: 404; No. of seedlings in stock: 271.

Fig.86. Seedling generation of *Garcinia xanthochymus*

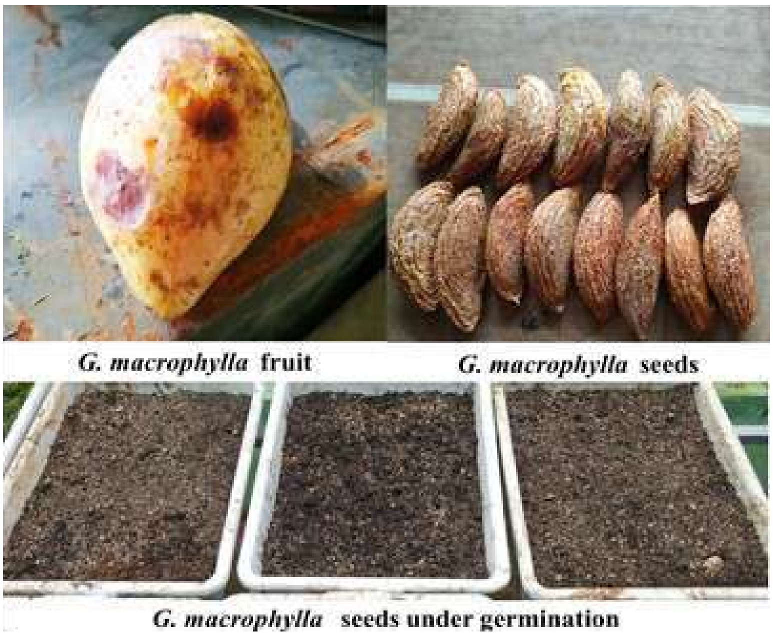


Fig.87. Seedling generation of *Garcinia macrophylla*

Fig.88. Seedling generation of *Bursera serrata*

Fig.89. Seedling generation of *Docynia indica*

Docynia indica

Fruits of *D. indica* are well known for their nutritive property and are often eaten when half ripe. The fruits are rich in sugar, organic acid, phosphorus, and iron. It has also been found to be used as a food.

Hovenia dulcis

Hovenia dulcis, also known as the Japanese raisin tree, is commonly found in East Asia. The ripe fruits have a pear like flavour and are often dried and used as raisins. The Fruits can also be processed as candies and as a substitute for honey, can be fermented to make wine and vinegar. The wood is used in making furniture and in construction works. According to Chinese traditional medicine, *H. dulcis* is believed to promote diuresis and detoxifying alcoholic intoxication. It also alleviates lingering intoxication, treating thirsty, emesis and urinal disorder and constipation. Modern medicine researches show that the extract of *H. dulcis* or its complex formulas hasten detoxification of alcoholic person. It acts by decreasing alcohol concentration in blood. It also possesses antioxidant properties. Place of collection: Mungchen village, Nagaland and Upper Shillong, Meghalaya; Seed Germination (%): 66.04; Seedlings Mortality (%): 34.66
Number of seedlings distributed: 472; No. of seedlings in stock: 644

Fig.90. Seedling generation of *Hovenia dulcis*

Gnetum gnemon

A shrub of high economic and ecological importance, and is used for dry land rehabilitation and reforestation. The seeds are nutritious and often boiled and roasted and eaten as snacks like peanuts. Young leaves are used as vegetable and sold in the market. Place of collection: Dimapur, Nagaland; Seed Germination (%): 61.25; Seedlings Mortality (%): 59.18; Number of seedlings distributed: 240; No. of seedlings in stock: 60.

Balakata baccata

It is an evergreen tree with edible fruits and often used as flavouring agent. The tree is of high ecological importance and used for reforestation, and used as timber. Place of collection: Pangti, Nagaland; Seed Germination (%): 57.14; Seedlings Mortality (%): 25.0; Number of seedlings distributed: 84; No. of seedlings in stock: 20.

Aegle marmelos

Aegle marmelos is commonly known as wood apple or Bael/Bilva. Tree has great medicinal, spiritual and religious significance. The leaves and fruits are of high commercial value @Rs. 30-40 per fruit. The leaves, bark, roots, fruits and seeds are used in Ayurveda and in various folk medicine to treat asthma, anemia, fractures blood pressure, diarrhoea, jaundice, diabetes, infertility/abortion in women. The fruit possesses broad range of therapeutic effects that includes free radical scavenging, antioxidant, antibacterial, antiviral, anti-diarrheal, hepatoprotective, anti-diabetic effects. Various chemical constituents like alkaloids, coumarins, steroids, polysaccharides, tannins carotenoids etc have been isolated and identified from distinct parts of the plant. Place of collection: Guwahati, Assam; Seed Germination (%): 15.0; Seedlings Mortality (%): NIL; Number of seedlings distributed: 30; No. of seedlings in stock: 10

Fig.91. Seedling generation of *Gnetum gnemon*

Fig.92. Seedling generation of *Balakata baccata*

Fig.93. Seedling generation of *Aegle marmelos*

Citrus maxima
Fruits are edible and a rich source of Vitamin C. Fruits are sold in local market @ Rs.20-30 per fruit. Place of collection: Shillong, Meghalaya; Seed Germination (%): 60.0; Seedlings Mortality (%): 25.0; Number of seedlings distributed: 77; No. of seedlings in stock: NIL; Rare, endangered, threatened and ecologically important species
Areca triandra
A. triandra is an evergreen ornamental palm. The seeds are highly economical and consumed by the Khasis as a substitute of *A. catechu.* The leaves can also be used for thatching. Nuts are sold in local market @ Rs. 200-300 per kg. The seeds have mild narcotic properties. The methanolic extracts of the nuts and leaves were found to have antioxidant properties. Catechin was found to be present in the *A. triandra* nut by UHPLC analysis investigated under this project. Place of collection: Mawtongreng, Thangkyrta and Pynursla, Meghalaya; Seed Germination (%): 95.0; Seedlings Mortality (%): 21.58; Number of seedlings distributed: 351; No. of seedlings in stock: 1115.
Michelia champaca
Michelia champaca or Champak is a famous fragrant flowering plant. Its flowers and stem bark are used in treating diabetes, wound healing, cardiac disorders, gout and dysuria. The methanol extracts of various plant parts are known to possess antibacterial activity. Place of collection: Shillong, Meghalaya; Seed Germination (%): 16.0; Seedlings Mortality (%): 27.08; Number of seedlings distributed: 100; No. of seedlings in stock: NIL
Aesculus assamica
A. assamica is a widespread species in the tropical and sub-tropical monsoon forest zones of North-East India. It is reported vulnerable by IUCN. The tree is ornamental and the wood is used for making vases, cups and toys. Two novel triterpenoid saponins with insulin-like activity, termed assamicin I and II were isolated from the roots. Place of collection: Laitmawsiang village, Meghalaya; Seed Germination (%): 47.5; Seedlings Mortality (%): NIL; Number of seedlings distributed: 93; No. of seedlings in stock: 02.
Adinandra griffithii
A. griffithii is endemic to Meghalaya and confined to areas like Cherrapunjee and Shongpung forests. It is an IUCN Red list Endangered species, threatened by anthropogenic activity like habitat loss and forest fires. Place of collection: Laitmawsiang village, Meghalaya; Seed Germination (%): 80.0; Seedlings Mortality (%): 47.50; Number of seedlings distributed: 750; No. of seedlings in stock: 3450.
Ilex khasiana
Ilex khasiana is a rare and classified as a critically endangered plant in the IUCN red list of threatened species. Tree is endemic and fruits are used for decorations during Christmas in Meghalaya. The Khasi of Meghalaya use the bark and root decoction in the treatment of tuberculosis and severe cold. The aerial plant parts (mainly the fruit) serve as fodder for wild animals like palm civets, squirrels, and birds. Place of collection: Upper Shillong, Meghalaya; Seed Germination (%): 70.76; Seedlings Mortality (%): 7.69; Number of seedlings distributed: 3134.
Ilex venulosa
Fruits are rich in protein, carbohydrate and total dietary fibre. Place of collection: Laitmawsiang village, Meghalaya; Seed Germination (%): 65.0; Seedlings Mortality (%): 28.15; Number of seedlings distributed: 1511; No. of seedlings in stock: 367
Acer laevigatum
A. laevigatum is a rare tree species and found in the North-Eastern states of Nagaland, Manipur, Meghalaya, and Arunachal Pradesh. Their population is declining in the wild due to habitat loss. Wood is used as planks for making tea boxes and scantlings. Place of collection: Laitmawsiang village and Jowai, Meghalaya; Seed Germination (%): 83.33; Seedlings Mortality (%): 15.40; Number of seedlings distributed: 3214; No. of seedlings in stock: NIL.

Fig.94. Seedling generation of *Citrus maxima*

Fig.95. Seedling generation of *Areca triandra*

Fig.96. Seed of *Michelia champaca*

Fig.97. Seedling generation of *Michelia champaca*

Fig.98. Seedling generation of *Aesculus assamica*

Fig.99. Seeds of *Adinandra griffithii*

Fig.100. Seedling generation of *Adinandra griffithii*

Fig.100. Seeds of *Ilex khasiana*

Fig.101. Seedling generation of *Ilex khasiana*

Alnus nepaulensis
A. nepalensis is a large alder tree found in the subtropical highlands of the Himalayas. It is distributed throughout Bhutan, China, India, Myanmar, Nepal and Pakistan. Bark is a source of tannin. Wood is used for making boxes and in light construction works and as firewood. Leaves are used in treating cuts and wounds and roots are used in diarrhoea, dysentery and stomach ache. It is a potential candidate tree for reforestation. Place of collection: Upper Shillong, Meghalaya; Seed Germination (%): 70.0; Seedlings Mortality (%): 82.14; Number of seedlings distributed: 414; No. of seedlings in stock: 100.

Fig.102. Seedling generation of *Acer laevigatum*

Fig.103. Seedling generation of *Alnus nepaulensis*

Rhododendron arboreum
R. arboreum is an ornamental tree. The dried flowers of *R. arboreum* are highly efficacious in checking diarrhoea and blood dysentery. The young leaves are said to be poisonous (causes intoxication in large quantities) as well as medicinal and applied on the forehead to alleviate headache. Leaves have been reported to have anti-diarrhoeal, hepatoprotective activity, anti-

diabetic activity, anti-inflammatory and anti-nociceptive. The tincture of dried leaves of *R. arboreum* has been used in gout & rheumatism. Flowers are also used for making wine in Sikkim and Arunachal Pradesh. Place of collection: Shillong, Meghalaya; Seed Germination (%): 89.23; Seedlings Mortality (%): 95.69; Number of seedlings distributed: 50; No. of seedlings in jute bags: 200; No. of seedlings in trays: 3000.

Fig.104. Seedling generation of *Rhododendron arboreum*

Cephalotaxus mannii

Cephalotaxus mannii has been catalogued as a vulnerable species in IUCN Red list. It has high demand for its fine timber and for high medicinal values. This plant is characterised by the presence of Cephalomannine, a new antitumor (antileukemic) alkaloid that has been extracted from its stem and root. Oil extracted from the seed is also used in painting. Place of collection: Mungchen village, Nagaland; Seed Germination (%): 97.06 Seedlings Mortality (%): 87.88; Number of seedlings distributed: 90; No. of seedlings in stock: 200

Fig.105. Seedling generation of *Cephalotaxus mannii*

Prunus cerasoides

It is commonly known as cherry blossom. Every year, in the month of November International Cherry Blossom Festival is organised in Meghalaya. *P. cerasoides* has a range of traditional uses including gum, various medicinal applications, timber, dyestuff, tannins and beads. Gum exuding from trunk and branches are chewed and can be employed as a substitute for gum tragacanth (plant resins). Wood of the tree is moderately hard, strong, durable and aromatic, so used by locals in several rituals. The heartwood that seasons well is occasionally used for buildings and making ornamental furniture. The bark is a source of tannins. The seeds are used in making beads of necklaces and rosaries. Place of collection: Shillong, Meghalaya; Seed Germination (%): 78.82; Seedlings Mortality (%): 2.42; Number of seedlings distributed: 3461; No. of seedlings in stock: 121

Fig.106. Seedling generation of *Prunus cerasoides*

Brucea mollis

Chemical compounds like Bruceine B, Brucine D, Brusatol, and Yandanziolide A, isolated from *Brucea mollis* have been found to have anticancer, antimalaria, amoebicidal, antiplasmodial, insecticidal, pesticidal, antiviral and antileukemic activities. The compound 1-Erythl-β-carboline, isolated from *B. mollis* has also been reported to be used as CNS-depressant and hypotensive; β-Carboline-1-propionic acid and Canthin-6-one have found as a cAMP inhibitor. Place of collection: Shillong, Meghalaya; Seed Germination (%): 96.67; Seedlings Mortality (%): 13.79; Number of seedlings distributed: 95; No. of seedlings in stock: 70.

Saraca asoca

Dried root is used in treatment of paralysis, hemiplegia and visceral numbness. Paste of roots is useful in freckles and external inflammations, ulcers and skin diseases. Used for treating itching in eczema, psoriasis, dermatitis, and herpes-kushta/visarpa. It is a favourite herb to help relieve pruritis. Externally it is used in a cream as it rejuvenates the complexion and skin tone may be applied in discoloration or loss of pigmentation. It is found to have anticancer, antimicrobial, anti menorrhagic and antioxytocic activity. Place of collection: Dimapur, Nagaland; Seed Germination (%): 85.0; Seedlings Mortality (%): 29.41; Number of seedlings distributed: 35; No. of seedlings in stock: NIL

Clerodendrum colebrookianum

It is a perennial shrub found in North-East region of India. Commonly used for relieving rheumatic pains and controlling high blood pressure by Khasi and Jaintia tribes of Meghalaya. In Manipur, it is used to treat cough, dysentery, and skin diseases. Tender leaves are used as vegetable and sold in the local market. Place of collection: Shillong, Meghalaya; Seed Germination (%): 83.33; Seedlings Mortality (%): 30.0; Number of seedlings distributed: 60; No. of seedlings in stock: 10

Betula alnoides

Betula alnoides is a deciduous tree native to Eastern Asia. The bark is used to make paper like sheets in olden times to write scriptures. The bark is usually used by the locals to cure hysteria, snake bites and antiseptic property. Bark is boiled with water and the liquid mass is applied to dislocated bone and injury. Bark is chewed orally to treat sore throat and to check excessive menstruation. Place of collection: Shillong, Meghalaya; Seed Germination (%): 75.0; Seedlings Mortality (%): 86.44; Number of seedlings distributed: 948; No. of seedlings in stock: 50

Fig.107. Seedling generation of *Brucea mollis*

Fig.108. Seedling generation of *Saraca asoca*

Fig.109. Seedling generation of *Clerodendrum colebrookianum*

Fig.110. Seedling generation of *Betula alnoides*

Podocarpus neriifolius
The leaf of the plant is found to have analgesic and antidiarrheal activities and antiproliferative activity. The plant is also of great ecological importance as it is found to possess nitrogen fixing ability. Place of collection: Jowai, Meghalaya; Seed Germination (%): 56.82; Seedlings Mortality (%): 4.0; Number of seedlings distributed: 88; No. of seedlings in stock: NIL

Fig.111. Seedling generation of *Podocarpus neriifolius*

Taxus baccata
Taxol compound extracted from *Taxus baccata* are used to treat a variety of cancers, including breast, lung and ovary carcinomas. The seeds and foliage of *T. baccata* are rich in toxic alkaloids (Miller 1980) all parts being poisonous apart from the aril. They contain taxin(e), a complex mixture of alkaloids that is rapidly absorbed from the digestive tract and interferes with the action of the heart (Cooper & Johnson 1984). Place of collection: Shillong, Meghalaya; Seed Germination (%): 92.17; Seedlings Mortality (%): 40.80; Number of seedlings distributed: 825; No. of seedlings in stock: 300

Fig.112. Seedling generation of *Taxus baccata*

Quercus griffithii
The trees are conserved both local community of Arunachal Pradesh as their leaves play a crucial role in sustaining 11 traditional cropping systems of the Monpa tribe. The leaf litters are used as organic fertilizers in agricultural systems and is vital to agroecosystem sustainability. Place of collection: Shillong, Meghalaya; Seed Germination (%): 93.33; Seedlings Mortality (%): 12.5; Number of seedlings distributed: 1988; No. of seedlings in stock: 100.

Fig.113. Seedling generation of *Quercus griffithii*

Fig.114. Seedling generation of *Celtis tetrandra*

Fig.115. Seedling generation of *Ficus virens*

Celtis tetrandra

Fruits are eaten raw. The wood is very tough, pliable, strong, and durable. Used in making oars, tool handles, etc. The wood is an excellent fuel. The juice from the seeds is used in the treatment of indigestion. Place of collection: Shillong, Meghalaya; Seed Germination (%): 96.67; Seedlings Mortality (%): 29.89; Number of seedlings distributed: 2729; No. of seedlings in stock: 321

Ficus virens

It has great significance in the origin of Naga Tribe in North Eastern India. The fruits were collected from Makhan village, Senapati district, Manipur. The tree is used as a source of medicine, wood and latex. It is also grown as an ornamental and shade tree along avenues. Place of collection: Makhan village, Manipur; Seed Germination (%): 30.0; Seedlings Mortality (%): 5.0; Number of seedlings distributed: 5; No. of seedlings in stock: 10

Mahonia nepalensis

Fruits are edible and bark is used in treatment of eye infections. Berberine, universally present in rhizomes of *Mahonia* species, has marked antibacterial effects and is used as a bitter tonic. Place of collection: Shillong, Meghalaya; Seed Germination (%): 87.5; Seedlings Mortality (%): 28.57; Number of seedlings distributed: 1529; No. of seedlings in stock: NIL

Fig.116. Seedling generation of *Mahonia nepalensis*

Trachycarpus martianus

The fruit, young flower buds is eaten raw or cooked and used as an alternative for bamboo shoots. The flowers and the seeds are used as astringent and haemostatic. The root and the fruit is decocted as a contraceptive. The ashes from the silky hairs of the plant are haemostatic and when mixed with boiling water used in the treatment of haemopytsis, nose bleeds, haematemesis, blood in stools, metrorrhagia, gonorrhoea and other venereal diseases. The fibres from within the leafstalk are used for making brushes, ropes, etc. Mats are also made from the bark mixed with some of the stem fibres. The leaves are woven into hats and fans. Place of collection: Shillong, Meghalaya; Seed Germination (%): 80.0; Seedlings Mortality (%): 58.33; Number of seedlings distributed: 53; No. of seedlings in stock: NIL

Fig.117. Seedling generation of *Trachycarpus martianus*

Cinnamomum glanduliferum

Essential oils extracted from leaves are reported to have antimicrobial property especially against foodborne pathogenic and spoilage bacteria and also cytotoxic activities. Anti-inflammatory and gastroprotective potential of leaf essential oil of the plant have also been reported by S.S Azab (2017). Ethnomedicinally the roots are used for healing wounds and toothache; leaves are used as stimulant, and to treat coughs and colds, analgesic, antiseptic, astringent, and carminative properties; seeds are used for curing cold, cough, toothache and taenias, muscular swellings, seed oil in treating muscular spasm, joint pain and body aches; the bark is used for curing kidney trouble as mentioned by S Kumar (2019). Place of collection: Pomlum village, Meghalaya; Seed Germination (%): 83.67; Seedlings Mortality (%): 12.35; Number of seedlings distributed: 999; No. of seedlings in stock: NIL

Fig.118. Seedling generation of *Cinnamomum glanduliferum*

Ligustrum robustum

Aqueous extract of processed leaves of *Ligustrum robustum* could prevent AAPH-induced haemolysis of red blood cells. In comparison with green tea, oolong tea and black tea, processed leaves of *L. robustum* exhibited comparable antioxidant potency in scavenging superoxide radicals and in preventing red blood cell haemolysis. Place of collection: Shillong, Meghalaya; Seed Germination (%): 68.46; Seedlings Mortality (%): 60.67; Number of seedlings distributed: 55; No. of seedlings in stock: NIL

Aglaia perviridis

The species is of great concern as it is included in the IUCN vulnerable category. Ripe fruits of the plant are eaten. Methanolic extracts of a combination of the fruits, leaves, barks, twigs and the roots of the plant possess anticancer properties Li Pan (2013); Zhi Ran (2016). Leaves of the plant are also reported to have anti-inflammatory activities Fa-LiangAn (2020). The plant possesses compounds that bear a unique cyclopenta-tetrahydrobenzofuran skeleton which is a potent insecticidal, antifungal, antiviral, antibacterial or anthelmintic in nature. The dark reddish-brown wood is hard and is used in construction, ship and boat-building, for household utensils and agricultural tools. Place of collection: Laitmawsiang, Meghalaya; Seed Germination (%): 83.3; Seedlings Mortality (%): 17; Number of seedlings distributed: 550; No. of seedlings in stock: 250

Fig.119. Seedling generation of *Ligustrum robustum*

Fig.120. Seedling generation of *Aglaia perviridis*

Fig.121. Seedling generation of *Hydnocarpus kurzii*

Hydnocarpus kurzii

The plant is of great economic and medicinal importance and is found to be sold at a very high price @ Rs.3000 /kg by local villagers. Seed oil for treatment of leprosy and leaf and seed paste for treatment of leg infections MH Kabir et al. (2013). Erena Islam et al. (2015) found that methanolic extract of bark of *H. kurzii* possess antihyperglycemic potential and may be used for lowering blood sugar. Seed oil from species of the *Hydnocarpus* is used for medicinal purposes, predominantly for various skin disorders. This oil is reported to contain a characteristic class of compounds known as cyclopentenyl fatty acids. Furthermore, seeds of this genus are reported to contain triglycerides of fatty acids, sterols, flavonoids, and flavonolignans. Hydnocarpin, a flavonolignan, is reported to potentiate antimicrobial and anticancer activity. Place of collection: Laitmawsiang, Meghalaya; Seed Germination (%): 20; Seedlings Mortality (%):40; Number of seedlings distributed: NIL; No. of seedlings in stock: 10

Ormosia pinnata

The wild fruit is commonly known as Soh khuaitur in Jaintia and Sohskei in Khasi. *O. pinnata* has also been reported to have great environmental importance as it is a fast-growing tree and also reported to have nitrogen fixing property and withstand water-logging stress. Place of collection: Laitmawsiang, Meghalaya; Seed Germination (%): 40; Seedlings Mortality (%):40; Number of seedlings distributed: NIL; No. of seedlings in stock: 27.

Prunus carmesina

P. carmesina is commonly called 'wild cherry' is common in the hills of Meghalaya, Nagaland and Manipur. Traditionally, juice of the bark is applied externally to treat backaches. Bark paste is applied over the forehead for hemicranias and is also used as plaster for fractured bone, burns, indigestion, fever, foot and mouth diseases, wound healing and bone dislocations. Stems and branches are used for the treatment of gravel, kidney stones, asthma, thirst, leprosy and vomiting. Heartwood is moderately hard, strong, aromatic, astringent, bitter, acrid, refrigerant, antipyretic and tonic. Flowers are diuretic and laxative. Place of collection: Upper Shillong, Meghalaya; Seeds kept for germination

Fig.122. Seedling generation of *Ormosia pinnata*

Fig.123. Seedling generation of *Prunus carmesina*

Dillenia indica

It is known as 'Elephant Apple'. Fruits are eaten raw or cooked. It is used in the treatment of abdominal disorders and is mixed with sugar to be used against coughs. The bark and leaves are astringent and used as a mouthwash to treat thrush. The fruits can be rubbed in water to make soap. The pulp is used as a hair wash. The leaf juice is applied to the scalp to prevent baldness. The dried leaves are used to polish ivory. The wood ash is added to clay bricks to increase their fire resistance. Place of collection: Barapani, Meghalaya; Seed Germination (%): 84; Seedlings Mortality (%):20; Number of seedlings distributed: 215; No. of seedlings in stock: 200

Illicium griffithii

I. grifithii is an IUCN categorised endangered and endemic tree species of Meghalaya. High anthropogenic disturbances and changing climate is threatening its existing population. Place of collection: Umtong, Meghalaya; Stem cuttings for vegetative propagation carried out.

Fig.124. Seedling generation of *Dillenia indica*

Fig.125. Seedling generation of *Illicium griffithii*

Details of plants/ seeds collected for macropropagation in Arunachal Pradesh, Darjeeling and Sikkim (Kolkata Unit):

- Near about 8000 fruits of Prunus cerasoides were collected from various locations of East Sikkim. Seeds were depulped and dried for sowing in seed beds at Botanical Survey of India (BSI), Sikkim Himalayan Regional Centre (SHRC) garden.
- Near about 2000 seeds of Oroxylum indicum were collected from Yang-yang village, South Sikkim and sowed in BSI, SHRC garden.
- Approximately 15 saplings of Amomum kingii are recovered from Pangthang area of East Sikkim and conserved at BSI, SHRC garden.

- Approximately 25 saplings of Magnolia doltsopa were recovered from various areas of East Sikkim and relocated and raised in BSI, SHRC.
- Approximately 5000 saplings of various medicinal, useful and threatened plants were propagated in BSI, Arunachal Pradesh Regional Centre (APRC), Itanagar throughout the project tenure.
- Medicinal plants viz. Bischofia javanica, Castanopsis indica, Cinnamomum bejolghota, Clerodendrum colebrookeanum, Curcuma caesia, Oroxylum indicum, Saraca asoca, Terminalia arjuna, Wrightia coccinea were propagated in BSI, APRC.
- Approximately 500 saplings of two canes species viz. Calamus flagellum and C. tenuis were recovered from various areas of Arunachal Pradesh and raised in BSI, APRC, finally distributed to locals.
- Approximately 100 saplings of threatened plant Livistona jenkinsiana propagated in BSI, APRC.
- About 500 saplings of plant species propagated in BSI, APRC were planted on various locations of Itanagar on 8th August 2019, on celebration of office foundation day.
- More than 1500 seedlings and saplings of plant species developed in the APRC, were distributed among ITBP and CRPF, Itanagar World Ozone Day, 16th September, 2020.
- About 700 saplings were distributed among locals on Earth Day, 22nd April 2021.
- Nearly 500 saplings of various plants were distributed and some were planted on office premise on International Day for Biological Diversity, 22nd May 2022.

Fig.125. A.Net house at BSI, APRC, Itanagar; B. Seedbeds in BSI, APRC Net house; C. Recovered saplings of Oroxylum indicum; D. Recovered Saplings of Bischofia javanica; E. Recovered saplings of Calamus flagellum and C. tenuis F. Recovered saplings of Cinnamomum bejolghota.

Table:14. Details of the plants collected (Kolkata Unit)

Arenga micrantha C.F. Wei (Arecaceae)
Tibetan sugar palm, Tasse
IUCN status: Endangered (EN)
Key Characters:
Tree with solitary stem, 2-8 m tall. Pinnae many per side of rachis, linear-lanceolate, very briefly lobed along margins, with ears at bases, regularly arranged and spreading in same plane. Inflorescences 80-100 cm long.
Plants collected: Kurungkumey, Arunachal Pradesh

Arenga westerhoutii Griff (Arecaceae)
Key Characters:
Single-stemmed, evergreen palm growing up to 12 metres tall. The unbranched stem can be 40cm in diameter, crowned by a rosette of around 6 – 12 leaves. The plant is harvested from the wild for local use as a food and source of materials. Plants collected: Kurungkumey, Arunachal Pradesh

Ormosia robusta Baker (Leguminosae)
Key Characters:
Tree, up to 12 m tall; stem bark brown, warty, yellowish inside. Leaves are compound, 30-40 cm, with 7-9 leaflets which are ovate-lanceolate shaped. Flowers are borne in clusters at branch-ends; flowercluster- stalk and flower-stalk densely rusty velvethairy. Flowers are creamy-white. Sepal cup is persistent, bell-shaped; teeth broadly triangular. Pods are 1 or 2 seeded, cy lindric or slightly compressed between seeds, hairless, yellowish-green, tip slightly beaked; valves woody, splitting open.
Plants collected: Ganga Lake area, Arunachal Pradesh

Curcuma caesia Roxb. (Zingiberaceae)
Key Characters:
Erect, rhizomatous herb. Leaves arise from the underground rhizome, 30–60 x 10 – 15 cm, broadly lanceolate or oblong, glabrous, with a deep ferruginous purple cloud down the middle. Petiole and sheath are about as long as the blade. Flowers pale yellow, reddish at the outer border and shorter than their bracts. Rhizomes are useful in treating leukoderma, piles, bronchitis, asthma, Plants

collected: Itanagar WLS, Arunachal Pradesh Curcuma caesia Roxb. (Zingiberaceae)
Key Characters:
Erect, rhizomatous herb. Leaves arise from the underground rhizome, 30–60 x 10 – 15 cm, broadly lanceolate or oblong, glabrous, with a deep ferruginous purple cloud down the middle. Petiole and sheath are about as long as the blade. Flowers pale yellow, reddish at the outer border and shorter than their bracts. Rhizomes are useful in treating leucoderma, piles, bronchitis, asthma, Plants collected: Itanagar WLS, Arunachal Pradesh

Oroxylum indicum (L.) Kurz (Bignoniaceae)

Key Characters:
Trees, 6-10 m tall. Stem 15-20 cm in diam.; bark gray-brown. Leaves bipinnately compound, borne nearly at stem apex.Flowers usually open at night, with foul smell. Calyx purple, campanulate, glabrous, membranous, becoming subwoody in fruit. Corolla purple-red, bilipped. Stamens inserted at middle of corolla tube; anthers ellipsoid. Capsule woody. Plants collected: Itanagar WLS, Arunachal Pradesh

Cinnamomum bejolghota (Buch.-Ham.) Sweet (Lauraceae)

Key Characters:
Large trees, up to 25 m tall. Bark green, scented, Leaves subopposite, elliptic-oblong, Panicle axillary on upper part of branchlet, densely many flowered, much branched. Flowers yellow. Perianth tube short, obconical; lobes 6, ovate-oblong, gray pubescent. Fertile stamens 9. Staminodes 3. Ovary oblong; style slender; stigma discoid. Fruit ellipsoid. The bark, leaves and flowers used in traditional medicines.
Plants collected: Nyapin, Arunachal Pradesh

Amomum kingii Baker (Zingiberaceae)

Key Characters:
Rhizomatous herb, covered glabrous leaf sheaths.
Leaf sheaths membranous, glabrous, maroon. Leaves oblong-lanceolate; midrib pink; ligule entire, coriaceous, dark maroon. Flower white tinged with yellow, many blooms at a time. Calyx 3- toothed, white, membranous. Corolla tube pale yellow, Labellum obovate, obscurely 3-lobed. Staminodes ribbon-like. Epigynous glands two, oblong. Ovary inferior, trigonous; stigma cup shaped, white. Capsule globose or spherical, green with red tinged.
Plants collected: Kabi, Sikkim.

Cinnamomum impressinervium Meisn. (Lauraceae)
Key Characters:
Small tree, up to 15m tall. Leaves elliptic or ovate-elliptic, finely acuminate, glossy above with strongly impressed veins; petioles 8-13mm. Panicles 6-10 cm, appressed pubescent. Perianth segments deciduous. Fruit ellipsoid, borne on shallow entire perianth cup. The dry leaf powder is used as a traditional treatment for diabetes.
Plants collected: Itanagar Sarlii, Arunachal Pradesh

Magnolia doltsopa (Buch.-Ham. ex DC.) Figlar
Key Characters:
Trees up to 20 m high. Branchlets ferruginous tomentose. Leaves elliptic to lanceolate. Flowers 7-12 cm across, white to pink, mildly fragrant. Follicles ovoid. Planted as ornamental plant. Wood is used as building material.
Plants collected: Itanagar WLS, Arunachal Pradesh
Collections made from Pangthang, Sikkim

Fraxinus floribunda Wall. (Rosaceae)
Key Characters:
Large trees; branches warty. Leaves pinnate; leaflets usually 7, elliptic-lanceolate, acuminate, toothed, puberulous on nerves beneath. Flowers in terminal, compound panicles, white. Samaras narrow, oblanceolate, obtuse or emarginate with enlarged calyx.
Plants collected: Pangthang, Sikkim

Prunus cerasoides D. Don (Rosaceae)
Key Characters:
A large tree; younger parts pubescent. Leaves ovate or oblong–lanceolate, 7.5–15 cm long, variable both in length and breadth, caudate–acuminate, shortly serrate, glabrous. Stipules laciniate. Flower solitary, fascicled or in umbel. Calyx tube about 12 mm, glabrous; lobes ovate, acute. Petals linear–oblong to obovate; drupe oblong or ellipsoid, yellowish to reddish. Collections made from BSI, campus, SHRC, Sikkim.

Rhododendron thomsonii Hook. f. (Ericaceae)
Key Characters:
Shrub to small tree, to 5 m tall. Leaves broadly elliptic to obovate, glabrous and glaucous beneath. Flowers few, in terminal head, deep crimson to brown–red. Calyx cup– shaped, obscurely lobed or not. Corolla campanulate. Capsule oblongoid, glaucous purple
Collections made from Kyangnosla, Sikkim

Quercus lamelleosa Sm. (Fagaceae)
Key Characters:
Medium-sized to large evergreen tree, up to 40 m tall. Leaves spirally arranged, ovate-elliptic, with a sharply saw-toothed margin. Flowers borne in catkins. The female flowers mature into large, broad acorns, set in a deep cup with concentric rings of woody scales.
Collections made from Kabi, Sikkim

Bischofia javanica Blume (Phyllanthaceae)
Key Characters:
Evergreen or semievergreen woody tree, up to 40 m tall. Leaves trifoliate, rarely palmate; leaflet papery, ovate, elliptic, sub ovate, or elliptic-ovate, pointed and broadly wedge shaped to obtuse at base, with two to three teeth per centimetre along the serrated margin. Flowers small, dioecious, in panicles from leaf axils, greenish-yellow. Berries light brown, globular or sub globular.
Collections made from Mangan, Sikkim.

Aesculus assamica Griff. (Sapindaceae)
Key Characters:
Deciduous tree, up to 32 m tall. Leaves digitately compound, leaflets 5-9, oblong-lanceolate to oblong-oblanceolate, rarely lanceolate to oblanceolate. Spikes cylindric. Flowers fragrant. Calyx abaxially grey or pale yellowish grey puberulent. Petals 4, white or pale yellow, with purple or brown spots, unequal, 2 spatulate to oblong and 2 oblong obovate or obovate. Capsule yellowish brown, ovoid to obovoid. Collections made from Near Hawa camp, Arunachal Pradesh.

Castanopsis indica (Roxb. ex Lindl.) A. DC. (Fagaceae)
Key Characters:
Trees, up to 15 m tall. Leaves ovate-elliptic, elliptic, or sometimes obovate-elliptic, thickly papery, abaxially puberulent or glabrescent. Cupule globose, usually splitting into 4 segments when mature. Bracts spinelike, entirely covering cupule, straight or bent, base connate into bundles. Nut 1(or 2) per cupule, broadly conical, densely hairy; scar covering ca. one-fourth of nut.
Collections on way to Kururng kumey

Quercus glauca Thunb. (Fagaceae)
Key Characters:
Tree, up to 18 m tall. Leaves ovate to ellipticlanceolate, entire or toothed, long pointed. Male catkins are 3.5-6 cm long, in clusters, velvety; bracts prominent, 3-4 mm long, ciliate and pubescent. Petals lance shaped, unequal, pubescent. Stamens10-14; filaments 1 mm long, anthers slightly shorter, glabrous. Female flowers are on short peduncles up to 1.5 cm long; styles 3, recurved. Cupule is 1.2-1.3 cm broad, scales accrescent, in annular rings; rings5-6 in number. Acorn is ovoid, 1.8 cm long, glabrescent.
Collections made from Sagali, Arunachal Pradesh.

Schima wallichii Choisy (Theaceae)
Key Characters:
Medium sized, evergreen tree, up to 15 m tall. Stem cylindrical, branchless for up to 25 m, with a steep buttress; bark surface ruggedly cracked into small, thick, angular pieces. Leaves leathery, ellipticoblong, margins entire or slightly toothed. Flowers white, fragrant. Sepals rounded. Petals 5, broadly ovate to rounded. Stamens many, orange-yellow.
Collections made from Near Singtam, Sikkim.

Fig.126. Collection of seeds of Arenga westerhoutii and Sterculia sp. from Arunachal Pradesh

Fig.127. A.*Cinnamomum* sp., B. *Ormosia sp.*, C. *Cinnamomum bejolghota* sapling, D. *Amomum kingie*, E. *Oroxylum indicum* fruit

Fig.128. A. Flowering twig of Casatanopsis indica; B. Fruiting twig of Castanopsis indica; C. Cinnamomum bejolghota; D. Curcuma caesia; E. Data collection during collection of Arenga westerhoutii; F. Arenga westerhoutii; G. A. micrantha; H. Mature Fruits of A. micrantha

Fig.129. A. Seeds of Oroxylum indicum, B. seeds of O. indicum in poly bags, C. Seeds of O. indicum in polytrays, D - F. Germinated seeds of Prunus cerasoides in polytrays,G. Seed sowing of P. cerasoides in seedbeds, H. Recovered Saplings of P. cerasoides in Polybags.

Fig.130. Net house at BSI, SHRC

Fig.131. Seed collection at **Varsey Rhododendron Sanctuary**

Table:15. Details of the seedlings of plants from north east India generated in Botanical Survey of India gardens

Sl.no	Name	No. of seedlings distributed
1	*Aegle marmelos*	30
2	*Aglaia pervirides*	550
3	*Adinandra griffithii*	750
4	*Acer laevigatum*	3214
5	*Aesculus assamica*	93
6	*Alnus napaulensis*	414
7	*Aphananthe cuspidata*	2289
8	*Areca triandra*	331
9	*Baccaurea ramiflora*	732
10	*Betula alnoides*	948
11	*Balakata baccata*	84
12	*Bursera serrata*	250
13	*Brucea mollis*	95
14	*Carallia brachita*	311
15	*Cephalotaxus mannii*	90
16	*Castanopsis tribuloides*	280
17	*Castanopsis indica*	2799
18	*Celtis tetrandra*	2729
19	*Chrysophylum roxburghii*	520
20	*Cinnamomum glanduliferum*	999
21	*cinnamomum tamala*	140
22	*Citrus indica*	77
23	*Clerodendrum colebrookianum*	60
24	*Dillenia indica*	215
25	*Docynia indica*	404
26	*Ficus virens*	5
27	*Garcinia cowa*	365
28	*Gnetum gnemon*	240
29	*Gynocardia odorata*	837
30	*Garcinia macrophylla*	-
31	*Garcinia xanthochymus*	1460
32	*Hovenia dulsis*	472
33	*Hydnocarpus kurzii*	_
34	*Ilex khasiana*	3134
35	*Ilex venulosa*	1511
36	*Jaccaranda mimosifolia*	395
37	*Ligustrum robustum*	55

38	*Mahonia napaulensis*	1529
39	*Myrica esculenta*	428
40	*Michelia champaca*	100
41	*Myrica nagi*	75
42	*Ormosia pinnata*	_
43	*Prunus crasoides*	3461
44	*Prunus carmesina*	_
45	*Prunus napaulensis*	2556
46	*Podocarpus nerifolius*	88
47	*Quercus graffithi*	1988
48	*Rhododendron arboretum*	50
49	*Saraca asoca*	35
50	*Syzygium cumini*	452
51	*Syzygium tetragonum*	152
52	*Trachycarpus martians*	53
53	*Teccoma stans*	462
54	*Taxus baccata*	825
55	*Chrysophyllum griffithii*	1100
56	*Phyllanthus emblica*	1500
57	*Baccaurea ramiflora*	1200
58	*Canarium strictum*	690
59	*Spondia pinnata*	720
60	*Choreospondias axillaris*	700
61	*Caralia brachiata*	860
62	*Arthocarpus chama*	870
63	*Quercus serrata*	1100
64	*Syzygium cumini*	900
65	*Prunus nepaulensis*	560
66	*Artocarpus lakoocha*	820
67	*Quercus serrata*	1500
68	*Juglans regia*	750
69	*Prunus cerasoides*	2250
70	*Gnetum gnemon*	710
71	*Garcinia xanthochymus*	310

Micropropagation work:

***Phlomoides superba*:**

Shoot initiation and Shoot multiplication:

Shoot organogenesis in shoot tip explants was promoted by inoculating these explants on Murashige and Skoog (MS) medium fortified with cytokinins (BAP, TDZ & Kinetin) and auxin (NAA).. The shoot tips of *in vitro* raised seedlings were excised and cultured in MS medium. The MS medium was supplemented with different concentration of BAP (4.4 to 11.1µM), TDZ (2.27-9.02 µM) and Kinetin (4.6-11.6 µM). Subsequently, the most suitable concentration of BAP (6.6 µM), TDZ (4.54 µM) and kinetin (6.9 µM) was tested in combination with different concentration of NAA (0.53-1.59 µM). The medium was supplemented with activated charcoal (1.0 g l^{-1}) or poly-vinyl-pyrrolidone (PVP:1.5g l^{-1}) (Himedia Laboratories, India), to prevent the browning of culture medium and necrosis of tissues from white-milky exudate of explants. The best morphogenetic response (number of shoots per explant, shoot length and frequency of shoot regeneration) was observed when explants were incubated on half-strength MS medium containing 6.66 µM BAP and 0.53 µM NAA.

Table: 16. Effect of cytokinin and NAA on shoot regeneration from shoot tip explants of *P. superba* in half-strength MS medium after 6 weeks of culture.

Cytokinin (µM)			Cytokinin + NAA (µM)			Explants with shoots (%)	No. of shoots per explant	Shoot length (cm)
BAP	**TDZ**	**Kinetin**	**BAP + NAA**	**TDZ + NAA**	**Kinetin + NAA**			
0	0	0	0	0	0	20.0	1.5 ± 0.18^{f}	1.42 ± 0.13^{o}
4.4	0	0	0	0	0	65.6	13.6 ± 1.01^{c}	3.8 ± 0.27^{g}
6.6	0	0	0	0	0	77.8	17.8 ± 1.04^{b}	4.1 ± 0.41^{d}
8.9	0	0	0	0	0	74.3	15.2 ± 1.03^{c}	4.0 ± 0.4^{e}
11.1	0	0	0	0	0	69.1	10.7 ± 0.9^{d}	3.5 ± 0.26^{i}
0	2.27	0	0	0	0	54.0	7.3 ± 0.7^{e}	3.2 ± 0.21^{j}
0	4.54	0	0	0	0	65.0	11.9 ± 0.92^{c}	3.7 ± 0.27^{h}
0	6.81	0	0	0	0	61.7	9.3 ± 0.87^{d}	3.1 ± 0.20^{k}
0	9.09	0	0	0	0	57.3	7.8 ± 0.76^{e}	2.7 ± 0.19^{n}
0	0	4.6	0	0	0	54.3	9.7 ± 0.88^{d}	2.8 ± 0.19^{m}
0	0	6.9	0	0	0	66.2	13.5 ± 1.02^{c}	3.1 ± 0.2^{k}
0	0	9.3	0	0	0	64.0	12.9 ± 1.01^{c}	3.0 ± 0.2^{l}
0	0	11.6	0	0	0	59.0	10.8 ± 0.9^{d}	2.8 ± 0.19^{m}
0	0	0	6.6 + 0.53	0	0	100.0	24.5 ± 1.8^{a}	5.7 ± 0.56^{a}
0	0	0	6.6 + 1.06	0	0	95.0	21.3 ± 1.0^{a}	5.6 ± 0.54^{b}
0	0	0	6.6 + 1.59	0	0	90.0	18.3 ± 0.98^{b}	4.8 ± 0.51^{c}
0	0	0	0	4.54 + 0.53	0	70.23	13.3 ± 1.01^{c}	3.9 ± 0.28^{f}
0	0	0	0	4.54 + 1.06	0	67.18	12.1 ± 1.0^{c}	3.7 ± 0.27^{h}
0	0	0	0	4.54 + 1.59	0	63.0	11.0 ± 0.98^{d}	3.5 ± 0.25^{i}
0	0	0	0	0	6.9 + 0.53	78.2	17.03 ± 1.04^{b}	4.8 ± 0.51^{c}
0	0	0	0	0	6.9 + 1.06	75.0	16.8 ± 1.01^{b}	4.03 ± 0.4^{e}
0	0	0	0	0	6.9 + 1.59	70.0	15.3 ± 0.99^{c}	3.08 ± 0.27^{l}

Data are presented as the mean ± SD. Means followed by different letters within columns indicate significant differences at $P \leq 0.05$

Rooting:

Cluster of three to five shoots, measuring around 4.2 cm in length were transferred to various rooting media. Initially, the shoot clusters were cultured on MS, and modified MS supplemented with major salts reduced to half, quarter and zero strength. Later, these basal media were supplemented with various auxins (Himedia Laboratories, India), viz. IAA (2.85 to 14.27 µM), IBA (2.46 to 12.26 µM), and NAA (2.65 to 13.25 µM) individually. The quarter-strength MS medium was found most suitable for the growth, followed by half, full and zero-strength MS mediums supplemented with IBA (7.36 µM). Subsequent rooting experiments were performed involving activated charcoal, PVP and gelling agents such as agar (0.8 and 0.6% w/v), agar gel (0.4% w/v), gelrite (0.2% w/v) and liquid media only. Quarter-strength MS media fortified with IBA (7.36 µM) was found optimum for the root development.

Fig.132. Micropropagation of *P. superba*. A-C. Shoot initiation and proliferation in *P. superba* from shoot tip explants, (D-E). root initiation in *P. superb*, (F-G) hardening and acclimatization of plantlets into pots.

Hardening and transplantation:

After 4 weeks of culturing in rooting medium, the in vitro raised healthy plantlets with well-developed shoots and roots were taken out from the culture tubes, and washed gently under running tap water to detach the traces of the medium from the roots. Plantlets were shifted to root trainers containing sterile soil and vermiculite in 1:1 ratio. To ensure high humidity, plantlets were covered with transparent polythene foil and were watered every three days with half strength modified Hoagland solution (Epstein, 1972). The polythene foil was removed after 2 weeks in order to acclimatize plants to field conditions.

Table:17. Effect of auxins on root induction in in vitro regenerated shoots of *P. superba* in quarter-strength MS medium after 2 weeks of culture.

Auxins (µM)			Rooting (%)	No. of roots per shoot	Root Length (cm)
IBA	**NAA**	**IAA**			
0	0	0	5.0	0.87 ± 0.06[i]	2.1 ± 0.26[h]
2.46	0	0	61.0	7.6 ± 1.02[d]	4.3 ± 0.48[d]
4.9	0	0	85.0	8.7 ± 1.04[c]	4.8 ± 0.57[c]
7.36	0	0	100.0	16.4 ± 1.3[a]	5.6 ± 0.59[a]
9.8	0	0	93.0	14.3 ± 1.2[b]	5.3 ± 0.58[b]
12.26	0	0	87.0	9.4 ± 1.08[c]	5.0 ± 0.51[c]
0	2.65	0	32.0	1.6 ± 0.18[h]	3.7 ± 0.29[f]
0	5.3	0	57.0	4.8 ± 0.72[f]	4.0 ± 0.41[e]
0	7.95	0	67.0	7.3 ± 1.02[d]	4.8 ± 0.57[c]
0	10.6	0	64.0	6.9 ± 0.9[e]	4.4 ± 0.53[d]
0	13.25	0	51.0	4.6 ± 0.7[f]	3.9 ± 0.3[e]
0	0	2.85	23.0	1.3 ± 0.13[h]	3.1 ± 0.21[g]
0	0	5.71	47.0	3.9 ± 0.27 [g]	3.7 ± 0.25[f]
0	0	8.56	53.0	4.6 ± 0.71[f]	4.02 ± 0.37[e]
0	0	11.42	51.0	4.6 ± 0.71[f]	4.0 ± 0.3[e]
0	0	14.27	48.0	4.01 ± 0.37[f]	4.01 ± 0.27[e]

Data are presented as the mean ± SD. Means followed by different letters within columns indicate significant differences at $P \leq 0.05$

***Sophora mollis*:**

Shoot induction and proliferation

The excised shoot tip explants were inoculated onto the shoot initiation basal MS medium (control). Explants inoculated onto control medium did not show any morphogenic response. When both the basal media were enriched with 6-benzylaminopurine (BAP) (2.2 to 11.1 µM), N-phenyl-N0-1,2,3-thiadiazol-5-urea (Thidiazuron/TDZ) (2.27 to 6.8 µM) and Kinetin (2.32 to 9.3 µM), a significant increase was observed in shoot formation percentage and maximum 96.27% shoot development was observed in BAP substituted medium followed by TDZ (78.69%) and kinetin (76.78%), respectively (Table 1). Since BAP (8.9 µM) TDZ (4.54 µM) & kinetin (6.9 µM) yielded the maximum shoot proliferation rate in the MS medium and were further tested in combination with various concentrations of NAA (0.53-2.65 µM). But no significant difference was observed in the shoot proliferation rate and besides shoot formation callusing was also observed which consequently reduced the number of shoots. MS medium reinforced with BAP (8.9 µM l^{-1}) was found to be the optimal medium for the shoot initiation and proliferation and followed by TDZ (4.5 µM l^{-1}) and kinetin (6.9 µM l^{-1}), respectively. Based on all the experiments, MS medium reinforced with 4.4 µM BAP was observed optimal for the shoot development and proliferation and maximum 96.27% shoot formation was achieved with 55.32 mean shoot number per culture and 4.5 cm shoot length, respectively (Fig. 1 a-c). The current finding is in accordance to the earlier finding on *Sophora tonkinensis* (Jana et al. 2013) in which shoot development was observed in MS medium fortified with 2ip (2.0 µM l^{-1}) and 5.0 shoots per culture was obtained. While contrary to this shoot development was achieved in combination of BAP and auxin (NAA, IBA & IAA) such as *S. tonkinensis* (Kun-Hua et al. 2013), *S. flavescens* (Zhao et al. 2003) and *S. toromiro* (Iturriaga et al. 1994). Explants inoculated onto MS medium enriched with TDZ and NAA, exhibit hyperhydricity in shoots and thus reducing the total shoot number and similar phenomenon was also reported in *S. flavescens* (Zhao et al. 2003). Among all the cytokinin used BAP alone was proved to be the most optimal and maximum shoot formation (55.32) was achieved.

Root induction

A tuft of healthy shoots (4.0 cm height) was shifted for the root induction onto basal MS and modified MS medium (half and quarter-strength). Shoots shifted to basal MS medium did not yield any rooting response, while 10.14 and 7.32% rooting was observed in the half and quarter-strength MS medium, respectively. Since half-strength MS medium yielded better morphogenic response, further experiments were conducted in the half-strength MS medium. By incorporation of IBA (4.9 - 14.7 µM), NAA (5.3 - 23.85 µM) and IAA (5.71 - 22.84 µM) into half-strength MS medium a remarkable increase was observed in the rooting percentage. Maximum root development 86.3%, 37.29% & 39.45% rooting was observed in NAA, IAA and IBA augmented half-strength MS medium, respectively. The half-strength MS medium, augmented with NAA (21.2 µM) was found to be the optimal for root development in *S. mollis* and 86.3% rooting was achieved with average 25.26 numbers of roots per shoot after 6-weeks of incubation (Fig. 1 d-g). NAA was also proved to be more appropriate root inducer in *S. flavescens* (Zhao et al. 2003).

Hardening and transplantation

The plantlets with well-developed roots were shifted to plastic poly bags containing soil and sand in 1:1 (w/v) and in plastic cups containing sand and were kept inside the greenhouse for one month. Plantlets shifted to sand responded better and after two-month plants were shifted to poly bags containing compost enriched soil in the green house. Fully acclimatized plants were finally transferred to the open environment with 90% success and plants were also transferred to wild suitable habitat under the habitat rehabilitation and species recovery programme.

Table:18. Effect of cytokinin's and NAA on shoot development from shoot tip explants of *S. mollis* inoculated onto MS medium.

Plant growth Hormones (µM)	Explants with shoots (%)	No. of shoots per explant	Shoot length (cm)
MS_0	-	-	-
BAP			
2.2	68.24	20.74 ± 0.5^{k}	2.5 ± 0.6^{f}
4.4	75.81	45.22 ± 0.78^{c}	3.5 ± 1.1^{e}
8.9	96.27	55.32 ± 0.83^{a}	4.5 ± 1.3^{a}
11.1	66.58	50.21 ± 0.8^{b}	4.2 ± 1.0^{bc}
TDZ			
2.22	54.59	21.22 ± 0.5^{k}	1.5 ± 0.69^{h}
4.54	78.69	34.54 ± 0.3^{ef}	3.5 ± 1.0^{e}
6.81	65.38	30.21 ± 0.29^{g}	2.7 ± 0.8^{f}
Kinetin			
2.32	53.87	11.15 ± 0.3^{m}	2.5 ± 0.78^{f}
4.6	68.18	18.69 ± 0.28^{kl}	3.5 ± 1.1^{e}
6.9	76.78	33.86 ± 0.36^{ef}	4.3 ± 1.2^{ab}
9.3	70.09	30.85 ± 0.3^{g}	4.1 ± 1.1^{c}
BAP + NAA			
8.9 + 0.53	85.98	41.26 ± 0.39^{c}	4.1 ± 1.2^{c}
8.9 +1.59	82.21	39.68 ± 1.3^{cd}	3.9 ± 0.9^{d}

8.9 + 2.65	80.23	35.26 ± 0.4^{e}	3.9 ± 0.9^{d}
TDZ+NAA			
4.5 + 0.53	78.65	30.21 ± 0.31^{g}	2.5 ± 0.46^{f}
4.5 +1.59	72.34	28.96 ± 0.42^{gh}	2.4 ± 0.4^{fg}
4.5 + 2.65	69.23	23.17 ± 0.47^{j}	2.4 ± 0.41^{fg}
Kinetin + NAA			
6.9 + 0.53	76.16	31.21 ± 0.71^{g}	4.0 ± 1.1^{c}
6.9 +1.59	74.25	29.11 ± 0.29^{gh}	3.9 ± 1.0^{d}
6.9 + 2.65	68.95	26.24 ± 0.2^{ghi}	3.9 ± 0.9^{d}

#Data are presented as the mean ±SD. Means followed by different letter within columns indicate significant differences at $p \leq 0.05$

Table:19. Effect of auxins on root induction in *in-vitro* regenerated shoots of *S. mollis* in half-strength MS medium.

Auxins (µM)			**Rooting (%)**	**No. of roots per shoot**	**Root Length (cm)**
IBA	**NAA**	**IAA**			
½ MS	0	0	10.14	1.9± 0.39^{j}	0.5± 0.2^{g}
4.9	0	0	18.11	4.9± 0.87^{i}	1.5± 0.29^{f}
7.36	0	0	21.32	7.96± 0.41^{fg}	2.7± 0.3^{c}
9.8	0	0	27.21	8.85± 0.7^{f}	2.8± 0.27^{c}
12.26	0		39.45	12.08± 0.71^{d}	3.1± 0.4^{b}
14.7	0		33.19	10.30± 0.9^{e}	3.0± 0.3^{b}
0	5.3	0	28.89	12.15± 0.81^{d}	1.5± 0.49^{f}
0	10.60	0	55.28	17.33± 0.62^{c}	2.0± 0.4^{e}
0	15.90	0	75.38	23.54± 1.0^{b}	4.2± 0.82^{a}
0	21.20	0	86.30	25.26± 1.2^{a}	4.5± 1.0^{a}
0	23.85	0	80.18	24.10± 0.92^{b}	4.3± 0.9^{a}
0	0	5.71	17.24	5.69± 0.42^{h}	1.6± 0.28^{f}
0	0	11.42	23.54	8.14± 0.69^{f}	2.5± 0.35^{cd}
0	0	17.13	37.29	11.23± 0.29^{de}	2.9± 0.4^{b}
0	0	22.84	31.12	10.21± 0.5^{e}	2.7± 0.39^{c}

#Data are presented as the mean ±SD. Means followed by different letter within columns indicate significant differences at $p \leq 0.05$

***Gentiana kuroo*:**

Shoot initiation and Shoot multiplication:

Shoot tip explants of *Gentiana kuroo* were collected from the wild habitat and were inoculated onto MS media supplemented with different concentrations of BAP (2.22-8.90µM) and NAA (0.53-2.65µM). The best response (number of shoots per explant, shoot length and frequency of shoot regeneration) was observed in explants inoculated on full-strength MS medium containing 4.4 µM BAP and 0.53 µM NAA. Maximum shoot multiplication was observed in full strength MS medium enriched with 4.4 µM BAP, 0.53 µM NAA and 0.3% activated charcoal. The dormant buds were induced at a faster rate when the apical bud was trimmed at regular interval with subsequent sub-culturing.

Fig.133. Micropropagation of *Sophora mollis*: **(a)** initiation of shoots from shoot tip explants inoculated onto MS medium enriched with BAP (8.9 µM L^{-1}) after 14-days of incubation, **(b & c)** proliferation of shoots in shoot proliferation medium, **(d, e & f)** root induction in half-strength MS medium augmented with NAA (21.20 µM L^{-1}) after 6-weeks of incubation, **(g)** tuft of shoots with fully developed roots, **(h & i)** properly rooted plantlets transferred to polybags and plastic cups containing soil and sand, respectively for the hardening, **(j)** fully acclimatized plants transferred to pots containing soil after six months of transfer.

Table:20. Effect of PGR's on shoot proliferation from shoot tip/nodal segment explants of *Gentiana kurroo* Royle inoculated in MS medium.

Plant growth Regulators (µM)	Explants with shoots (%)	No. of shoots per explant	Shoot length (cm)
MS_0	-	-	-
BAP			
2.2	18.09	5.37 ± 0.9	1.9 ± 0.2
3.1	36.87	6.08 ± 0.5	3.1 ± 0.4
4.4	68.15	7.8 ± 0.72	3.4 ± 0.47
6.6	59.04	7.26 ± 0.68	3.2 ± 0.4
TDZ			
2.27	17.58	3.27 ± 0.8	1.8 ± 0.4
3.18	35.47	4.00 ± 0.8	2.8 ± 0.2
4.54	51.27	6.67 ± 0.7	3.3 ± 0.2
6.8	46.38	4.48 ± 0.6	3.1 ± 0.2
Kinetin			
3.25	13.48	4.98 ± 0.8	1.7 ± 0.6
4.6	34.23	6.89 ± 0.6	2.7 ± 0.3
6.92	46.29	5.55 ± 0.3	3.3 ± 0.2
9.3	41.85	4.07 ± 0.36	3.0 ± 0.15
BAP + NAA			
4.4 +0.53	98.23	11.32 ±1.0	4.6 ± 0.6
4.4 +1.06	91.89	7.8 ± 0.9	4.4 ± 0.9
4.4 +1.59	80.26	6.9 ± 0.6	4.3 ± 0.8
TDZ+NAA			
4.5+0.53	74.82	8.89 ± 1.0	4.1± 0.6
4.5+1.06	89.01	10.01 ± 1.2	4.3 ± 0.8
4.5+1.59	79.72	7.6.36 ± 1.03	4.2 ± 0.6
Kinetin + NAA			
6.9+0.53	68.86	9.44 ± 0.7	4.2 ± 0.5
6.9+1.06	80.82	8.18 ± 1.0	4.0 ± 0.6
6.9+1.59	77.66	8.05 ± 0.8	3.9 ± 0.6

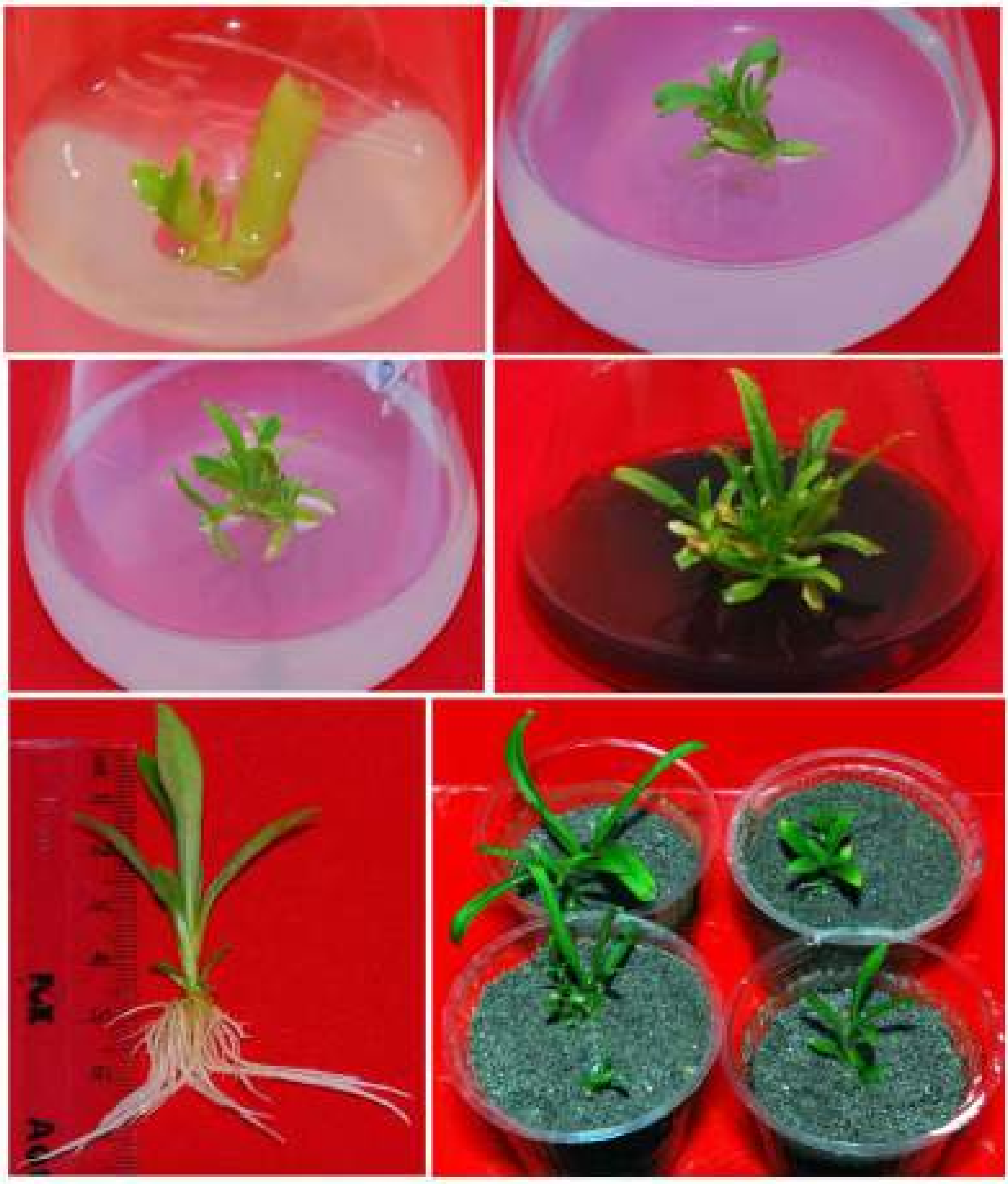


Fig. 134: Micropropagation of *Gentiana kuroo*: A. Bud break and shoot initiation *(*B-D) proliferation of shoots from nodal explants.

Root induction

The properly developed shoots were shifted to root induction into basal MS and modified MS medium (quarter and half-strength). But none of the medium yielded any morphogenic response. Later supplementing the shoot induction medium [BAP (4.4 µM) and NAA (0.53 µM)] with 0.3% activated charcoal played a significant role and profuse rooting was observed in the *Gentiana* shoots. The healthy plantlets with properly developed roots were transferred to plastic cups containing autoclaved sand. Plants were watered with modified Hoagland solution at regular intervals and to maintain humidity plants were initially covered with transparent sheet.

***Jasminum parkeri*:**

Seeds and nodal segment explants were collected from Chamba, Himachal Pradesh in the month of December. Seeds were inoculated into MS medium without any plant growth regulator while nodal segments were inoculated into MS media supplemented with 2.22-8.90µM BAP and 0.53-2.65µM NAA which results into callus formation.

Fig.135. Callus induction in *Jasminum parkeri* from nodal explants.

***Rhododendron wattii* Cowan**

R. wattii is an endemic species to the state of Manipur and Nagaland (Dzukou valley). However, due to anthropogenic activities like harvesting this species for firewood, and natural calamities, such as forest fires during the dry season have contributed to the rapid decline of the species from its natural habitat. Therefore, to increase its population in the wild, the plant has been taken under the project for micropropagation and mass multiplication.

Media preparation and culture conditions

Micro propagated shoots were routinely sub-cultured on Woody and Plant media incorporated with 2 mg/l NAA for root and shoot induction. The media is fortified with 3% sucrose 0.2% activated charcoal (AC). All the cultures were incubated at controlled temperature of $25\pm2^{\circ}C$ and kept under culture conditions of 14h photoperiod and photosynthetic photon flux of $60 \mu mol m^{-2} s^{-1}$ provided by cool-white fluorescent lamps. The survival percentage and the response of the plants were regularly monitored and recorded.

Hardening: The tissue culture raised plants of *Rhododendron wattii* with healthy roots and shoots were hardened in two substrate compositions (i) soil with sand and (ii) soil, decayed wood and sand mixture. Of the two-substrate composition, soil decayed wood and sand mixture shows a much better response.

Results:

Number of plantlets hardened – 284
Number of plants surviving – 103
Survival Percentage – 36.26 %

Fig.136. Culture of *R. watti* maintained in culture room and plantlets ready for hardening.

Fig.137. Culture of *R. watti* maintained in culture room and plantlets ready for hardening.

Nepenthes khasiana Hook. f.

Nepenthes khasiana Hook.f. is an endangered and endemic tropical pitcher plant, endemic to Meghalaya (Khasi & Jaintia hills) –India. It possesses many medicinal properties which are used by Khasi and Garo tribes as eye drops to cure cataract and night blindness, in treating stomach troubles, diabetes and gynaecological problems. The pitcher with its contents is made into a paste and is applied on affected parts of leprosy patients.

The major threats this plant is facing are deforestation for jhum cultivation, coal mining, road construction, landslides, grazing, over-exploitation from wild for trading purposes, etc and hence the need for conservation .

Fig.138. Mother plant and seed pods of *Nepenthes khasiana*

Plant material and explant preparation

Seed pods of *N. khasiana* collected from BSI Botanical Garden, Barapani were taken as starter plant material for *in vitro* multiplication.

Media preparation and culture conditions

Routine subculturing of germinated seeds is being carried out in plain ½ MS medium. All the cultures were incubated at culture conditions with the survival percentage and the response of the plants regularly monitored and recorded.

Hardening of plantlets

Tissue culture raised plantlets with well-developed roots and shoots were transferred for acclimatisation in green house. Hardening is carried out in sterilised soil in combination with sand as compost. Monitoring and watering were done regularly or as and when required.

Results

Germination rate recorded: 90%; Numbers of hardened plants: 3,050; Number of plants surviving: 2,287; Survival percentage: 74.9%

Currently, 26 plantlets were planted in the Nepenthes House at BSI, ERC garden for conservation and 20 plantlets have been supplied to IBSD Shillong Node for plantation and 280 plantlets are ready for reintroduction in natural habitat.

Fig.139. In vitro seed germination of *Nepenthes khasiana*

Fig.140. One year culture stage of *Nepenthes khasiana* with healthy roots and shoots

ORCHIDS

Orchids are known for their aesthetic beauty and are widely used as ornamental plants, for horticulture and floriculture purposes. They are very rare habitat specific; the flowers are quite attractive, colourful with long lasting flowers which are often exploited for hybridization. Naturally, the seeds are exalbuminous and seeds are encapsulated which disburses millions of seeds carried by the wind miles away from the mother plant of which only 5% survive in nature. Due to its high demand, orchids are threatened in their natural habitat. The major threats orchids are facing includes destruction of natural habitat due to anthropogenic activities, deforestation for jhum cultivation, charcoal production, road construction, landslides, over-exploitation from wild for trading purposes, etc and hence the need for conservation. All orchids are listed as endangered under IUCN red list. The following lists of orchids are taken up for mass propagation and reintroduction in their natural habitat.

Cymbidium tigrinum C.S.P. Parish ex Hook.

Plant material and explant preparation

Protocorms of *in vitro* raised cultures of *Cymbidium tigrinum* from tissue culture laboratory of BSI, ERC were taken as starter plant material for *in vitro* multiplication.

Media preparation and culture conditions

Protocorms of *C. tigrinum* were routinely subcultured on plain MS medium for multiplying and generation of enough cultures for further scale-up these cultures with incorporation of growth regulators. Cultures were kept in culture conditions same as described earlier. The survival percentage and the response of the plants are regularly monitored and recorded.

Hardening of plantlets

Tissue culture raised plantlets with well-developed roots and shoots were transferred for acclimatisation in green house. The plantlets were hardened in coco peat with soil as compost and a layer of wooden chunks on top. Monitoring and watering were done regularly or as and when required.

Results

Number of hardened plants: 256; Number of plants surviving: 123; Percentage of survival in green house: 48%

Fig.141. Mother plant and close up of culture *of Cymbidium tigrinum*

Fig.142. Culture *of Cymbidium tigrinum*

Cymbidium eburneum Lindl.

Media preparation and culture conditions

Protocorms of *C. eburneum* were routinely subcultured on plain MS medium for multiplying and generation of enough cultures for further scale-up and maintained under culture. The survival percentage and the response of the plants are regularly monitored and recorded.

Results

After 2 months in culture conditions, the inoculated seeds have started to response and the seeds have started to swell up. Protocorms started forming after 5 months. Routine subculturing is carried out in plain MS Medium. Plantlets with shoots and roots from protocorms initiated after 5 months in culture.

Fig.144. Culture of *Cymbidium eburneum*

Cymbidium whiteae King & Pantl.

Protocorms of *C. whiteae* were routinely subculture on plain MS medium and maintained under culture conditions. The survival percentage and the response of the plants are regularly monitored and recorded.

Hardening of plantlets

Tissue culture raised plantlets with well-developed roots and shoots were transferred for acclimatisation in green house. The plantlets were hardened in coco peat with soil as compost and a layer of wooden chunks on top. Monitoring and watering was done regularly or as and when required.

Results

Number of hardened plants: 400; Number of plants surviving: 188; Survival percentage: 47%

Fig.145. Culture of *Cymbidium whiteae*

Cymbidium cyperifolium Wall. ex Lindl

Seeds of *C. cyperifolium* were cultured on plain MS medium and maintained under culture conditions.

Results

Cultures showed no response, culture initiation unsuccessful.

Fig.146. Culture of *Cymbidium cyperifolium*

Calanthe masuca (D.Don) Lindl

Seeds of *Calanthe masuca* were cultured on plain MS medium and maintained under culture conditions. Fresh inoculations on four different mediums namely full strength MS medium, ½ strength MS medium, Knudson C Medium and BM-1 Terrestrial Orchids Medium has been set up.

Results

The seed cultures showed germination after one year in culture and healthy shoots and roota developed after 6-7 months in culture.

Fig.147. Plants of *Calanthe masuca*

Fig.148. Culture of *Calanthe masuca*

Calanthe biloba Lindl.
Seeds of *Calanthe biloba* were cultured on plain MS medium and maintained under culture conditions.
Results
The cultures are still under observation; seeds started swelling up after 1 year but no protocorms formation has been observed so far.

Cephalantheropsis obcordata (Lindl.) Ormerod

Plant material and explant preparation

Seed capsule of *Cephalantheropsis obcordata* was collected from the orchidarium of BSI, ERC, Shillong were taken as starter plant material for in vitro multiplication.

Media preparation and culture conditions

Seeds of *C. obcordata* were cultured on plain MS medium and maintained under culture conditions.

Protocol for seed sterilisation

Seed capsule were flamed sterilised with 70% alcohol, was slit open with a scalpel blade longitudinally. The seeds were scooped out and inoculated on plain MS medium.

Protocol for micropropagation of the germinated seedlings

To multiply the regenerated seedlings leaves, shoots and root tips sections were used as explants for micropropagation on MS medium was supplemented with different concentrations of BAP (0, 0.5, 1&2 mg/l) singly and in combination with NAA (0,0.5 & 1 mg/l).

Results

The seed germination studies on *C. obcordata* on MS medium could not yield successful results mainly due to collection and culture of immature pods. Less than 1% seed germination was observed (after 6 months in culture) all of which regenerated into proper seedlings and ready to be hardened. Shoots tip explants in MS medium with BAP showed response and gave rise to seedlings within 4 months of inoculation.

Fig.149. Plants of *Calanthe biloba*

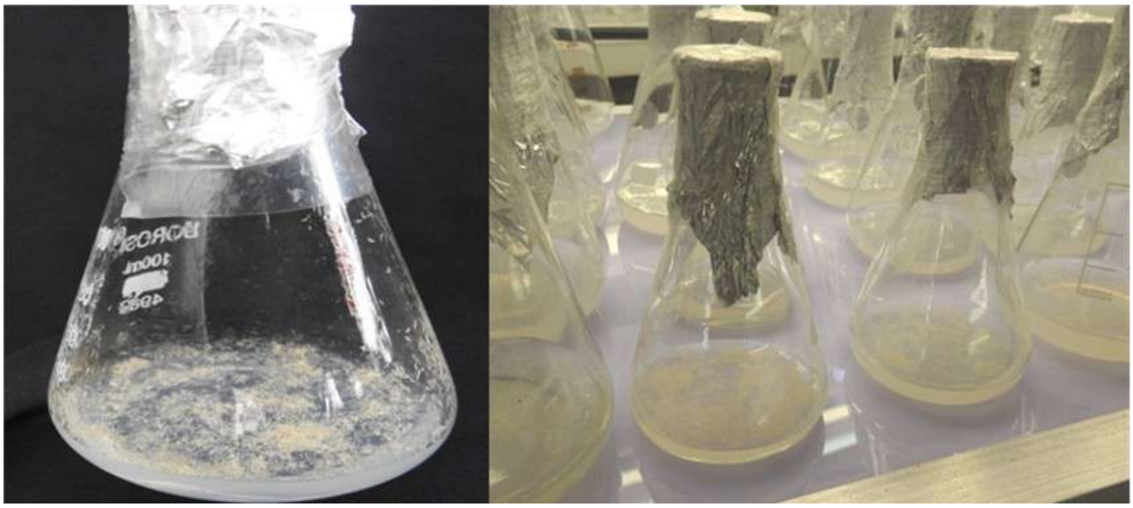


Fig.150. Culture of *Calanthe biloba*

Fig.151. Plants of *Cephalantheropsis obcordata*

Fig.152. Culture of *Cephalantheropsis obcordata*

Paphiopedilum venustum (Wall.ex Sims) Pfitzer

Plant material and explant preparation

Seed capsule of *Paphiopedilum venustum* was collected from the orchidarium of BSI, ERC, Shillong were taken as starter plant material for in vitro multiplication.

Media preparation and culture conditions

Seeds of *Paphiopedilum venustum* were cultured on plain BM1 terrestrial orchid medium. Seeds were sterilised following the same method discussed for *C. obcordata*. The seeds were scooped out and inoculated on plain MS medium.

Results

The cultures are kept under culture conditions and are still under observation, no response has been observed so far.

Cymbidium dayanum Rchb.f.

Plant material and explant preparation

Seed capsule of *C. dayanum* were collected from BSI, ERC garden and were taken as starter plant material for *in vitro* multiplication.

Media preparation and culture conditions

Seeds of *C. dayanum* were cultured on plain MS medium for seed germination experiment. All the cultures were incubated at controlled temperature of 25±2ºC and kept under culture conditions of 14h photoperiod and photosynthetic photon flux of 60µmolm^{-2}s^{-1} provided by cool-white fluorescent lamps.

Results

Protocorms formation observed after 5 months in culture.

Fig.153. Culture of *Paphiopedilum venustum*

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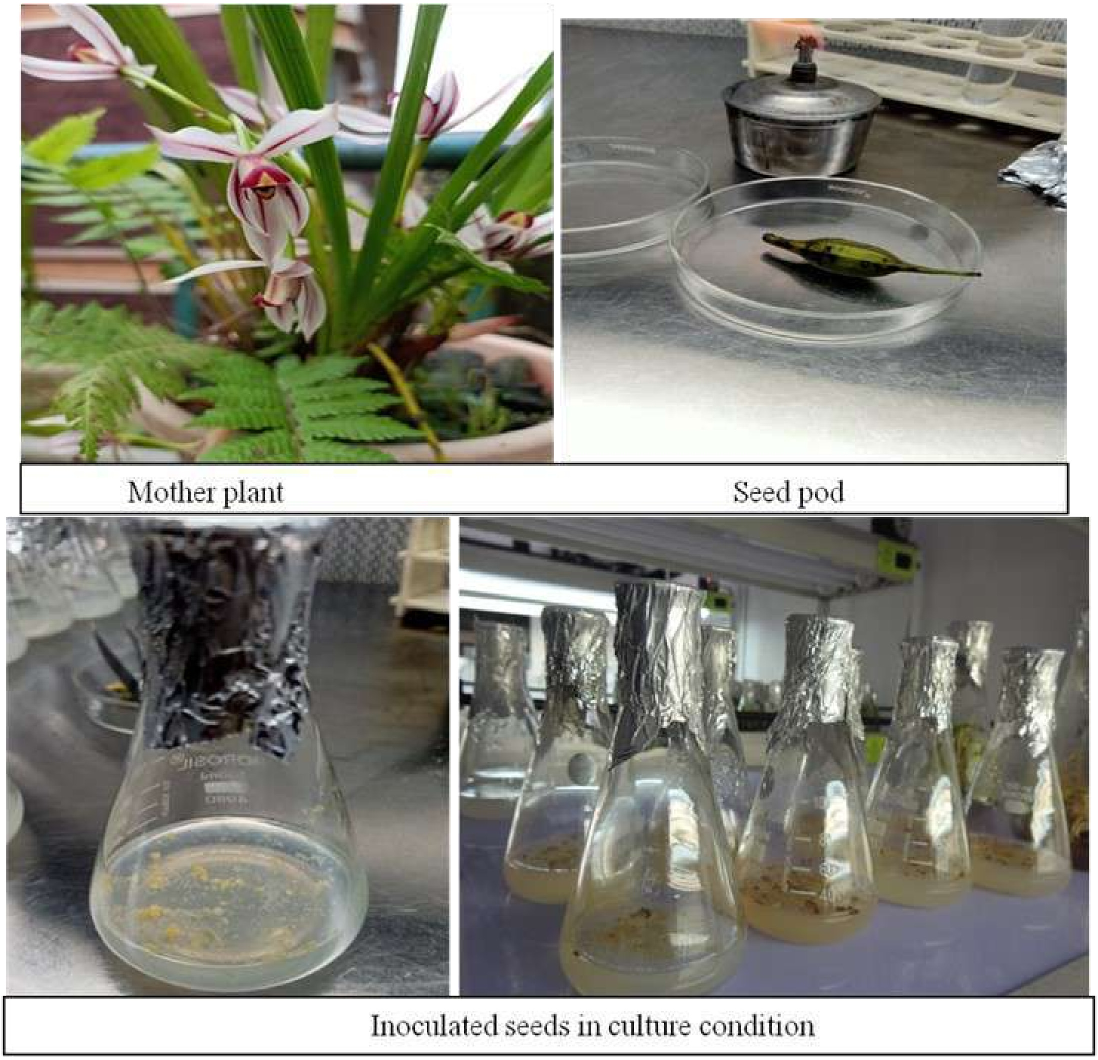


Fig.154. Culture of *Cymbidium dayanum*

Penkimia nagalandensis Phukan & Odyuo

Plant material and explant preparation

Seed capsule of *P. nagalandensis* were collected from BSI, ERC garden and were taken as starter plant material for *in vitro* multiplication.

Media preparation and culture conditions

Seeds of *P. nagalandensis* were cultured on plain MS medium for seed germination experiment. All the cultures were incubated at controlled culture conditions. The survival percentage and the response of the plants were regularly monitored and recorded.

Results

The cultures are still under observation for further response (7 months under culture conditions).

Acanthephippium striatum Lindl.

Plant material and explant preparation

Seed capsule of *A. striatum* were collected from BSI, ERC garden and were taken as starter plant material for *in vitro* multiplication.

Media preparation and culture conditions

Experiment of seed germination studies of *A. striatum* were initiated by inoculating the seeds on three different medium namely, MS medium, BM1orchid medium, B5 Gamborg orchid medium and Knudson C Modified Orchid medium. All the cultures were incubated at controlled culture conditions. The survival percentage and the response of the plants were regularly monitored and recorded.

Results

The cultures are still under observation for further response (3 months under culture conditions).

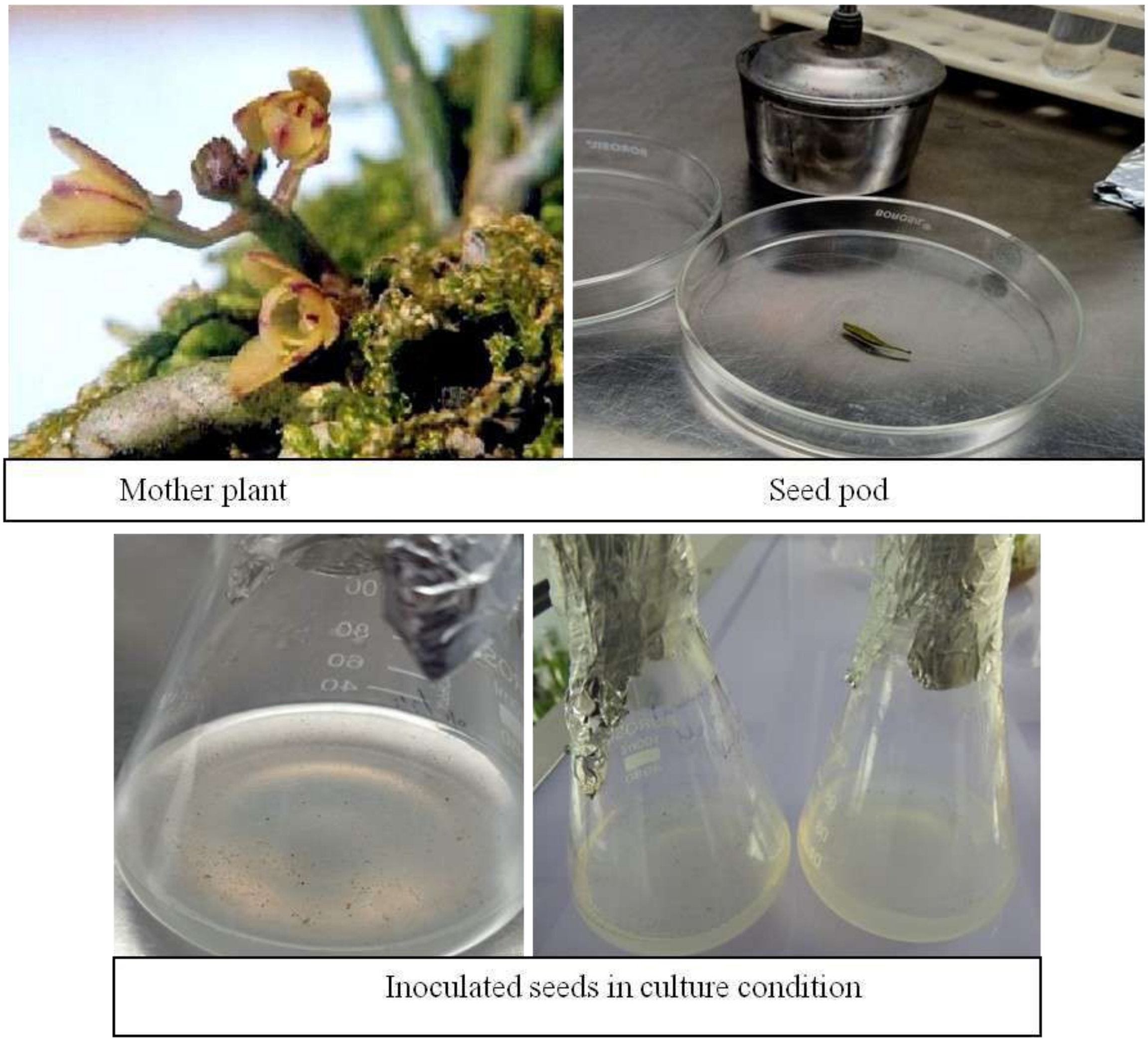


Fig.154. Culture of *Penkimia nagalandensis*

Brainea insignis (Hook) J.SM

B. insignis is a native to Southeast Asia and endemic to North East where it has a rather restricted and scattered distribution between 500 and 1400m. Frequent and prolonged fires as well as violent Jhum fires destroyed its population**.** It is listed under the Near Threatened (NT) category of IUCN. Timely steps for its conservation are therefore an urgent priority. For conservation of this plant micropropagation studies have been initiated for this fern.

Plant material and explant preparation

Matured fertile fronds of the *Brainea insignis* were collected from BSI garden, Shillong as starter plant material for in vitro multiplication.

Media preparation and culture conditions

For culture initiation experiments, inoculation was carried out onto different media viz., plain MS medium, ½ strength MS medium, Fern propagation medium with and without agar.

Protocol for seed sterilisation

Spores were scrape off the leave surface and were surface sterilized with 0.5%, 0.8% and 2% Sodium hypochlorite solution with Tween 80 for 10 mins and with 0.05% and 0.1% Mercuric chlorite solution for 1 min and followed by rinsing with sterile distilled water.

Results Culture initiation experiment unsuccessful.

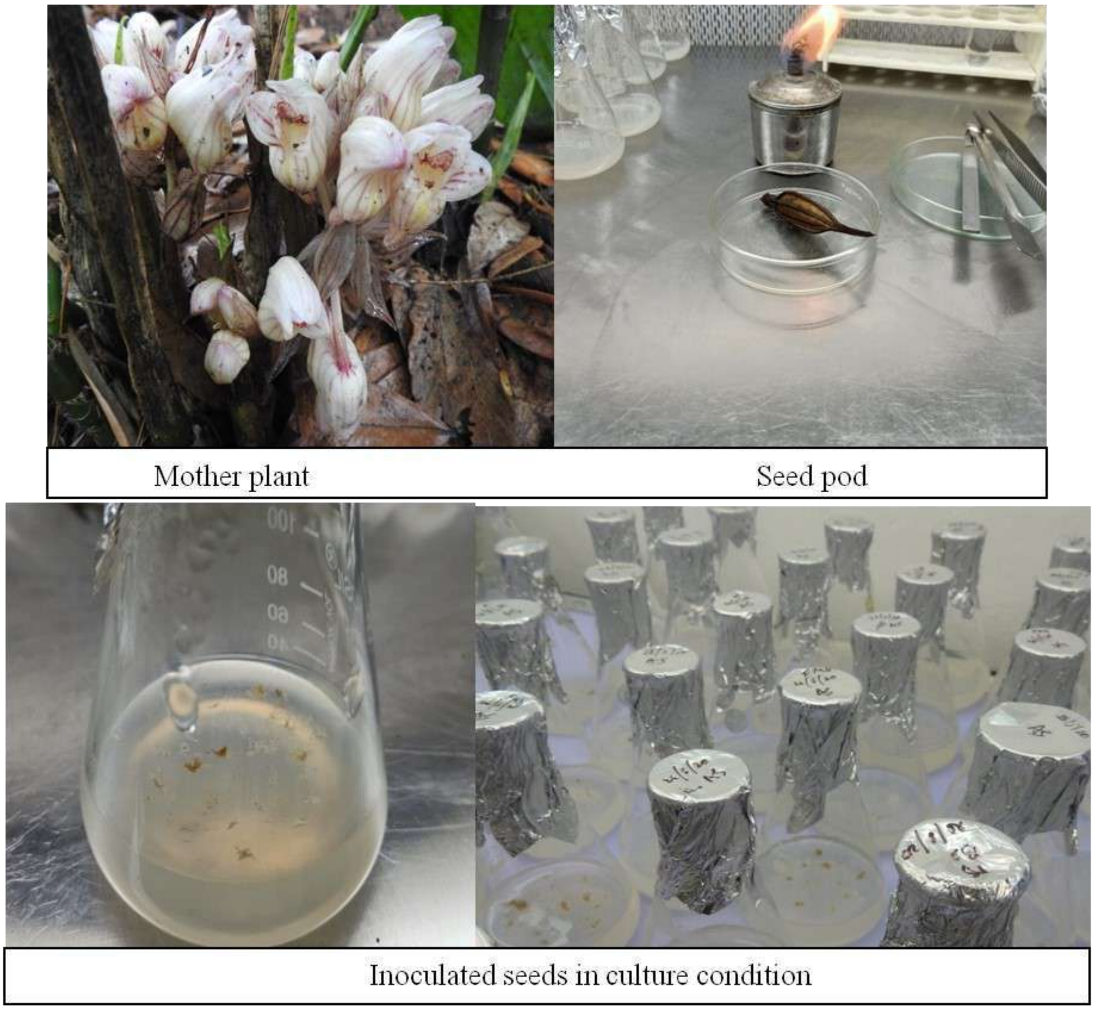


Fig.155. Culture of *Acanthephippium striatum*

Fig.156. Culture of *Brainea insignis*

Diplazium nagalandicum Fraser-Jenk., Odyuo & D.K.Roy

Diplazium nagalandicum was discovered newly from Nagaland and only one isolated population was found and recorded to be endemic to Nagaland. The plant has been included under the project and taken up for micropropagation studies.

Plant material and explant preparation

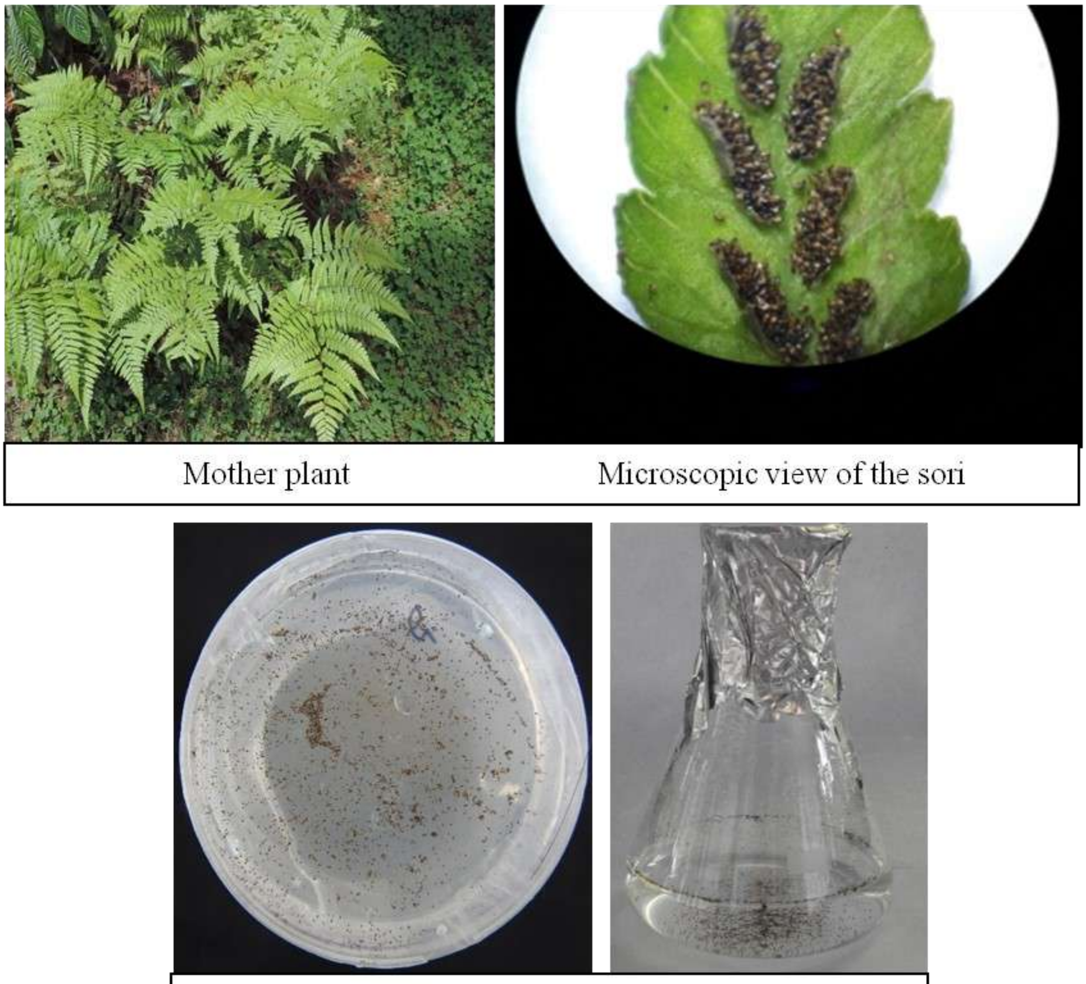
Spores of *D. nagalandicum* have been collected as explant from the Botanical Garden campus, ERC, Shillong, Meghalaya. Sterilisation of spores were done by 0.1% and 0.5% $HgCl_2$ for 5mins and 8mins and rinsed thrice through sterile water for 10mins each.

Media preparation and culture conditions

Spores were inoculated on plain Murashige and Skoog (MS) media, liquid MS media, Knudson C media and Fern Media with 3% sucrose in each media. To study the combination effect of various auxins and cytokinin on the growth of these cultures, α- Napthalene acetic acid (NAA) or 2,4-D and BAP(6-Benzylaminopurine) were supplemented in the medium. The response of the spores is regularly monitored and recorded.

Result

Culture initiation experiment was unsuccessful.



Mother plant Microscopic view of the sori

Spores in solid medium Spores in liquid medium

Fig.156. Culture of *Diplazium nagalandicum*

Cephalotaxus mannii Hooker

Cephalotaxus mannii (Mann plum yew) is sparsely distributed and seriously endangered by harvesting for timber and for medicinal purposes. It has also high pharmaceutical properties. For the conservation purpose the plant has been taken up under the project for micropropagation and mass multiplication studies.

Plant materials and explant preparation

Fruits were collected from Mokokchung, Nagaland during field tour. Explants were prepared from seeds by removing the pulps of fruits and washed thoroughly with water. Sterilisation of seeds was done using 10% Sodium hypochlorite (NaOCl) with three drops of surfactant reagent Tween 20 for10mins and rinse thrice with sterile water for 10mins each.

Media and culture conditions

Embryos were excised and were inoculated on plain MS media. To study the effect of auxins and cytokinin on induction of rooting and shooting in these cultures two growth regulators viz. 2,4-D and BAP were supplemented in the medium. The cultures were maintained in culture conditions. The response of the explants is regularly monitored and recorded.

Results

After 20 days after inoculation, the embryos have started showing germination. Recorded percentage response of the cultures was 30%.

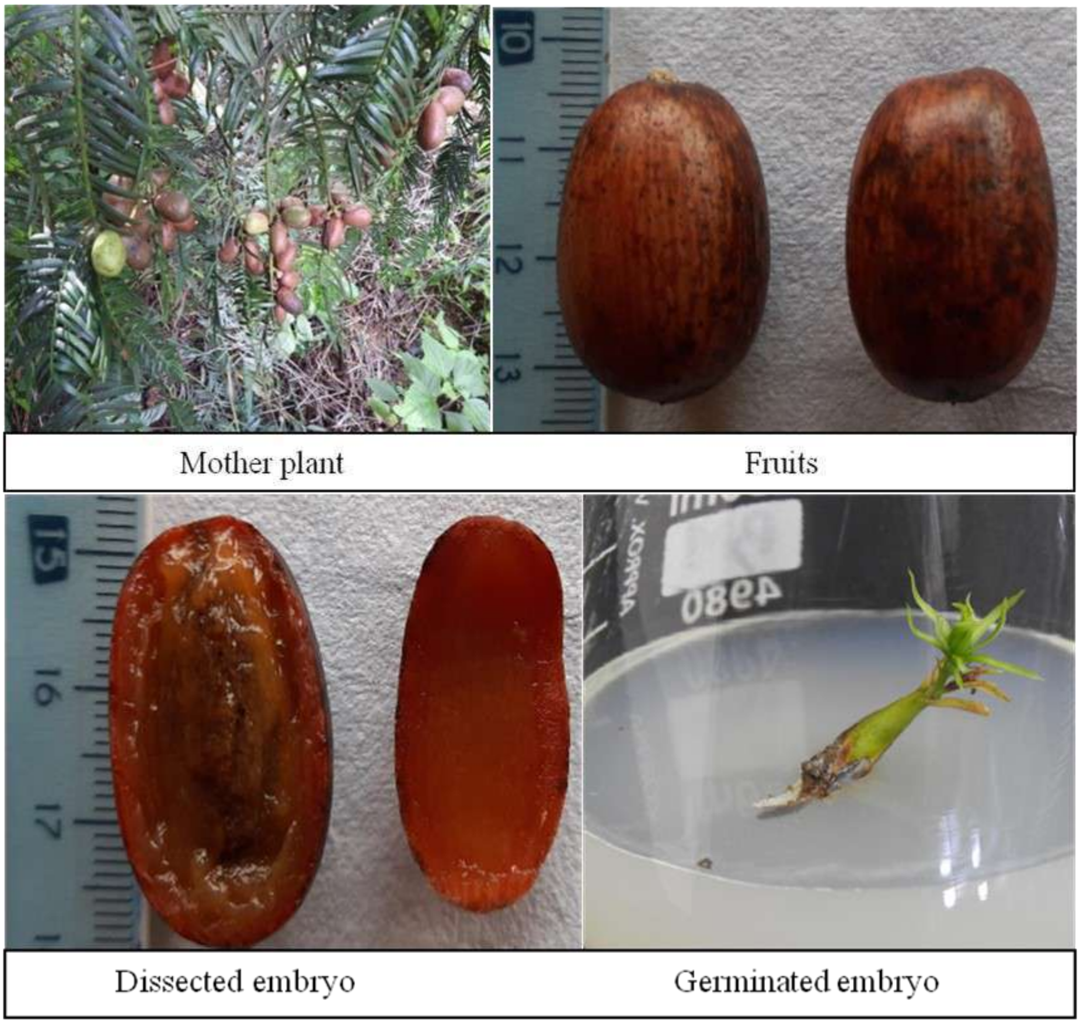


Fig.156. Culture of *Cephalotaxus mannii*

Adinandra griffithii Dyer

It is an IUCN Red list Endangered species, threatened by habitat loss. At Cherrapunji in East Khasi Hills District a cement factory has caused the degradation of natural population due to habitat destruction. It is endemic to Meghalaya.

Plant material and explant preparation:

Seeds were collected from Laitmawsiang village, Sohra. Seeds were sterilised with 10% Sodium hypochlorite (NaOCl) with 2-3 drops of Tween 20 as surfactant reagent and rinse thrice through sterile water for 10mins each.

Media and culture conditions:

Seeds were inoculated on plain Murashige and Skoog (MS) media. To study the effect of various auxins on the induction of rooting in these cultures three growth regulators namely Indole acetic acid (IAA) and α-Napthalene acetic acid (NAA) were supplemented individually in the medium. All the cultures were kept under controlled culture. The response of the explants are regularly monitored and recorded.

Result

Seeds started to germinate after 25 days of inoculation. Germination percentage: 50%

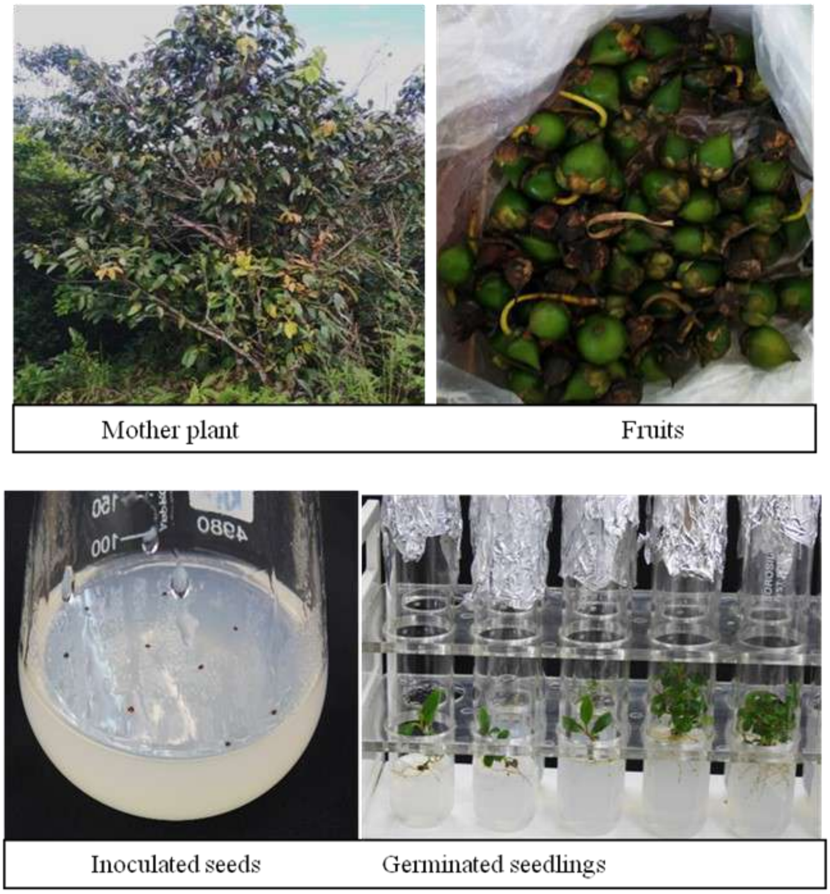


Fig.157. Culture of *Adinandra griffithii*

Paris polyphylla Sm.

A highly medicinal plant which is currently listed under endangered category as per the current IUCN criteria (Samant and Pal 2003; Ved et al. 2003) due to the unscientific exploitation of natural populations. The enormous demand of dried rhizomes in Chinahave led to en masse trading of rhizomes from India to China, through the Indo-Myanmar border especially from Manipur, leading to the present endangered status of the plant (Mao et al. 2009). Besides, the plant has characteristics like long dormancy period, poor seed germination, slow growth and annual fluctuations in the productions of seeds. Therefore, the plant has been considered for micropropagation studies under the project for mass propagation and reintroduction in its natural habitat.

Media preparation and culture conditions

Seed derived zygotic embryos have been germinated and routinely subcultured in ½ strength MS medium supplemented with 0.5mg/l BAP for their growth and development. Rhizome section derived cultures are maintained in MS medium supplemented with 0.5mg/l BAP and 2-Isopentyl (2iP) in combination. All the cultures are maintained in culture conditions and routinely monitored. Culture-raised plantlets with well developed roots and shoots are transferred for hardening.

Results

The germinated saplings are routinely subcultured for their growth and development. For rhizome sections experiments, the section cuttings swelled and showed multiple shoot primordia, which is further dissected for multiplification of culture. Number of plants hardened: 25; Number of plants surviving: 25

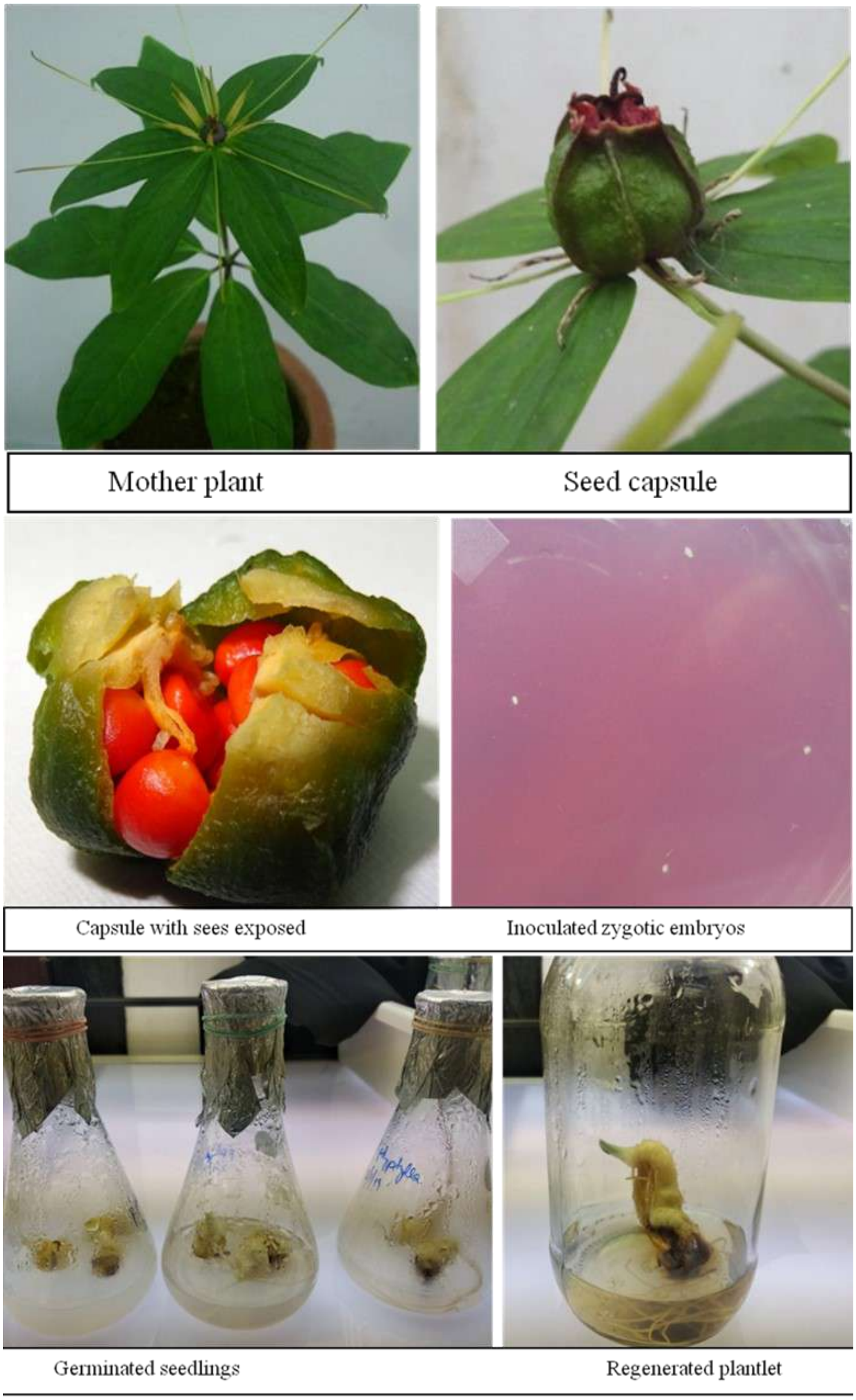


Fig.157. Culture of *Paris polyphylla*

Aglaia perviridis Heirn

An edible fruit tree listed as vulnerable under IUCN red list. Micropropagation of this vulnerable plant has been taken up under the project.

Plant material and explant preparation

Fruits of *A. perviridis* were collected in the month of May from Laitmawsiang village, East Khasi Hills, Meghalaya. The fruit pulp was cleaned and seeds thoroughly washed were used as explant for culture initiation under aseptic conditions. Nodal segments, axilliary buds and leaf explants were used for micropropagation.

Media preparation and culture condition

Washed and cleaned seeds were first surface sterilised with 0.1% Bavistin for 10 mins followed by rinsing under the tap water until water in the vessel becomes clear, followed by rinsing with distilled water twice. The seeds were taken inside the Laminar Air Flow for further surface sterilization.

Two different sterilising agent at different concentrations viz., Sodium Hypochlorite (10%, 20% and 30%) and Mercuric Chloride (0.1%, 0.15% and 0.2%) for 10 minutes followed by wash with autoclaved water distilled thrice was tested for their efficacy in producing healthy aseptic cultures. All explants were inoculated on Murashige and Skoog Medium. 20 replicates were kept for each treatment. All the cultures were incubated at controlled temperature of 25±2ºC and kept under culture conditions of 14h photoperiod and photosynthetic photon flux of 60µmolm^{-2}s^{-1} provided by cool-white fluorescent lamps. The survival percentage and the response of the plants were regularly monitored and recorded.

Nodal segments, axilliary buds and leaf explants were first treated with fungicide and few drops of detergent labolene for 20 minutes with occasional stirring. Followed by washing under running tap water until fungicide is clear. Later the explants were taken inside laminar air flow and treated with 0.2% mercuric chloride and few drops of Tween 20 for 5 minutes and rinsed with sterile water 3 times. Followed by 40% sodium hypochlorite treatment for 10 minutes and rinsed with sterile water 3 times. Sections of the sterilized explants were made and inoculated on MS mmedium+0.1% AC and supplemented with various concentrations of BAP (0.25-1.5mg/l).

Results: Seed sterilization experiments for culture initiation require standardization. The culture initiation from axilliary buds was successful.

Fig.158. Plants of *Aglaia perviridis*

Fig.159. Culture of *Aglaia perviridis*

Renanthera imchootiana Rolfe

Plant material and explant preparation

Seed capsule of *Renanthera imschootiana* collected from the orchidarium of BSI, ERC, Shillong were taken as starter plant material for in vitro multiplication.

Media preparation and culture conditions

Seeds of *R.imschootiana* were cultured on plain MS medium at 5.8 pH.

Seed capsule sterilisation protocol

Seed capsules were first surface sterilised with 70% ethanol and then was heat sterilised 2-3 times before inoculation.

Results

The cultures are still under observation for further response and swelling of seeds with no contamination has been observed till date (3 months in culture).

Dendrobium thyrsiflorum Rchb.f

Seed capsule of *Dendrobium thyrsiflorum* Rchb.f collected from the garden of BSI, ERC, Shillong were taken as starter plant material for in vitro multiplication.

Media preparation and culture conditions

Seeds of *D. thyrsiflorum* were cultured on plain MS medium at 5.8 pH, the protocorms were then subcultured in MS medium supplemented with 2% coconut water and 2% banana extract.

Seed capsule sterilisation protocol

Seed capsules were first surface sterilised with 70% ethanol and then was heat sterilised 2-3 times before inoculation.

Results

Seed germination and protocorm formation was observed after 1 month of inoculation. The cultures are still under observation for further response.

Threat Assessment of Selected Species from Western Himalaya

The selection of the species was made based on earlier reports on their threats, endemism, exploitation, population depletion etc. The data related to their distribution and occurrence was compiled from pertinent literature (IUCN reports, Red list of Threatened Plants (India), Local and regional floras, research papers, online articles and databases, http://bsienvis.nic.in/Database/RedlistedPlants_3940.aspx etc. and herbarium consultation.

Fig:160. Species selected: A. *Acer oblongum*, B. *Aconitum heterophyllum*, C. *Gentiana kurroo*, D. *Jasminum parkeri*, E. *Indopiptadenia oudhensis*, F. *Magnolia kisopa*, G. *Sophora mollis*, H. *Prunus cerasoides*,

Fig:161. Species selected: I. *Mahonia jaunsarensis*, J. *Stereospermum suaveolens*, K. *Phlomoides superb*, and L. *Indopiptadenia oudhensis*

SURVEY

a. Herbarium

The secondary data (literature & herbarium) were collected from different floras, research papers, online available dataset, and herbarium specimens. Within this period, six recognized herbaria *viz.*, CAL, JUH, GUH, RRLH, DD, PLP, BSD, PAN and PUN were visited to record the data of the concerned species. The library of BSI, NRC, Dehradun was consulted for literature study. All this dataset will be helpful in further relocation of the species, conservation status assessment and mapping of the species distribution range.

Table: 21. Names of Herbariums Consulted

Names of Herbariums		Acronym
1.	Botanical Survey of India, NRC, Dehradun	(BSD)
2.	Jammu University, Jammu	(JUH)
3.	Indian Institute of Integrative Medicine, Jammu	(RRLH)
4.	H.N.B. Garhwal University	(GUH)
5.	Dehradun Herbarium, Systematic Botany Discipline, Botany Division Forest Research Institute (FRI), Dehradun	(DD)
6.	Indian Institute of Bio-resource Technology, Palampur	(PLP)
7.	Botany Department, Punjab University, Chandigarh	(PAN)
8.	Botany Department, Punjabi University, Patiala	(PUN)
9.	Central National Herbarium, Botanical Survey of India, Howrah	(CAL)

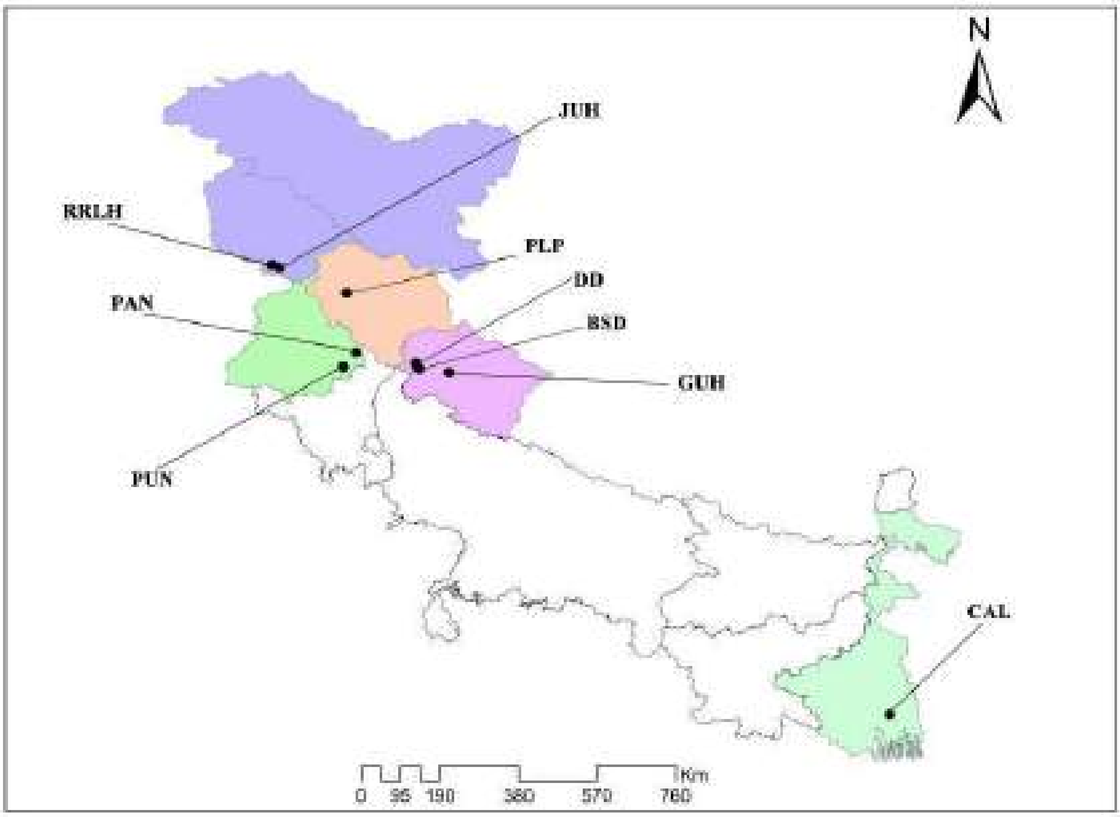


Fig:162. Map showing herbaria visited during the period

b. Field Survey, recording of Geo-coordinates and Demographic data

Twenty-seven field tours were conducted in the duration 2018-2020 in western Hiamalaya in which 15 tours were conducted for the collection of plant propagules in adjoining regions and for monitoring of plants propagated at nursery at Deoban as per *MoU* between BSI, NRC and Forest Department, Uttarakhand. Four field survey tours (duration ≥ 7 days) for locating RET species in the wild and to study the population status, potential threats and other related aspects of the species. These tours were mainly conducted in the high altitudinal remote regions of Himalayan belt in the states of Uttarakhand (Chamoli district) and Himachal Pradesh (Chamba, Kangra). The details of tours that were conducted are provided as follows:

Table:22. Field tours conducted for the collection of plant propagules.

S. No.	Localities	Purpose/Collected species
1.	Neelkanth glacier and adjoining areas	Population survey and collection of *Aconitum heterophyllum*
2.	Deoban, Chakrata	Population survey and collection of *Aconitum heterophyllum*, *Gentiana kurroo*
3.	Dhanolti, Tehri	Population survey of *Gentiana kurroo*
4.	Holi, Chamba, Himachal Pradesh	Population survey and collection of *Jasminum parkeri*, *Aconitum heterophyllum*
5.	Sangrah, Sirmour, Himachal Pradesh	Population survey and collection of *Gentiana kurroo*

6.	Uttarakhand (Mossy fall, Mussoorie)	Seeds of *Mahonia jaunsarensis, Acer oblongum* and *Prunus cerasoides* were collected.
7.	Uttarakhand (Mohand, Dehradun)	Seeds of *Stereospermum suaveolens* were collected.
8.	Uttarakhand (Rajaji National Park, Dhaulkhand range)	To collect seeds of *Stereospermum suaveolens*.
9.	Uttarakhand (Chakrata, Deoban)	To locate *Aconitum heterophyllum.*
10.	Uttarakhand (Haridwar)	Meeting with range officer of Chakrata and Haridwar division.
11.	Uttarakhand (Chakrata, Deoban)	Collection of *Mahonia jaunsarensis* seeds.
12.	Himachal Pradesh (IHBT herbarium, Palampur and Kangra, Holi)	To collect distribution data from herbarium and to locate *Jasminum parkeri* and *Phlomoides superba*.
13.	Uttarakhand (Chamoli, Rudraprayag)	To locate *Aconitum heterophyllum* and *Magnolia kisopa.*
14.	Uttarakhand (Rajaji National Park, Chila range)	To locate *Stereospermum suaveolens.*
15.	Uttarakhand (Srinagar, Chamoli, Bageshwar)	To meet local stakeholders, farmers and NGO people for collaboration in propagation/reintroduction work.
16.	Uttarakhand (Dehradun Mussoorie Forest)	To locate *Pittosporum eriocarpum* and *Acer oblongum*. The above said species were seen near Hathipaon.
17.	Uttarakhand (Deoban forest nursery)	Visited Deoban Forest nursery for supervision of *Aconitum heterophyllum* and *Gentiana kurroo* nursery.
18.	Uttarakhand (Bhadraj)	To locate the population of *Gentiana kurroo.*
19.	Himachal Pradesh, (Chamba, Sidhani, Sechu, Tuan, Tirund, Tatan etc.)	Two new localities of *Aconitum heterophyllum* were reported from Tuan and Sidhani.
20.	Uttarakhand (Golatappar, Nakraunda, Laxmansiddh)	Field survey in Laxmansiddh, Golatappar and Nakraunda area for locating *Stereospermum suaveolens* in wild. Recorded 12 trees in total during this survey.
21.	Uttarakhand (Badrinath, Mana, Neelkanth, Valley of Flowers, Tipra Glacier, Hemkund, Gangharia, Govindghat, Pandukeshwar)	Population survey of *Aconitum heterophyllum* and *Magnolia kisopa*
22.	Himachal Pradesh, (Khaijjiar WLS, Holi, Deol, Chamba, Bairagarh, Sach Pass, Bhagotu, Parmar)	7 plants of *A. heterophyllum* were seen in Parmar. *Acer oblongum* populations were seen in forest region preceding Chamba. Seeds and stem cuttings of *Jasminum parkeri* were collected for *ex-situ* conservation from Deol and Holi.
23.	Uttarakhand (Chakrata, Deoban forest nursery)	For nursery inspection and monitoring the growth of propagated species.
24.	Uttar Pradesh, (Chilkana)	To locate *Stereospermum suaveolens.*
25.	Uttarakhand (Chamoli, Pandukeshwar, Mana)	For collection of *Magnolia kisopa* seeds and meeting with local stakeholders.

26.	Uttarakhand (Bhadraj, Kempty falls and Jhari Pani.	For locating *Gentiana kurroo* and plantation of *Aconitum heterophyllum* and *Gentiana kurroo* saplings in suitable habitats.
27.	Uttarakhand (Mussoorie)	For collection of seeds of *Pittosporum eriocarpum*.

Table:23. Showing geo-coordinates of species occurrence locations.

S. No.	Species	Location	Latitude	Longitude
1.	*Gentiana kurroo*	Sangrah	30.68866 N	77.43969 E
		Deoban	30.7644917 N	77.897669 E
		Suwakholi	30.45382 N	78.16889 E
		Bhadraj	30.47726 N	77.94509 E
		Bhairon ghati, Vaishno Devi	33.022037 N	74.9497028 E
		Gharmaraini, Chamba	32.54198 N	76.17437 E
		Kullu	31.8318528 N	77.160175 E
2.	*Jasminum parkeri*	Dam side, Holi	32.3408 N	76.5369 E
		Deol	32.3091 N	76.5793 E
		FRH, Holi	32.3273 N	76.5563 E
		Grima 1	32.4433 N	76.4946 E
		Grima 2	32.4078 N	76.4874 E
		Kuleth 1	32.3211 N	76.5653 E
		Kuleth 2	32.3251 N	76.5577 E
		Sinur	32.4092 N	76.5041 E
		Taxi stand, Holi	32.3289 N	76.5543 E
		Tiari	32.339 N	76.5492 E
3.	*Phlomoides superba*	Kangra	31.87577 N	076.41039 E
		Khundian	31.6667 N	76.1667 E
		Mohand	30.21239 N	077.92415 E
		Jallow	32.79490 N	075.22942 E
		Sunderbani	33.08348 N	74.44216 E
		Tarha	32.82329 N	75.00737 E
		Domel	32.89006 N	74.95204 E
4.	*Pittosporum eriocarpum*	Barlowganj	30.44421 N	078.08263 E
		Kempty fall	30.50041 N	78.01131 E
		Sahastradhara	30.39124 N	78.13417 E
		Bhatta gaon	30.42462 N	078.07323 E
		Maldevta	30.32609 N	78.1654 E
		Nagni	30.30851 N	78.34414 E
		Nainital	29.37745 N	79.47039 E
5.	*Aconitum heterophyllum*	Badrinath	30.74627 N	79.50895 E
		Valley of flowers	30.71945 N	79.59534 E
		Pangi	32.92629 N	76.55427 E
		Gangotri	30.99317 N	78.93925 E

		Churdhar Kedarnath	30.83783 N 30.73482 N	77.45318 E 79.06485 E
6.	*Mahonia jaunsarensis*	Chakrata Deoban	30°42'21.74"N 30°44'2.15"N	77°51'51.74"E 77°51'38.12"E
7.	*Magnolia kisopa*	Mandal Pandukeshwar	30°27'30.37"N, 30°38'16.47"N	79°16'5.65"E 79°32'23.01"E
8.	*Sophora mollis*	Sahastradhara	30°23'5.07"N	78° 8'11.76"E
9.	*Acer oblongum var. membranaceum*	Mussoorie	30°26'28.59"N	78° 5'4.98"E


Map showing localities of *Phlomoides superba*


Map showing localities of *Pittosporum eriocarpum*


Map showing localities of *Jasminum parkeri*


Map showing localities of *Gentiana kurroo*


Map showing localities of *Aconitum heterophyllum*

Fig:163. Maps showing the localities reported during the field visit of targeted.

Table:24. Localities and population size of selected species in the surveyed localities.

Species	No. of reported localities	Surveyed localities	New localities discovered	No. of individuals	Threats
Aconitum heterophyllum	22	Badrinath Valley of flowers Pangi	3	15 - 150	Low regeneration and over exploitation
Acer oblongum var. *membranaceum*	4	Mussoorie Barlowganj	-	25	Habitat destruction
Gentiana kurroo	11	Sangrah Suwakholi Bhadraj	2	250 75 0	Exploitation & mining
Sophora mollis	8	Sahastradhara	2	50	Road broadening
Indopiptadenia oudhensis	13	-	-	-	-
Mahonia jaunsarensis	5	Chakrata, Deoban	-	12 3	Low regeneration
Magnolia kisopa	15	Mandal Pandukeshwar	1	3 8	Habitat destruction
Phlomoides superba	15	Mohand, Kangra	-	3 270	Habitat degradation
Pittosporum eriocarpum	12	Mussoorie Barlowganj Kempty fall Jharipani Sahastradhara	-	5 12 25 8 4	Land slide, mining
Jasminum parkeri	7	Holi Tiari Grima Deol	1	250 40 100 25	Habitat destruction

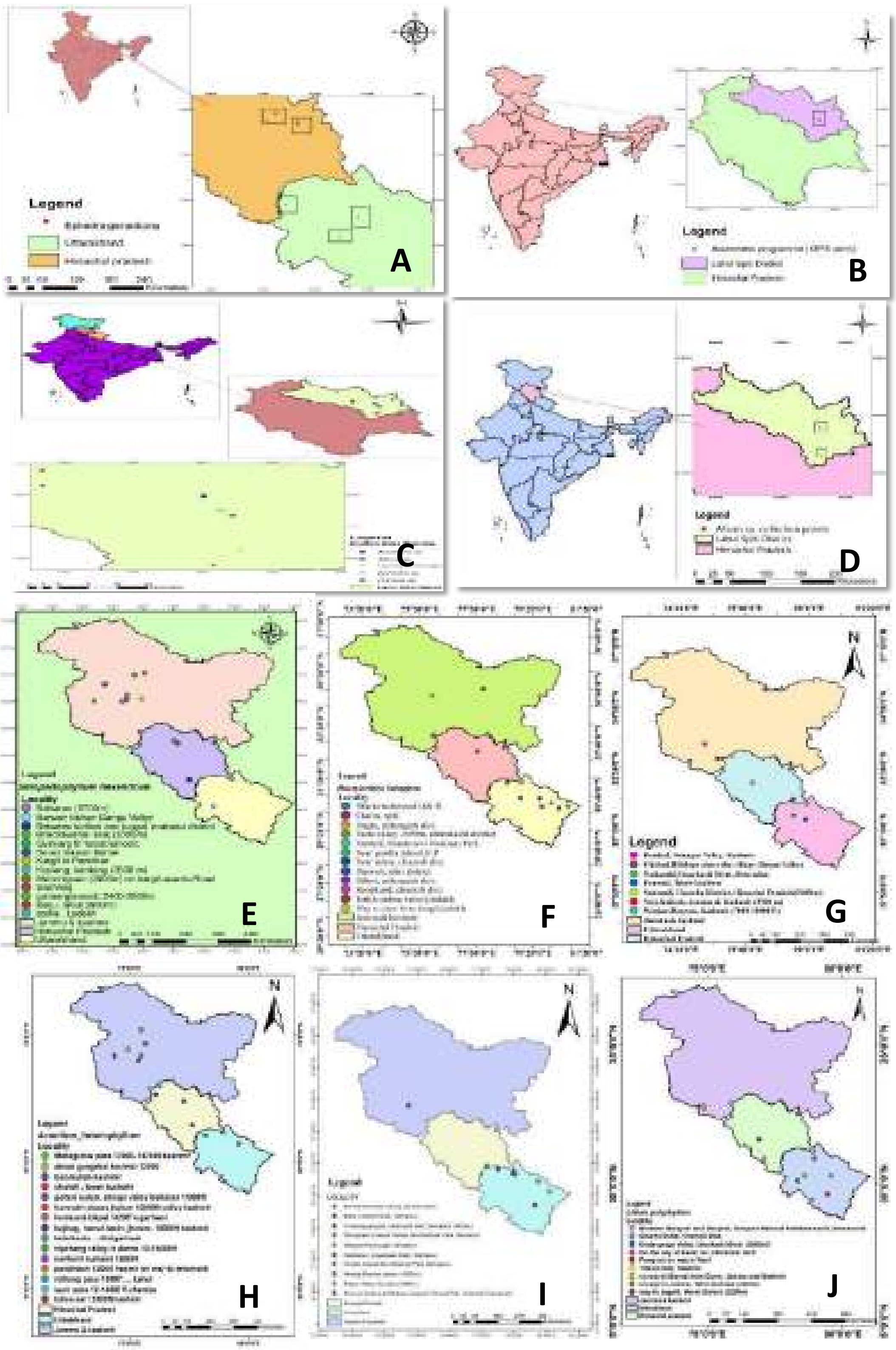


Fig:164. A- GIS Map of *Ephedra gerardiana*; B- GIS Map depicting site of Awareness programme C- GIS Map depicting site of collection in Lahaul & Spiti District D-GIS Map of *Allium* sp. E-Location Map of *Sinopodophyllum hexandrum* F-Geographical distribution of *Dactylorhiza hatagirea*; G- Geographical distribution of *Fritillaria cirrhosa* H-Geographical distribution of *Aconitum violaceum*; I-Geographical distribution of *Allium stracheyi*; J- Geographical distribution of *Lilium polyphyllum*

GIS is an acronym for Geographical Information System and is most mistaken to mean the same thing as GPS. GIS is a computer program that is designed to capture, analyse, interpret and store data that has been transmitted from navigation systems such as GPS and make the information available for use. GIS can be used to create or generate a map that can then be interpreted to show patterns such as the movement of people from one place to another, the spread of a particular disease, to find the suitable habitat for any species and so on. In other words, GIS makes the information from GPS more sensible such that without GIS, GPS would not be manipulated and utilized to its maximum. Its application includes Data mapping, Proximity analysis, Location analysis.

Table:25. Threat Assessment of Selected Species from Himalaya

Name of the species	Extent of Occurrence	Area of Occupancy
Aconitum ferox Wall. ex Ser.	141,999.579-LC	148.00-EN
Aconitum heterophyllum Wall. ex Royle	374651.638-LC	316.00-EN
Aesculus indica (Wall. ex Cambess.) Hook.	403176.272-LC	280.00-EN
Arenga westerhoutii Griff.	2393.701-EN	20.00-EN
Arnebia benthamii (Wall. ex G. Don) I.M.Johnst.	123502.289-LC	140.00-EN
Bischofia javanica Blume	25958.901-NT	32.00-EN
Cinnamomum impressinervium Meisn.	91476.031-LC	60.00-EN
Cypripedium cordigerum D. Don	87,236820-LC	68.00-EN
Galearis spathulata (Lindl.) P.F. Hunt	36,493.619-NT	104.00-EN
Loxostigma griffithii (Wight) C.B. Clarke	70,843522-LC	148.00-EN
Magnolia doltsopa (Buch. -Ham. ex DC.) Figlar	1038.452-EN	52.00-EN
Mallotus philippensis (Lam.) Müll.Arg.	181441.813-LC	80.00-EN
Picrorhiza kurrooa Royle	283,723.120-LC	152.00-EN
Taxus wallichiana Zucc.	364320.446-LC	76.00-EN
Sinopodophyllum hexandrum (Royle) T.S. Ying	481566.832-LC	84.00-EN
Saurauia punduana Wall.	203017.245-LC	116.00-EN

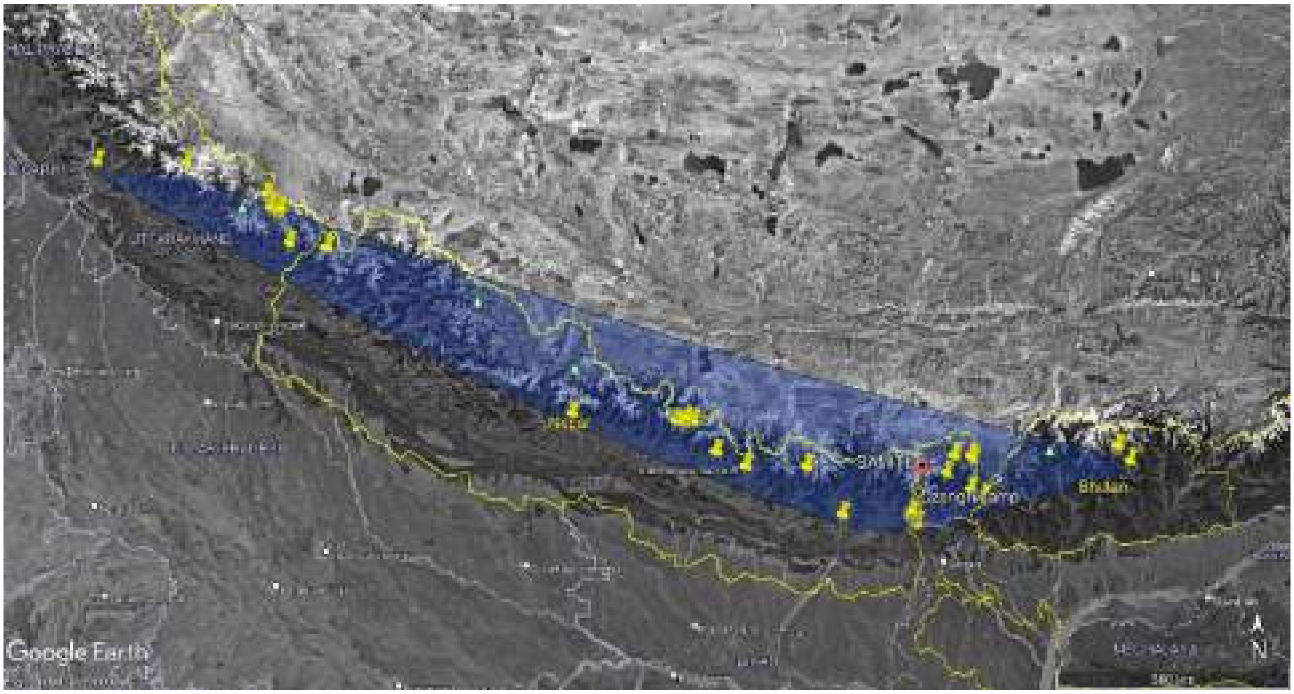


Fig:165. Map showing the geographic range of *Aconitum ferox* Wall. ex Ser. (a) View in Google Earth Map (b) View in GeoCAT

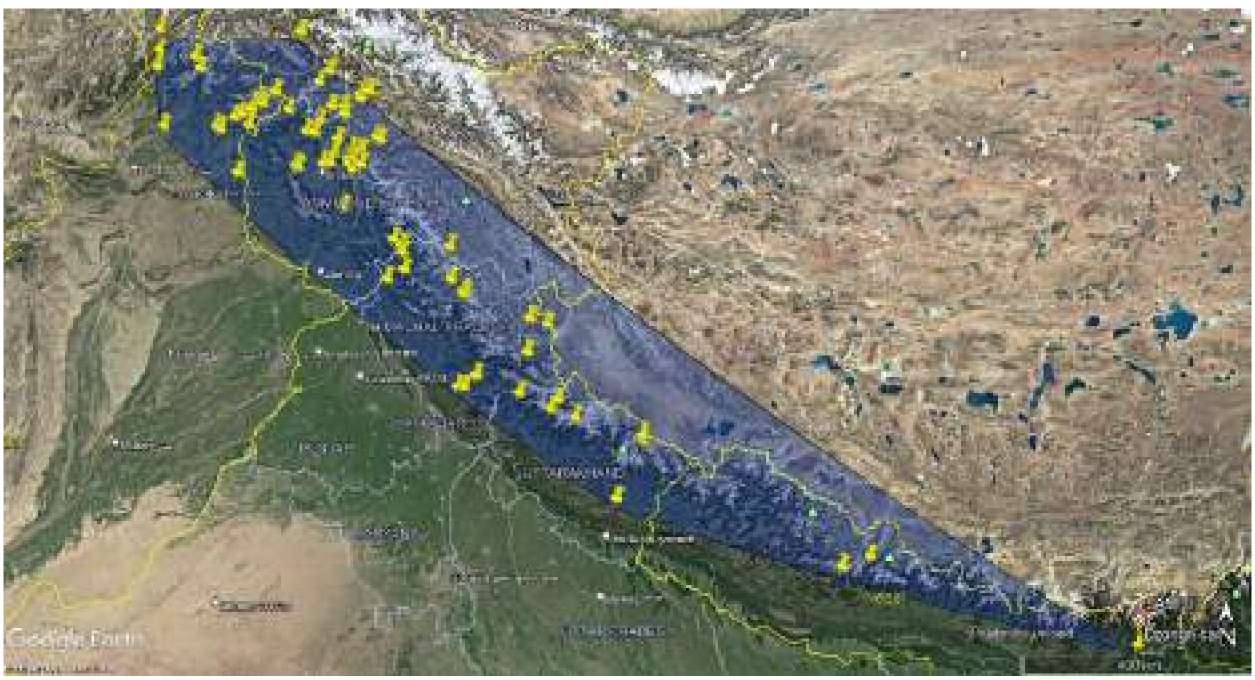


Fig:166. Map showing the geographic range of *Aconitum heterophyllum* Wall. ex Royle (a) View in GeoCAT (b) View in Google Earth Map

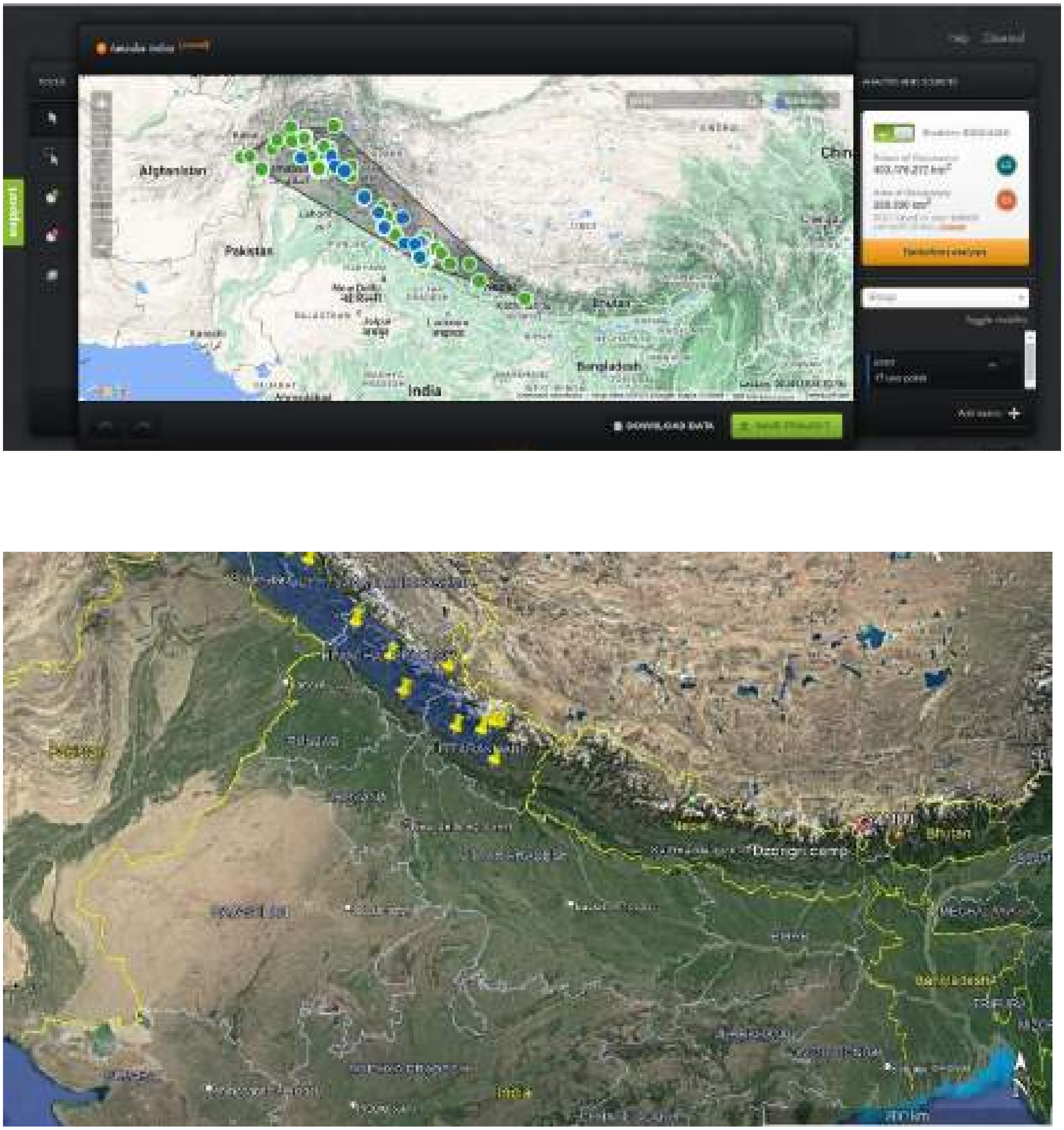


Fig:167. Map showing the geographic range of *Aesculus indica* (Wall. ex Cambess.) Hook. (a) View in GeoCAT (b) View in Google Earth Map

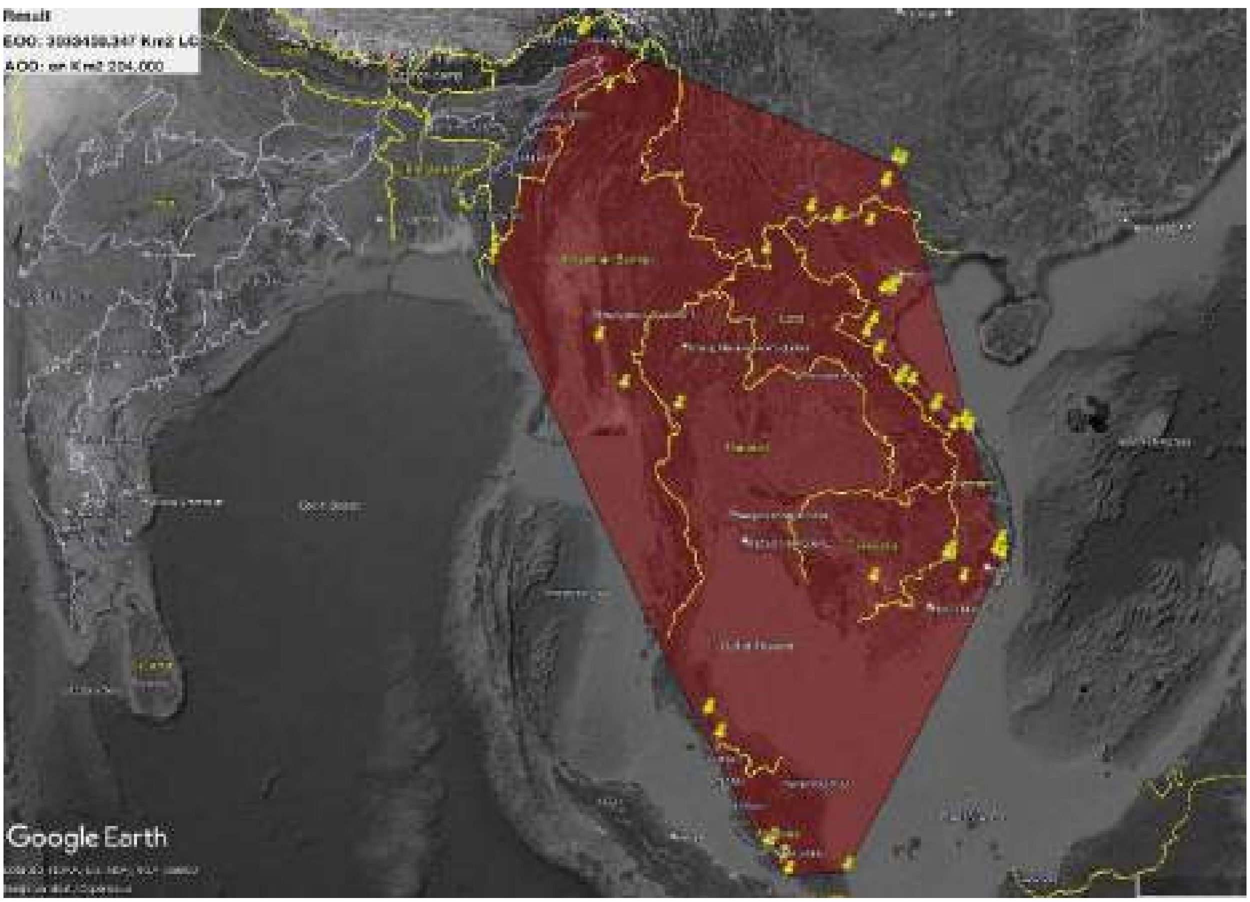


Fig:168. Map showing the geographic range of *Arenga westerhoutii* Griff. (a) View in GeoCAT (b) View in Google Earth Map

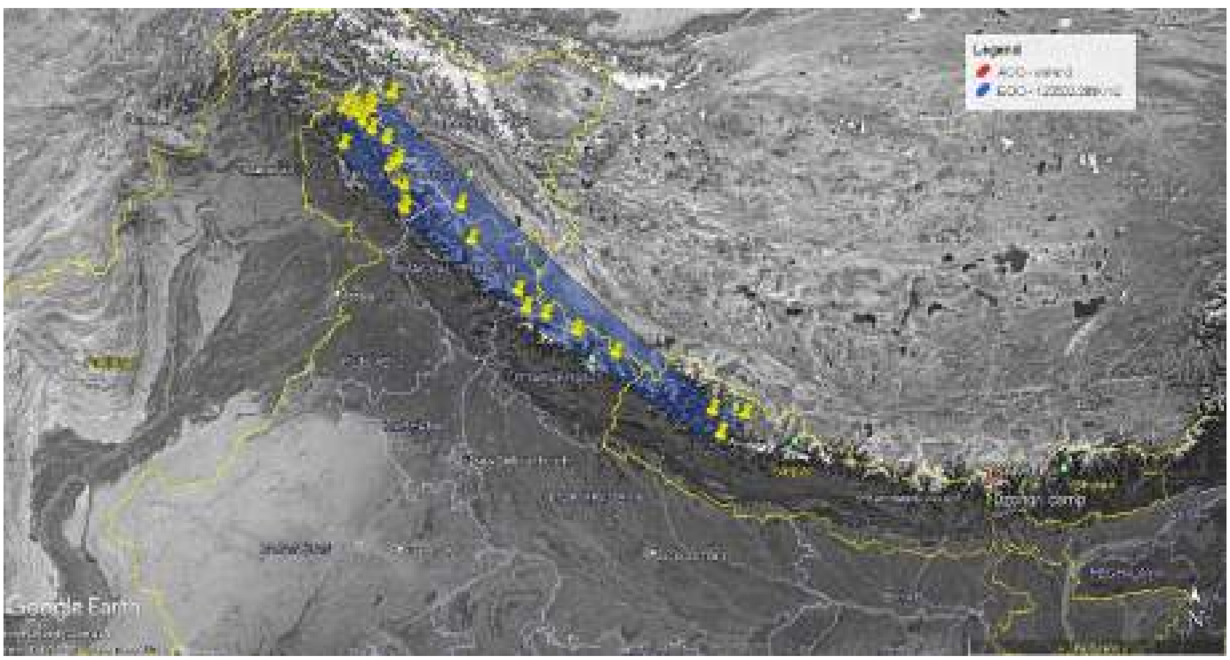


Fig:169. Map showing the geographic range of *Arnebia benthamii* (Wall. ex G. Don) I.M.Johnst. (a) View in GeoCAT (b) View in Google Earth Map

Fig:170. Map showing the geographic range of *Bischofia javanica* Blume (a) View in GeoCAT (b) View in Google Earth Map

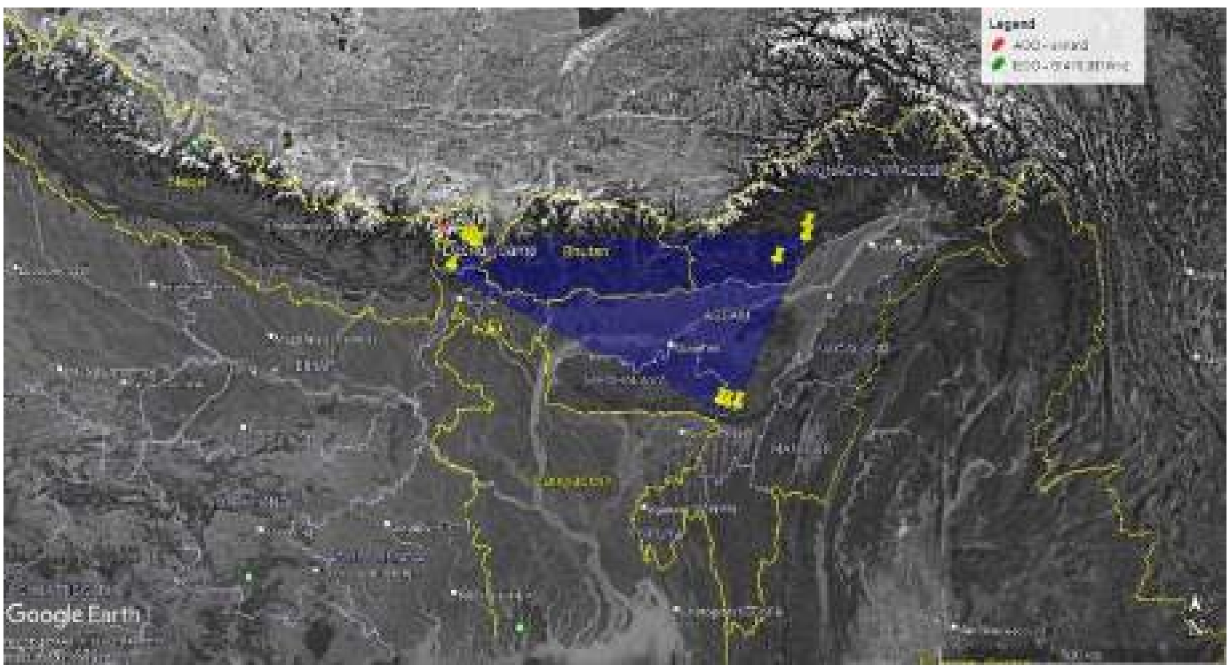


Fig:171. Map showing the geographic range of *Cinnamomum impressinervium* Meisn. (a) View in GeoCAT (b) View in Google Earth Map

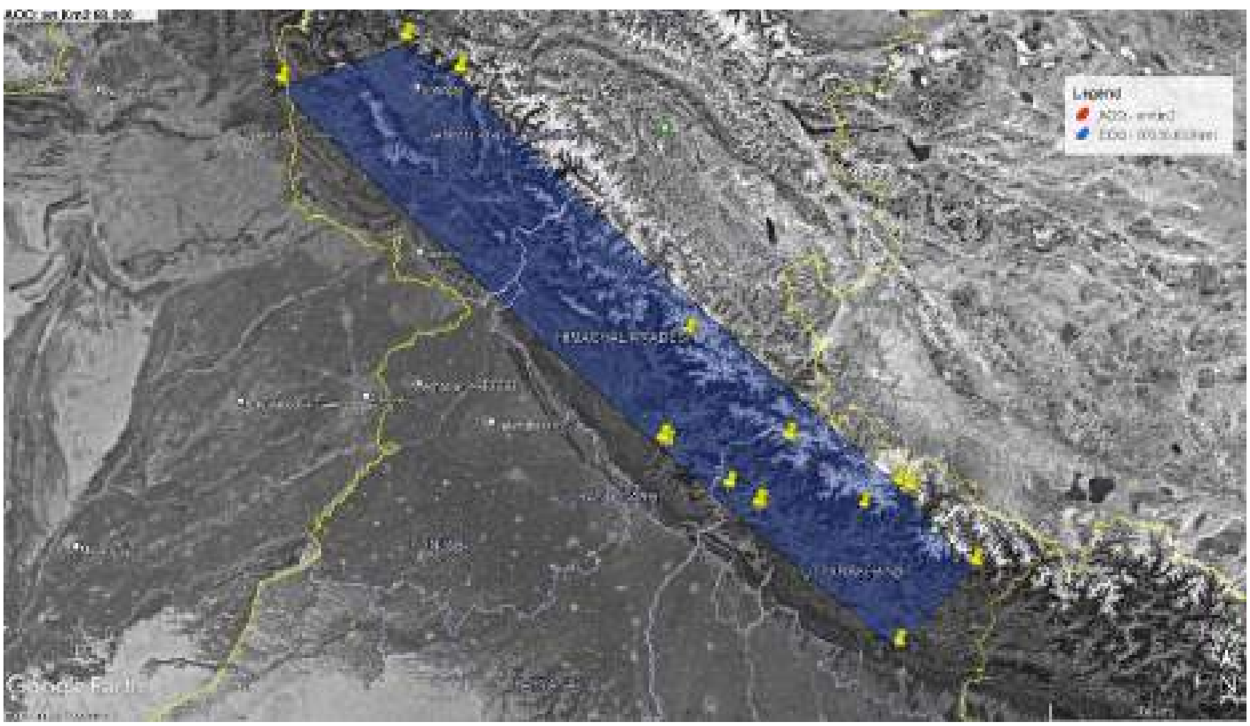


Fig:172. Map showing the geographic range of *Cypripedium cordigerum* D.Don (a) View in GeoCAT (b) View in Google Earth Map

Fig:173. Map showing the geographic range of *Galearis spathulata* (Lindl.) P.F. Hunt (a) View in GeoCAT (b) View in Google Earth Map

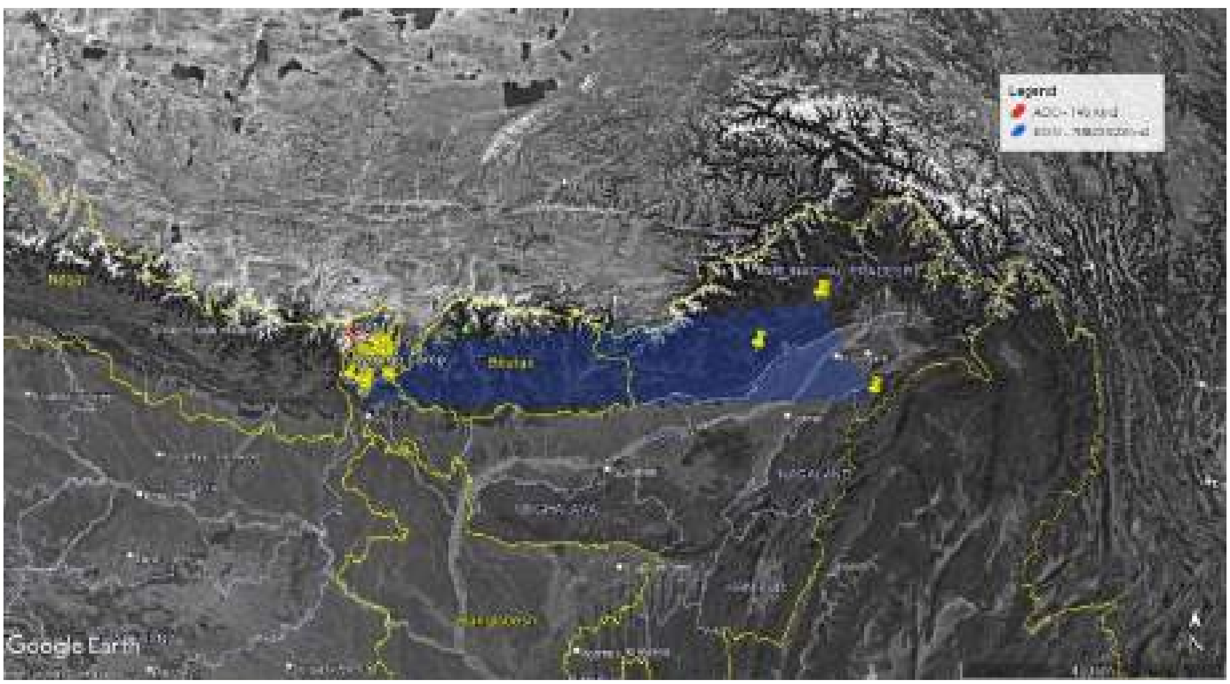


Fig:174. Map showing the geographic range of *Loxostigma griffithii* (Wight) C.B.Clarke (a) View in GeoCAT (b) View in Google Earth Map

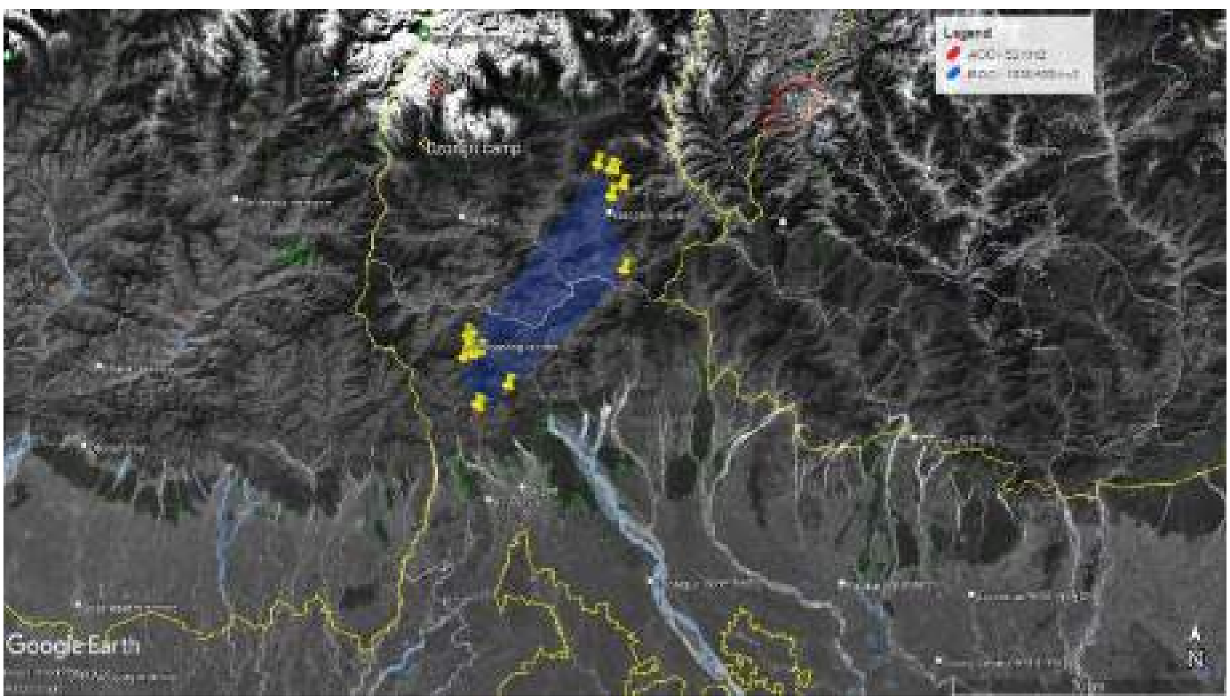


Fig:175. Map showing the geographic range of *Magnolia doltsopa* (Buch.-Ham. ex DC.) Figlar (a) View in GeoCAT (b) View in Google Earth Map

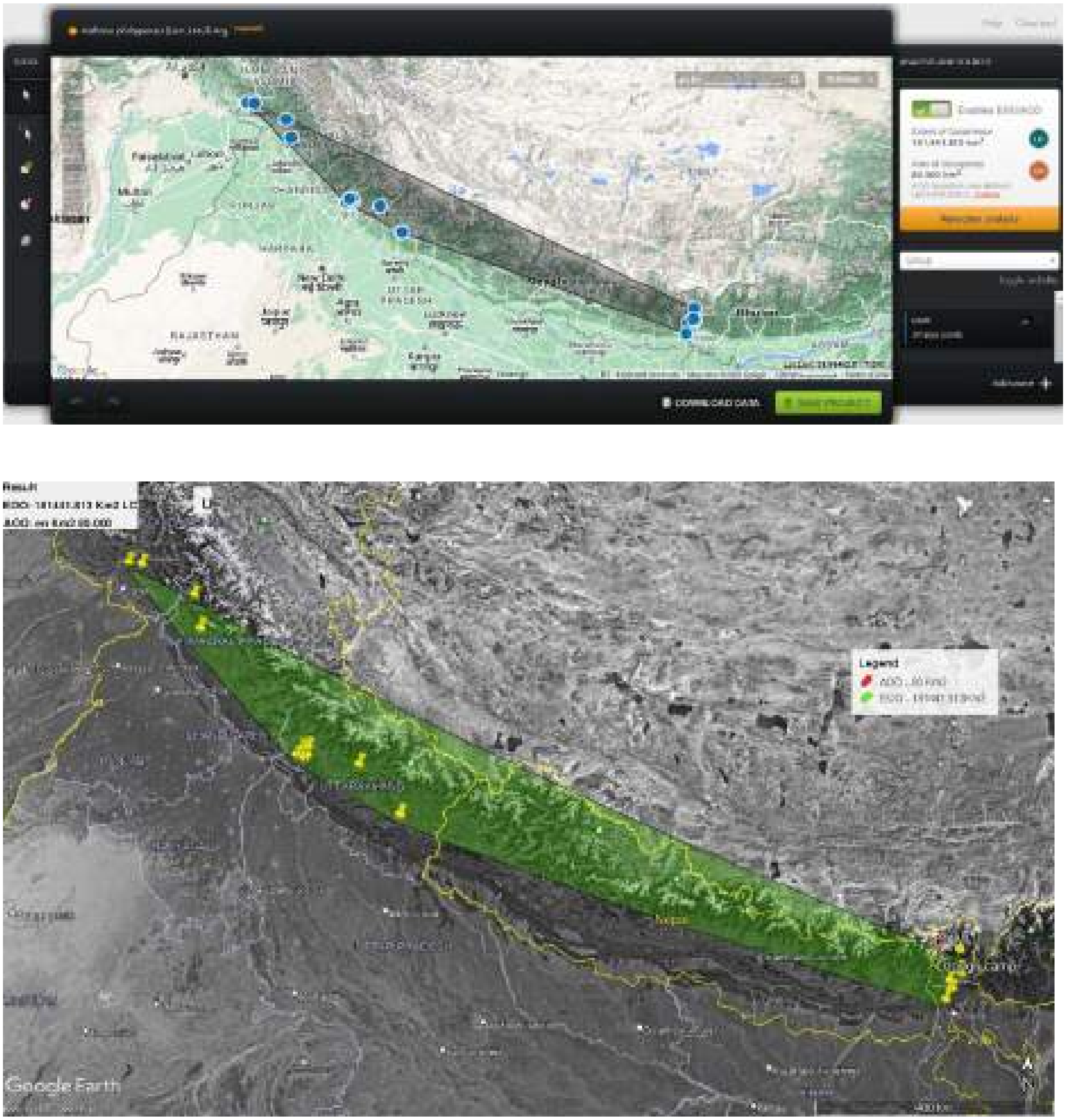


Fig:176. Map showing the geographic range of *Mallotus philippensis* (Lam.) Müll.Arg. (a) View in GeoCAT (b) View in Google Earth Map

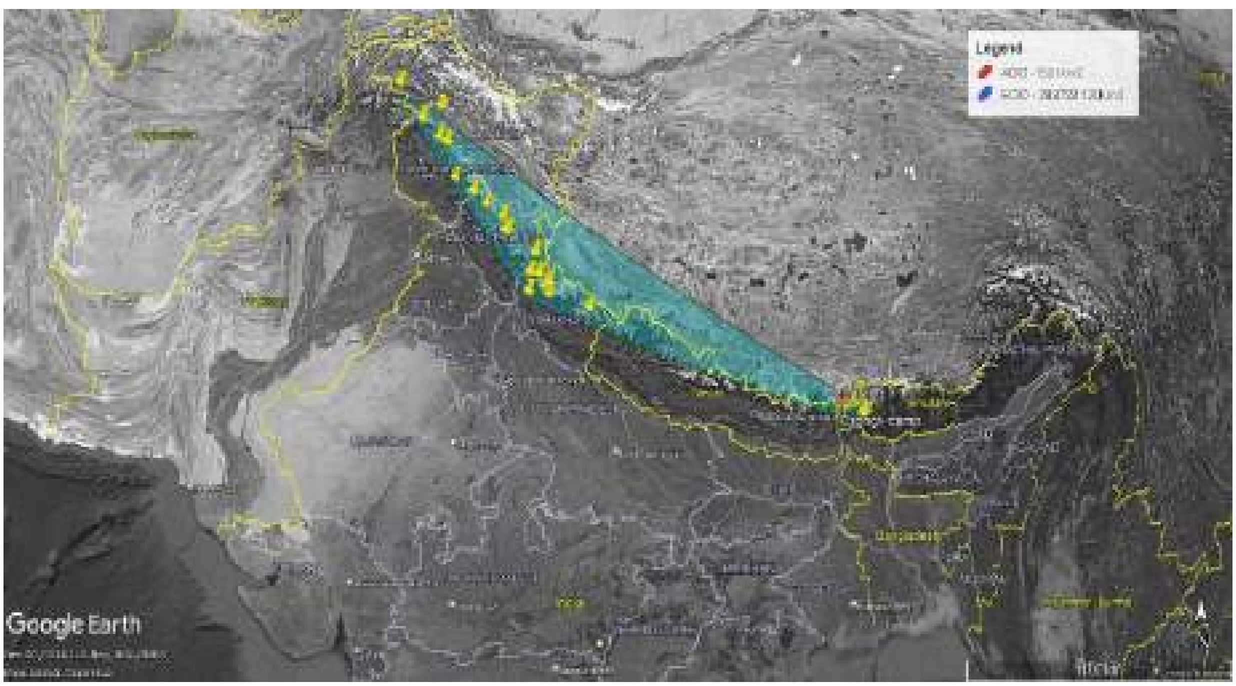


Fig:177. Map showing the geographic range of *Picrorhiza kurrooa* Royle (a) View in GeoCAT (b) View in Google Earth Map

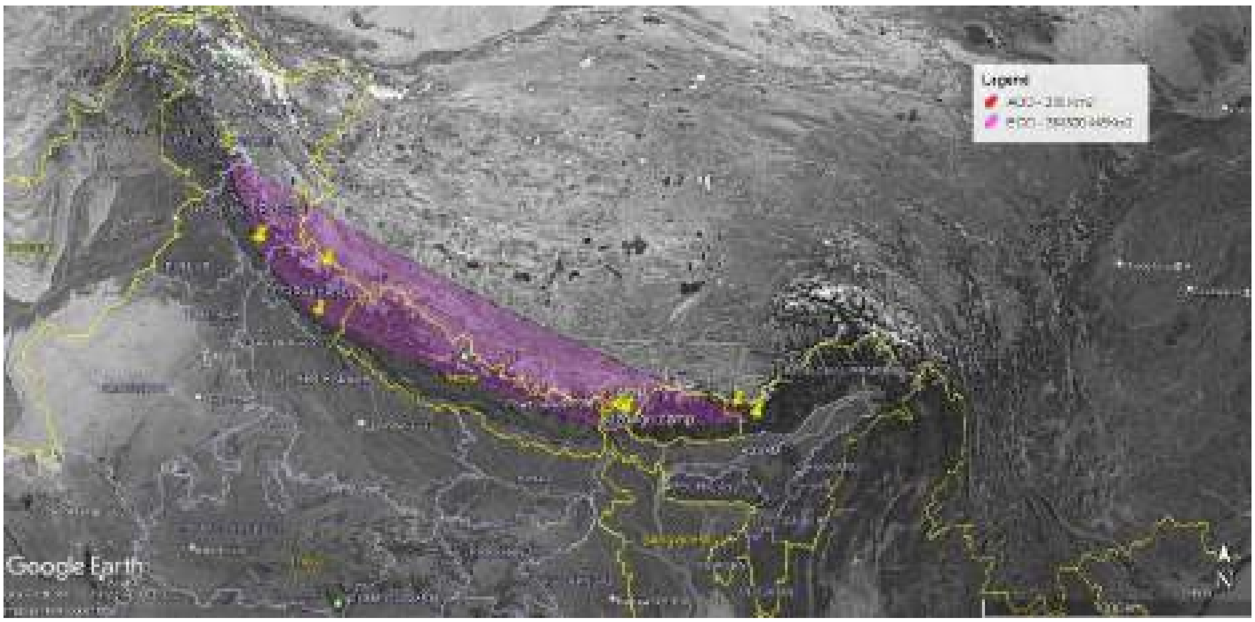


Fig:178. Map showing the geographic range of *Taxus wallichiana* Zucc. (a) View in GeoCAT (b) View in Google Earth Map

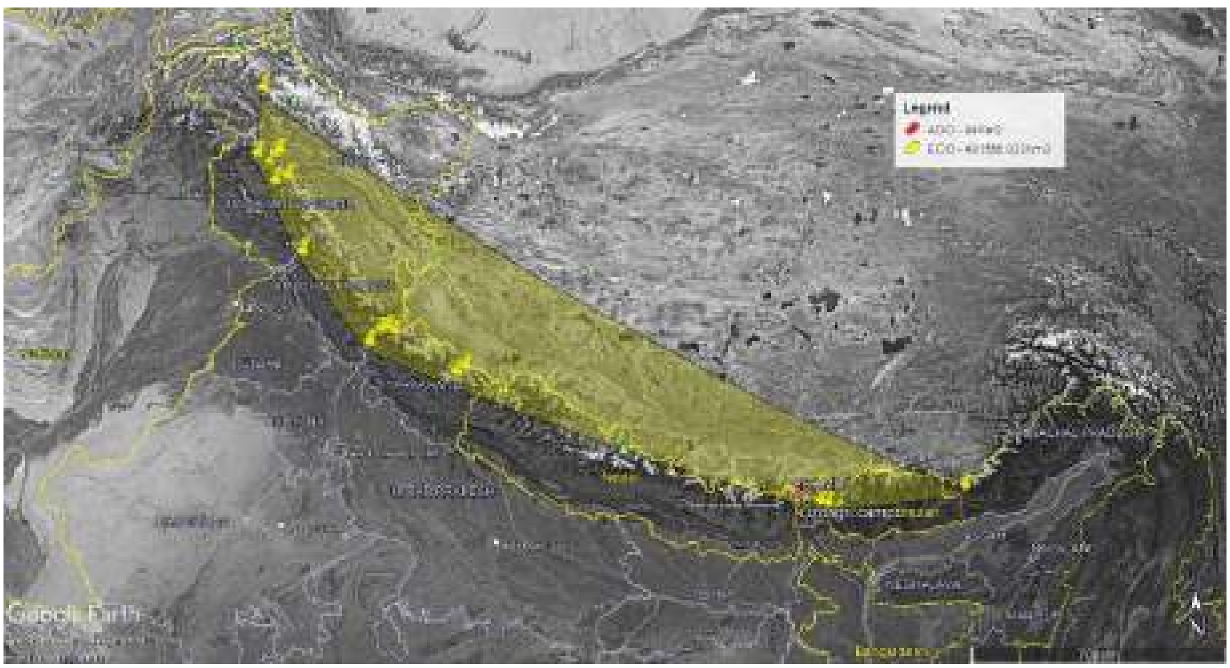
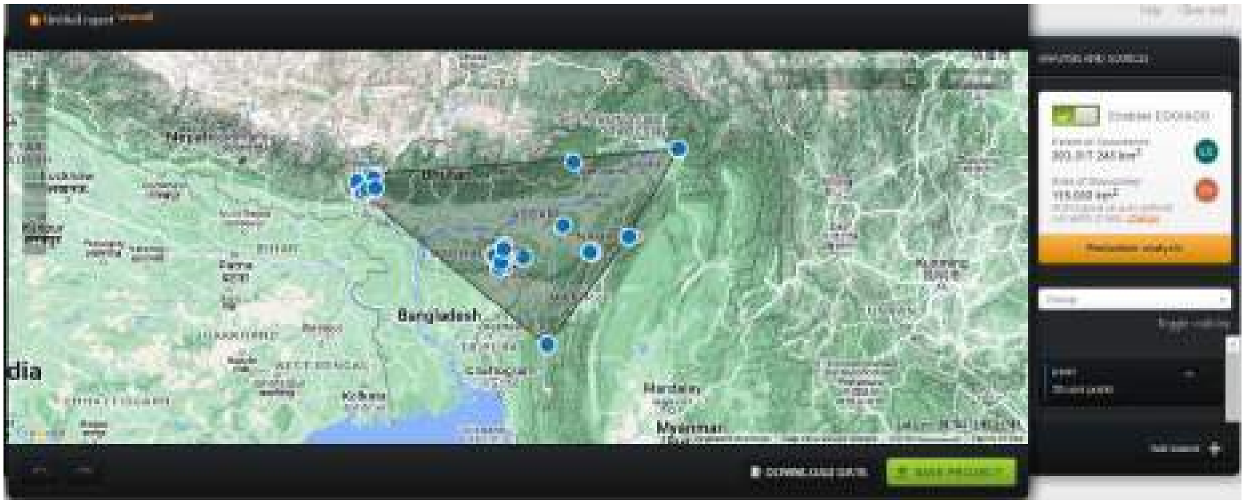


Fig:179. Map showing the geographic range of *Sinopodophyllum hexandrum* (Royle) T.S.Ying (a) View in GeoCAT (b) View in Google Earth Map



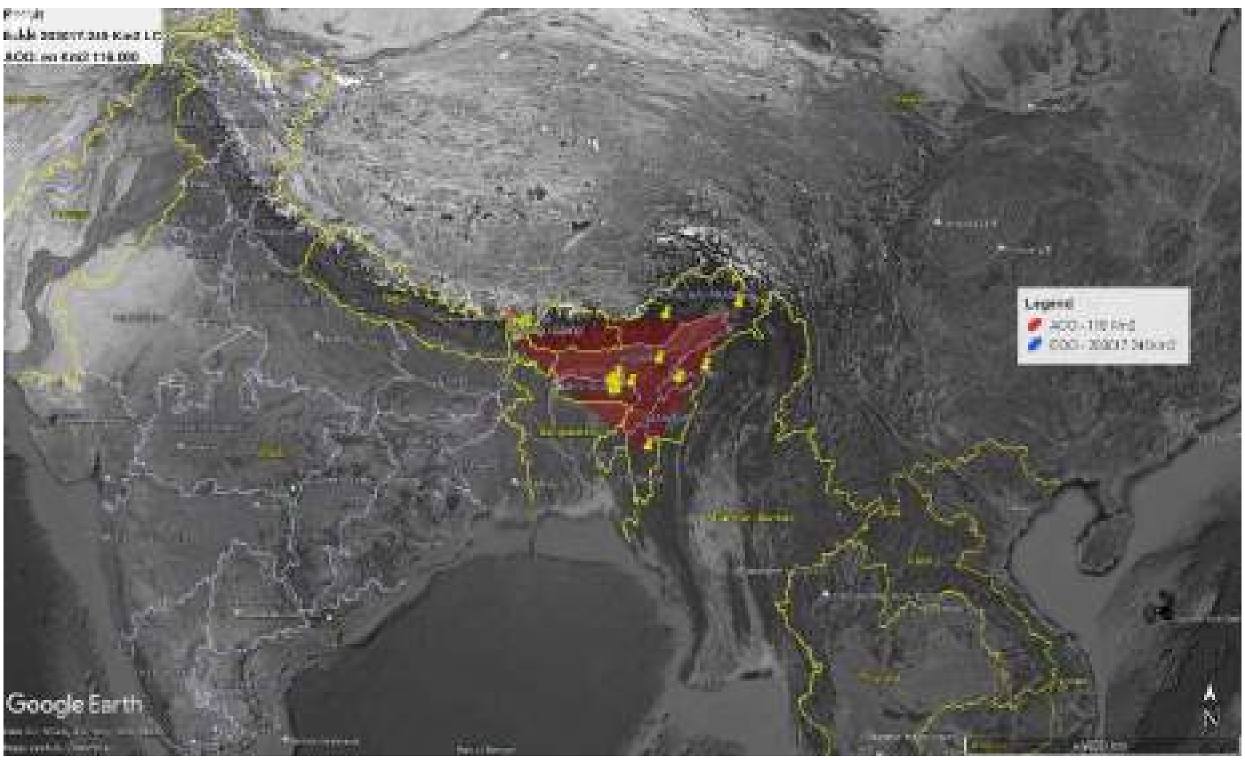


Fig:180. Map showing the geographic range of *Saurauia punduana* Wall. (a) View in GeoCAT (b) View in Google Earth Map

Molecular Diversity work

Celtis tetrandra Roxburgh

Celtis tetrandra is a deciduous tree whose fruits are usually taken by tribal to cure indigestion. During seedlings collection at BSI, ERC Shillong Garden some of the seedlings were found to possess root nodules at their roots. The presence of root nodules indicates atmospheric nitrogen fixing abilities of the plant with the help of nitrogen fixing bacteria that are host specific like rhizobia. These bacteria form a symbiotic relationship with the host (plant) by attaching to the roots of the plant and produces nodules. These nodules fix nitrogen and convert it to ammonia that can be used by the host plant for its growth and development. Such nitrogen fixing ability has not been reported in this tree species and hence experiments have been initiated to prove the same.

Plant material and explant preparation

Seedlings with root nodule were collected from BSI garden, Shillong as starter material for in vitro bacterial culture isolation.

Media preparation and culture conditions

The nodule was placed and crushed in a glass slide with a glass rod and the paste was used as inoculum for bacterial culture initiation. The parent cultures were then further sub-cultured onto petri-plates containing Yeast Mannitol Agar (YMA) medium. The cultures were kept under room temperature.

Grams staining of the bacterial cultures isolated from root nodules of *Celtis tetrandra* were also performed.

Protocol for nodule sterilisation

Nodules were collected and washed with mild detergent using a paint brush and thoroughly rinsed with water. Glass slides were wiped with ethanol and flame sterilised before use.

Results

The bacterial cultures are seen to start growing after 2 days of incubation. And the cultures were found to be gram negative in nature. Further DNA sequencing of the bacteria is to be done and some re-nodulation experiments are also to be carried out in future.

Fig:181. Mature lants of *Celtis tetrandra* showing seedling with a nodule on roots

Fig:182. Media preparation and culture conditions of *Celtis tetrandra*

***Rhododendron* Species:**

Molecular phylogenetic studies have numerous applications such as sequence-based classification, to understand pattern of relatedness and in strategizing conservation policies. Molecular phylogeny can be carried out using multi-marker approach targeting specific regions of the genomes such as ITS, rbcL, matK, etc.

To study the phylogenetic relationship among the *Rhododendron* species available at BSI, ERC, Shillong campus three molecular markers have been utilised for the study. The study will help in elucidating the relationships among the species as well as other related species.

Genomic DNA extraction and quality check of extracted DNA

DNA extraction of 18 different species of *Rhododendron* was carried out with CTAB method of DNA extraction described by Doyle and Doyle, 1990. However, the results were not satisfactory and hence, extraction was carried out using Qiagen extraction kit. The quality of isolated DNA was checked in 0.8% agarose gel for all the samples extracted and visualized in Gel Documentation System and photographed.

PCR standardisation and optimization:

PCR amplification for ITS region using ITS2 and ITS4 primer pair has been successfully standardized for 9 *Rhododendron* species. PCR amplification was carried out in a 20ul reaction containing 5X reaction buffer, 2mM of $MgCl_2$, 2.5mM each dNTPs, 0.5uM forward and reverse primers and 5U/ul Taq polymerase. The PCR program for the amplification was carried with initial denaturation of 94°C for 4 mins followed by 35 cycles of denaturation at 94°C for 40 secs followed by annealing at temperature range of 50-63°C with extension time for 1 min at 72°C, followed by final extension at 72°C for 8 mins.

The amplified products were electrophoresed and gel images were taken using gel Documentation system. The amplicons size ranged from 300-400bp.

Further experimental set-up for the remaining markers will be carried out in the future.

Results

All the amplified products will be sent for sequencing for further downstream processing and carrying out the phylogenetic studies.

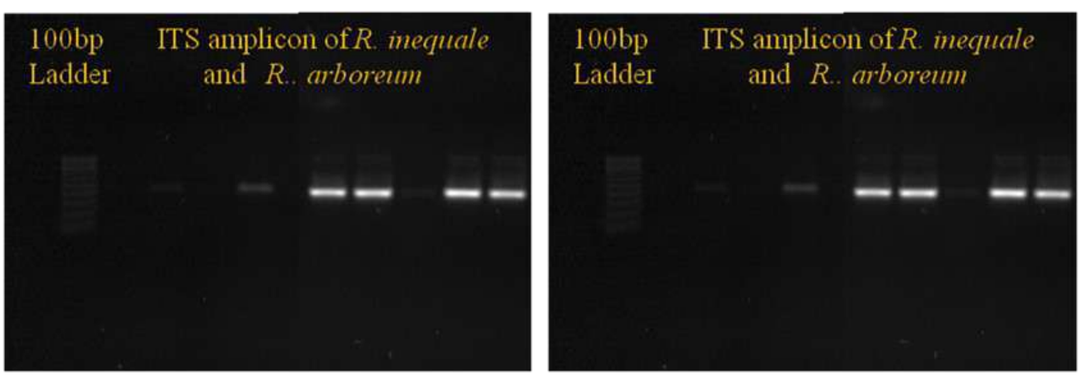


Fig:183. ITS amplicon of *R. inequale* and *R. arboreum*

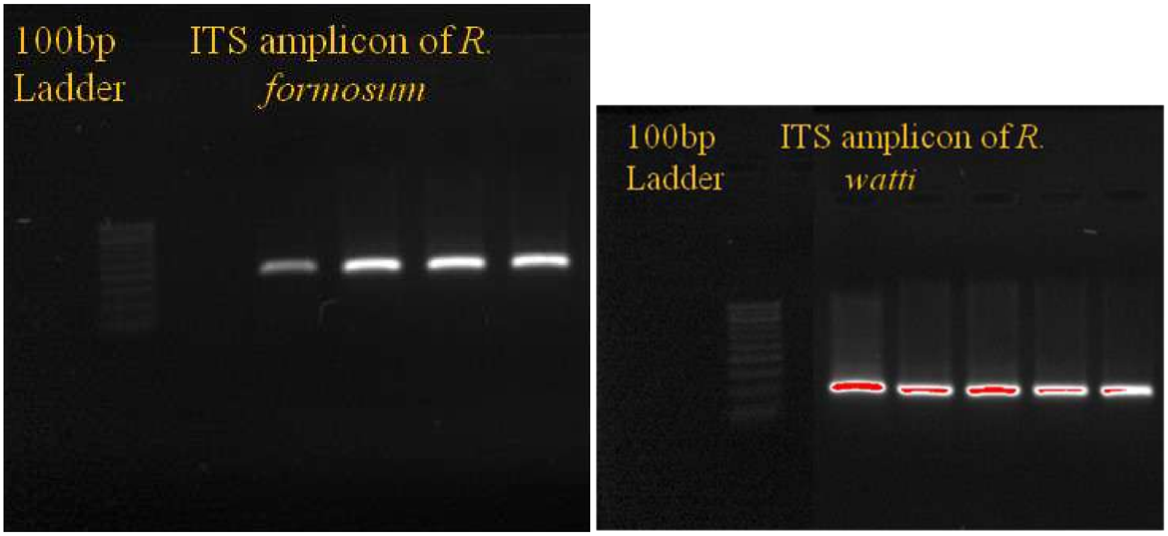


Fig:183. ITS amplicon of *R.formosum* and *R.arboreum*

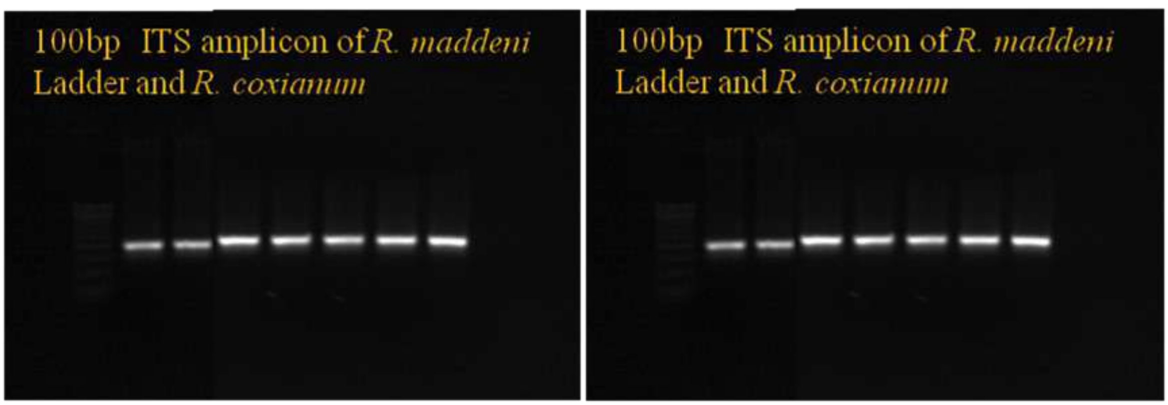


Fig:184. ITS amplicon of *R.madddeni* and *R. coxianum*

***Arundina* species**

Within the genus *Arundina*, only two taxa viz *Arundina graminifolia* and *Arundina graminifolia* var. *revoluta* (J.D.Hooker) A.L. Lamb, are truly accepted out of the 33 taxa recorded. A study by Yorifuji et al. (2014) based on morphological characters and single locus molecular markers, proposed that *Arundina graminifolia* var. *revoluta* should be considered as an ecotype rather than a variety. To address the proposed claim, Inter Simple Sequence Repeats (ISSR) marker was applied to understand the variability at molecular level using three different genotypes namely: *Arundinia graminofolia* morphotype 1 (pink flower), morphotype 2 (purple flower) and *Arundina graminifolia* var. *revoluta* (dwarf morphotype).

Genomic DNA extraction and quality check of extracted DNA

DNA extraction of the three species listed above was carried out with CTAB method of DNA extraction described by Doyle and Doyle, 1990. The quality of isolated DNA was checked in 0.8% agarose gel for all the samples extracted and visualized in Gel Documentation System and photographed.

PCR standardisation and optimization

Successful PCR reactions were performed in 25µl volume containing PCR mixture namely 30-50ng of template DNA, 200µM of each of the four dNTPs, 5X PCR buffer, 1.5mM $MgCl_2$, 0.6U Taq DNA polymerase and 10µmol of ISSR primer. A total of 20 primers were screened for assaying the extent of polymorphism of the primers out of which 11 primers were listed out for further studies. The reaction program for PCR was set at 95°C for 5min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 30sec, annealing at temperature gradient ranging from 40°C-60°C for 1min and extension at 72°C for 2min, and finally 7min for extension at 72°C.

Results

Variation studies among *Arundina graminifolia* morphotype 1 and morphotype 2 and the dwarf morphotype *Arundina graminifloia* var. *revoluta* at genetic level using ISSR marker revealed significant genetic variation of about 60% between the two taxa. Therefore, A. *graminifolia* var. *revoluta* may be may be retained as a variety. However, further studies using nuclear and chloroplast genes are being currently taken up to augment the present finding.

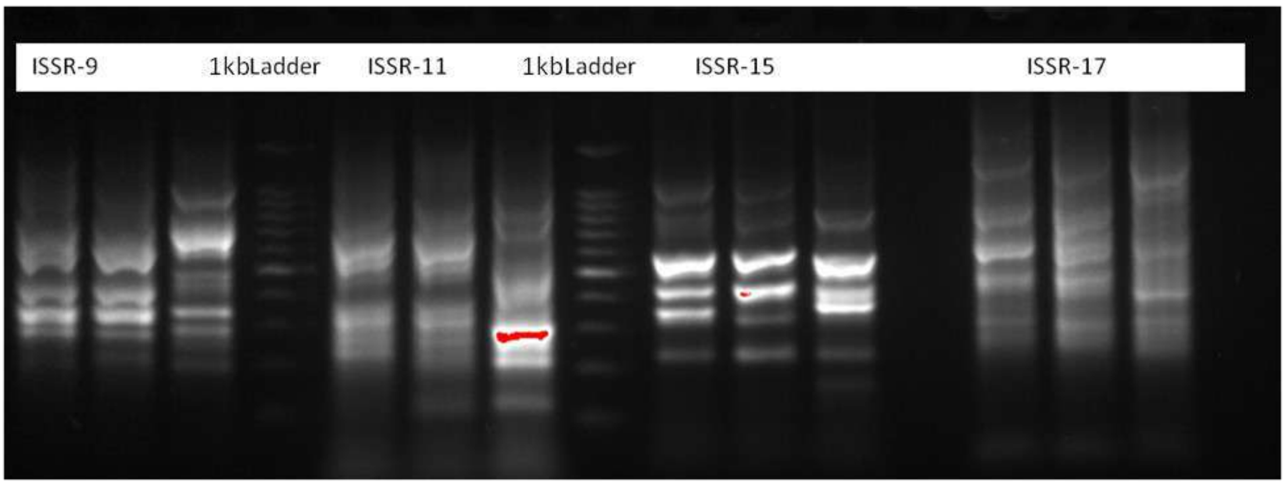


Fig:185. PCR amplification of the extracted DNA using ISSR markers

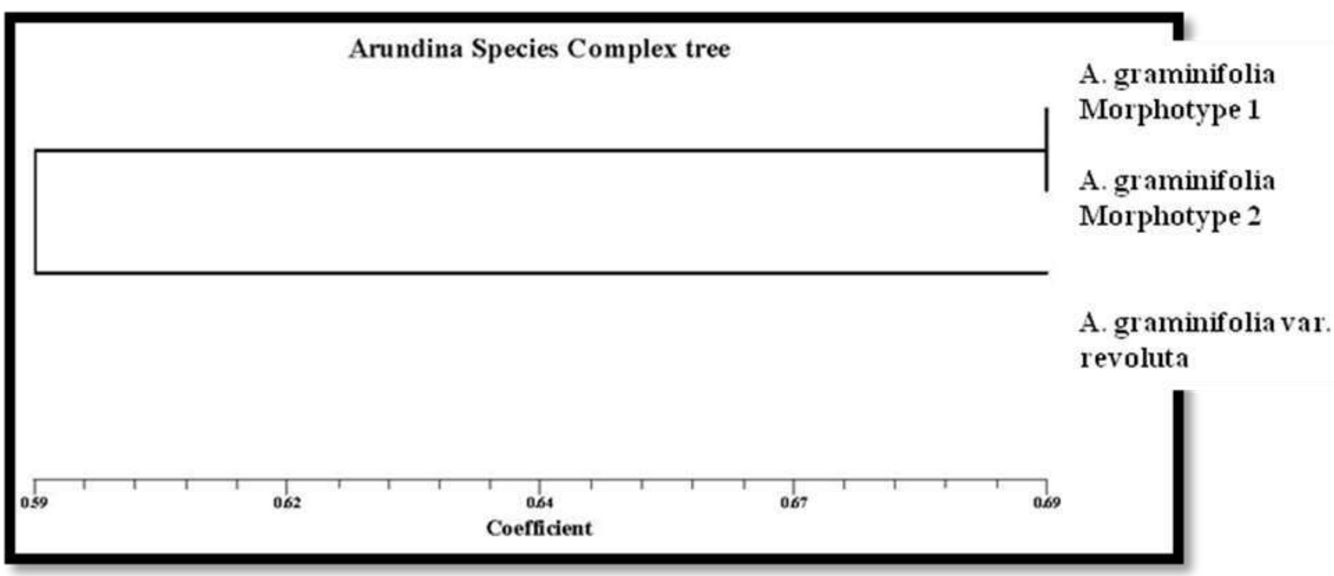


Fig:186. UPGMA dendrogram generated using ISSR marker

Fig:187. Different morphological variants in *Arundina* species

Fig:188. *Diplazium nagalandicum*

Diplazium nagalandicum was discovered recently and endemic to Nagaland. To study the phylogenetic relationship between already studied *Diplazium* spp. with this newly discovered species, this plant has been taken up using sequence specific molecular markers namely rbcL, ITS, matK and trnH-psbA.

Sample collection and DNA extraction

Plant sample collected from the garden of BSI, ERC, Shillong. Fresh fronds were used for extraction of DNA using Qiagen DNA extraction kit. Extracted DNA quality and quantity was checked using Spectrophotometer and gel electrophoresis, respectively.

Optimized PCR conditions

All extracted DNA were found to be of good quality without RNA contamination. Successful PCR reactions were performed in 25µl volume containing PCR mixture namely 50ng of template DNA, 2.5mM dNTPs mix, 10X PCR, 25mM $MgCl_2$, 3U Taq DNA polymerase 10pmol of primer

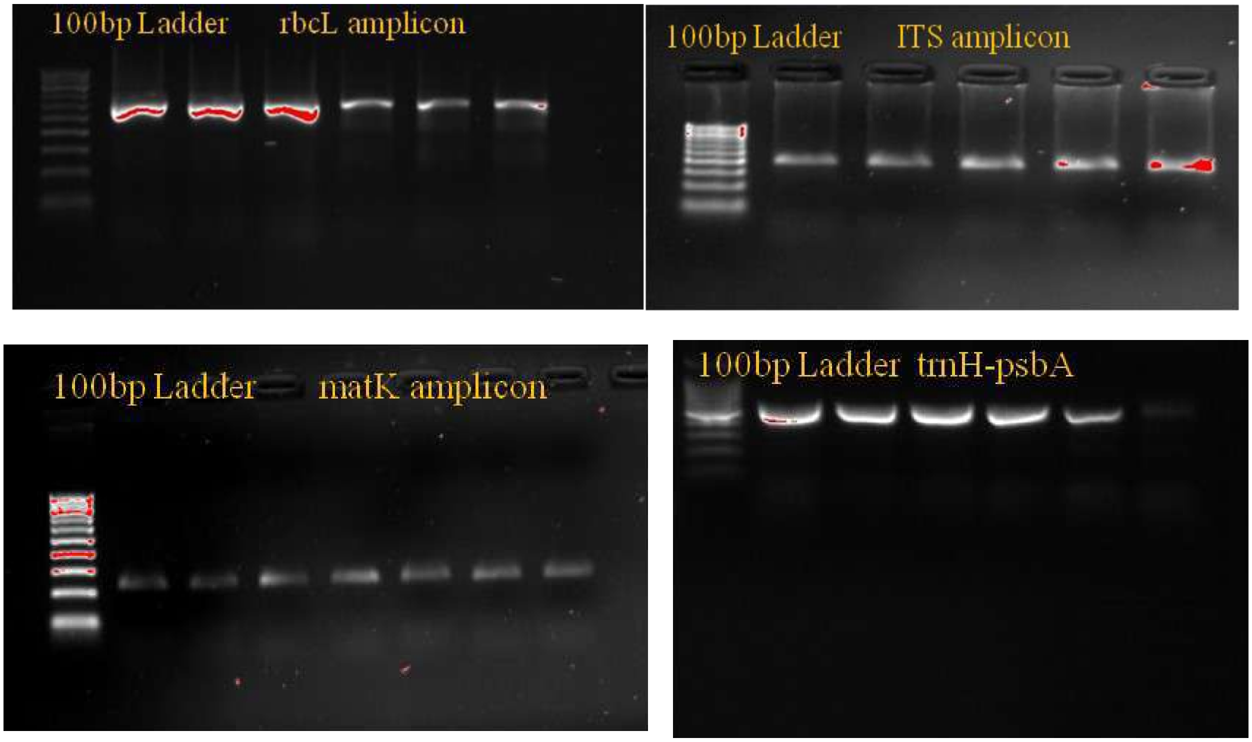


Fig:189. rbcL amplicon of *Diplazium nagalandicum*

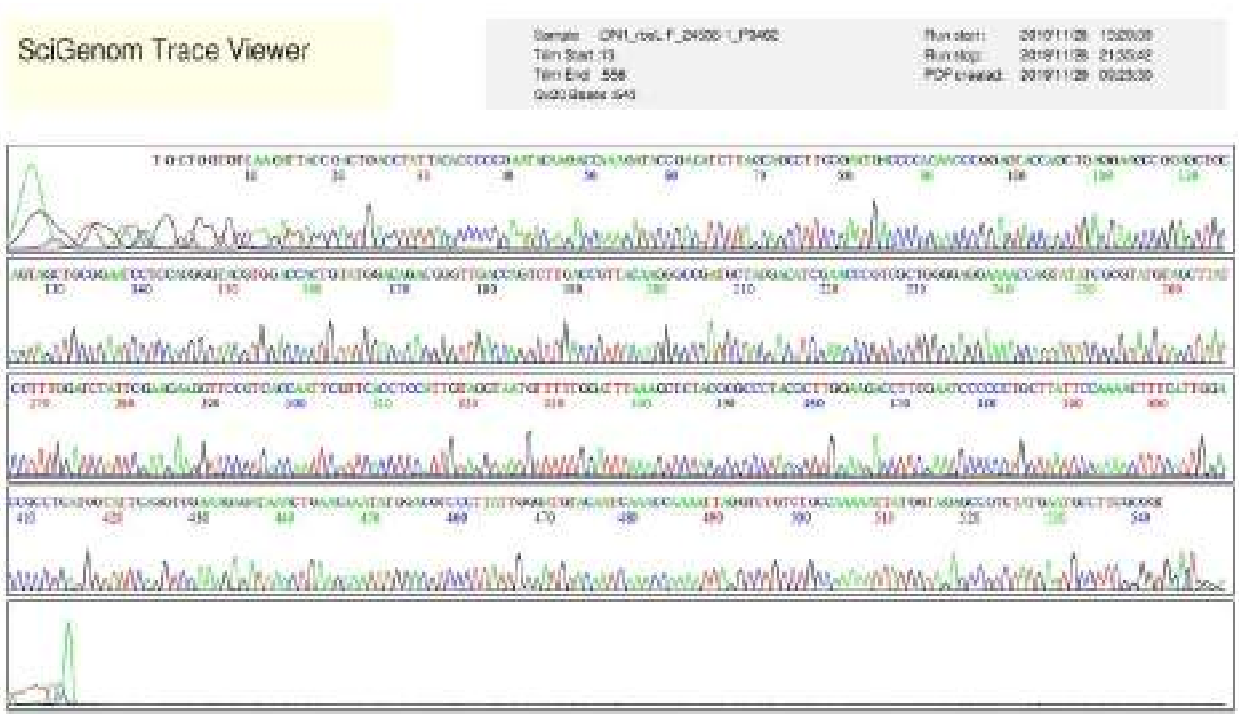


Fig:190. Electropherogram for DNA sequence of *Diplazium nagalandicum*

Reaction program for rbcL was set at 95°C for 1min (initial denaturation) followed by 35 cycles of denaturation at 95°C for 30sec, annealing at 54°C for 1min and extension at 72°C for 2min, and finally 7min for extension at 72°C. The amplicon size ranges between 500-600bp.

Reaction program for ITS was set at 94°C for 4min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 40sec, annealing at 55°C for 40sec and extension at 72°C for 1min, and finally 7min for extension at 72°C. The amplicon size was found to be 400bp for ITS region

Reaction program for matK was set at 94°C for 4min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 30sec, annealing temperature 60°C for 1min and extension at 72°C for 40sec and finally 7min for extension at 72°C. The amplicon size ranged between 200-250bp.

Reaction program for trnH-psbA was set at 95°C for 4min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 30sec, annealing temperature at 55°C for 1min and extension at 72°C for 1min and finally 7min for extension at 72. No successful amplification has been obtained.

Results:

Chloroplast *rbcL* DNA sequence analysis confirmed the uniqueness of *Diplazium nagalandicum,* as a species different from other known species. DNA sequence from this endemic fern from Nagaland has been submitted to genebank database (MT211906). The sequencing results for ITS, trnH-psbA and matK were found to be unsatisfactory and hence requires repetition of experiment.

Schima wallichii Choisy and **Schima khasiana** Dyer

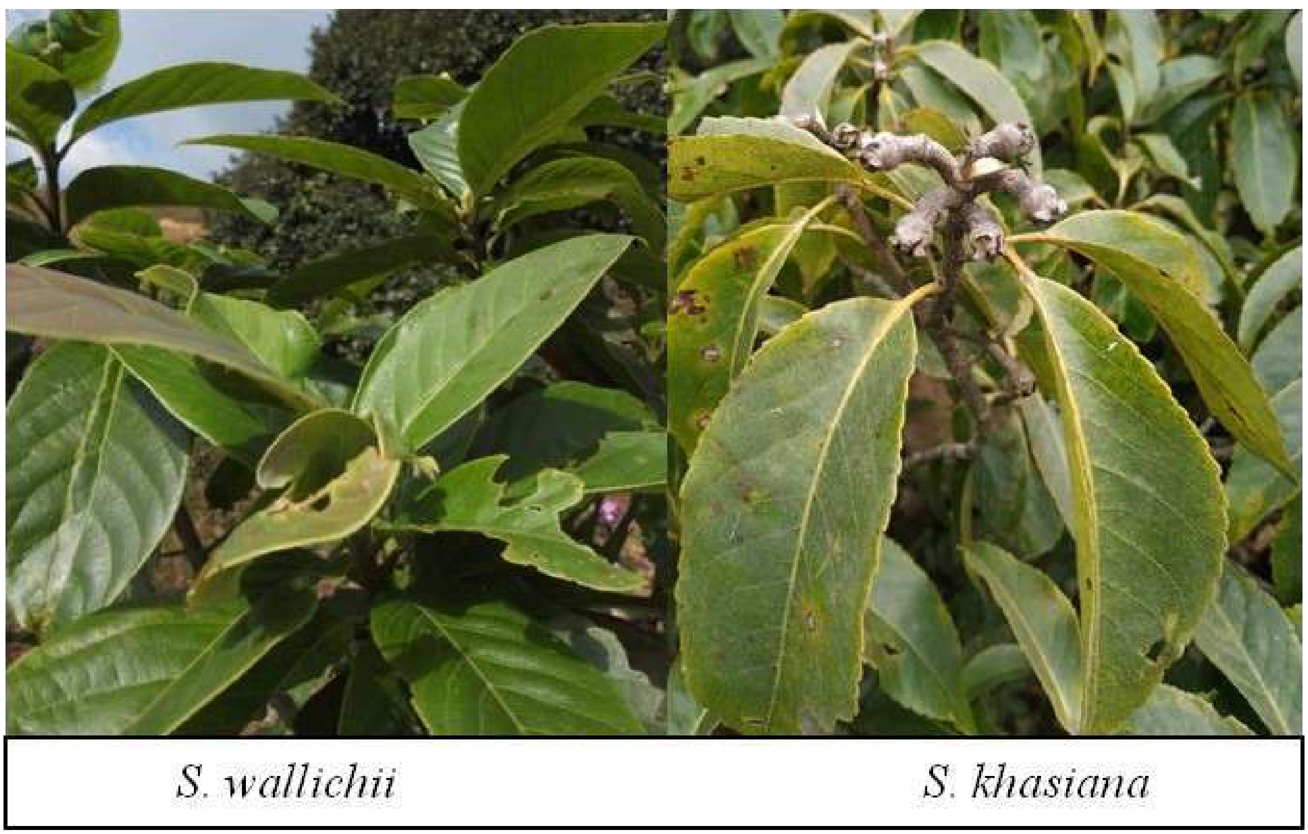


Fig:191. Mature plants of *Schima wallichii* and *Schima khasiana*

S .walllichii and *S.khasiana*, both are tree species belonging to the family Theaceae. They are economically important tress and are used for timber production. *S. wallichii* is reportedly medicinal and used for the treatment of uterine disorders and hysteria. The bark serves as a source of tannin and is also use for dyeing (Tropical Plants Database). Study of herbarium literature shows minor differences between the two species, i.e., leaf margin and size of the flowers and fruits. Both the species has been differentiated based on the mentioned criteria only. Therefore, to assess the differences at molecular level and augment the species delimitation, a molecular study was taken up under the project.

Sample collection

Leaf samples of both the species were collected from Laitmawsiang, East Khasi Hills District, Meghalaya. For the purpose of genomic DNA extraction, young, uninfected leaves samples was taken from both *S. wallichii and S. khasiana* and cleaned first with water followed by 70% alcohol. These leaves were then used for genomic DNA extraction.

DNA Extraction protocol and quality check of the isolated DNA

CTAB method of DNA extraction described by Doyle and Doyle, 1990 were followed for DNA extraction with few minor modifications. The quality of isolated DNA was checked in 0.8% agarose gel for all the samples extracted and visualized in Gel Documentation System and photographed.

PCR Optimization and standardization

Three sequence specific markers namely ITS, rbcL and matK have been employed for the present study.
All the PCR reactions were performed in 20µl volume containing PCR mixture namely 30-50ng of template DNA, 200µM of each of the four dNTPs, 5X PCR buffer, 1.5mM $MgCl_2$, 0.6U Taq DNA polymerase and 10µmol for each primer.
Reaction program for ITS-PCR was set at 94°C for 4min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 40sec, annealing at 56°C and extension at 72°C for 1min, and finally 7min for extension at 72°C.
Reaction program for rbcL-PCR was set at 94°C for 4min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 40sec, annealing at 61°C for 40 seconds and extension at 72°C for 1min, and finally 7min for extension at 72°C.
Reaction program for matK-PCR was set at 94°C for 1min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 1min, annealing at 60°C for 45 seconds and extension at 72°C for 1min, and finally 7min for extension at 72°C.

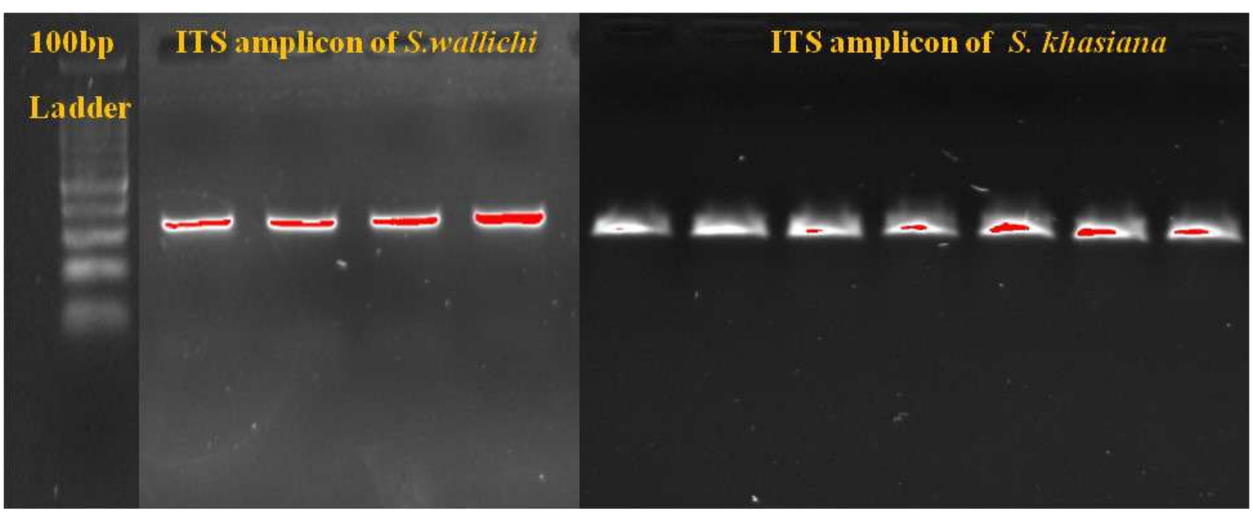


Fig:191. ITS amplicon of *Schima wallichii* and *Schima khasiana*

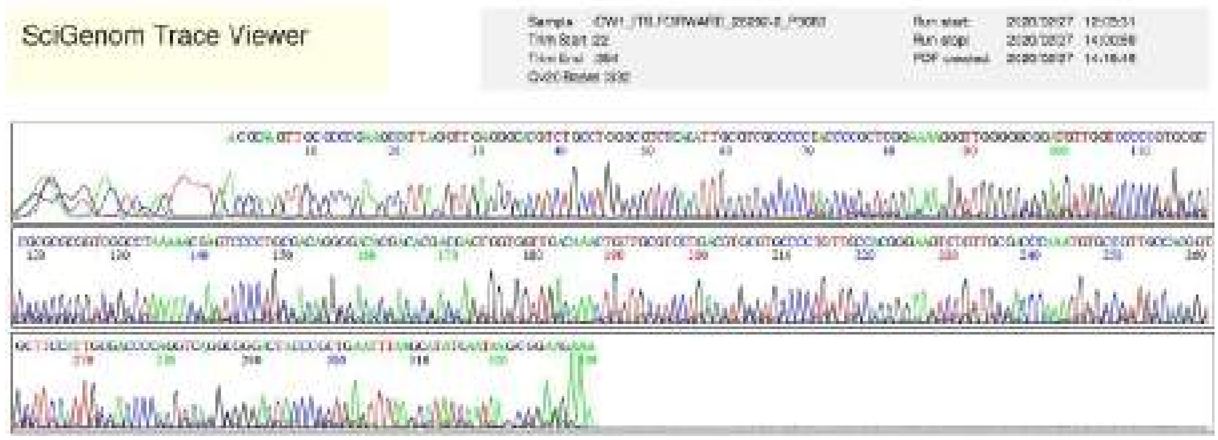


Fig:192. Electropherogram of DNA sequence of *S. khasiana*

Results: Nuclear ITS DNA sequenced for *Schima wallichi* and *S. khasiana*. BLAST analysis confirmed the identity of the two species. Multiple sequence analysis of the sequences obtained from the two species showed distinct variations between the two species.

Aspidistra hainanensis and **Aspidistra longifolia**:

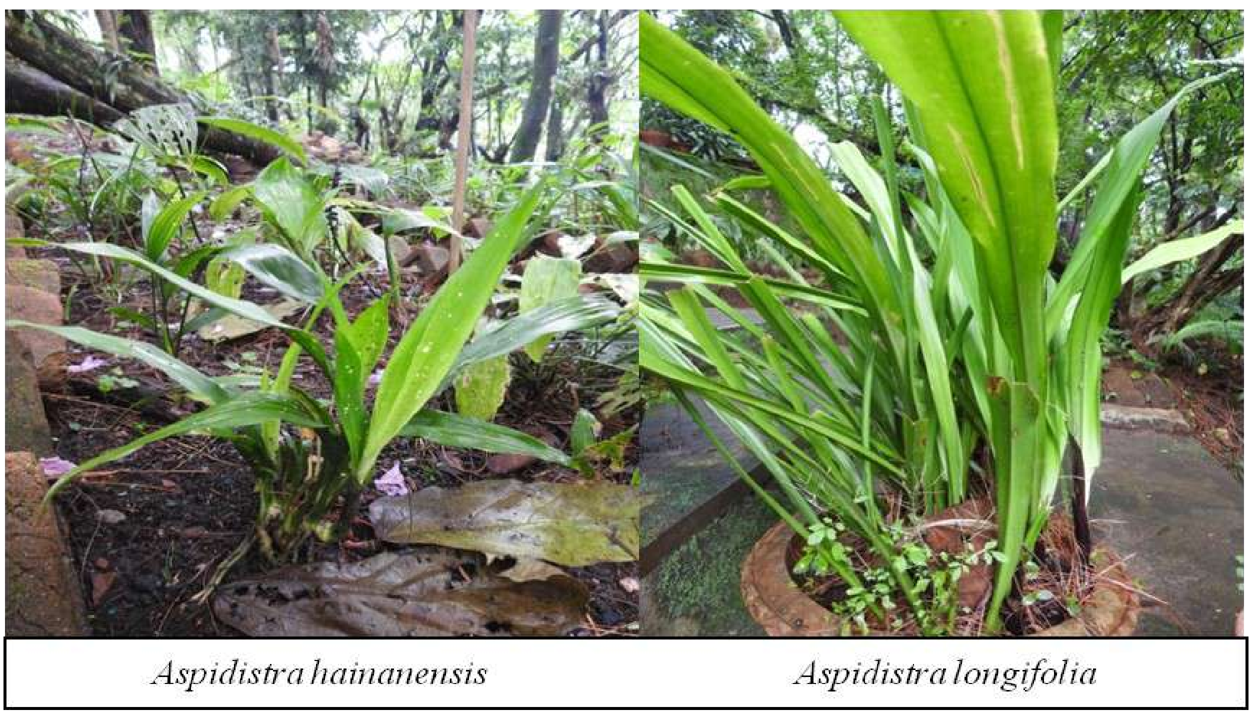


Fig:193. *Aspidistra hainanensis* and *Aspidistra longifolia*

A. hainanensis and *A. longifolia* both are plant species belonging to the family Asparagaceae. Experience with Aspidistra has shown that taxonomically meaningful solutions can be obtained only by studying plants from a great number of well documented collection sites side by side in cultivation. However, there is a problem in that Phonsena & de Wilde (2010) placed all these SE Asian plants into *A. longifolia* Hook.f., a species decribed from Assam, India, and based on two specimens from the Griffiths Herbarium at Kew.

Unfortunately, neither of these herbarium specimens are suitably preserved for detailed flower analysis but Hooker's description leaves no doubt that *A. longifolia* is clearly different from *A. hainanensis* morphologically. *Aspidistra* specimens with oblanceolate to lineate, tufted leaves as part of the *A. hainanensis* W.Y.Chun & H.W.How complex, until more comprehensive cultivation experiments can provide clarity regarding their variability and taxonomic status. Therefore, to assess the differences at molecular level and augment the species delimitation the study was taken up under the project.

Sample collection, genomic DNA extraction and quality check of extracted DNA

Plant sample collected from the garden of BSI, ERC, Shillong. Leaves were used for extraction of DNA using.

DNA extraction was carried out with CTAB method of DNA extraction described by Doyle and Doyle, 1990. The quality of isolated DNA was checked in 0.8% agarose gel for all the samples extracted and visualized in Gel Documentation System and photographed.

PCR standardisation and optimization:

PCR amplification for ITS region:

PCR amplification for ITS region using ITS2 and ITS4 primer pair has been successfully standardized. PCR amplification was carried out in a 20ul reaction containing 5X reaction buffer, 2mM of $MgCl_2$, 2.5mM each dNTPs, 0.5uM forward and reverse primers and 5U/ul Taq polymerase. The PCR program for the amplification was carried with initial denaturation of 94°C for 4 mins followed by 35 cycles of denaturation at 94°C for 40 secs followed by annealing at temperature range of 55-60°C with extension time for 1 min at 72°C, followed by final extension at 72°C for 8 mins.

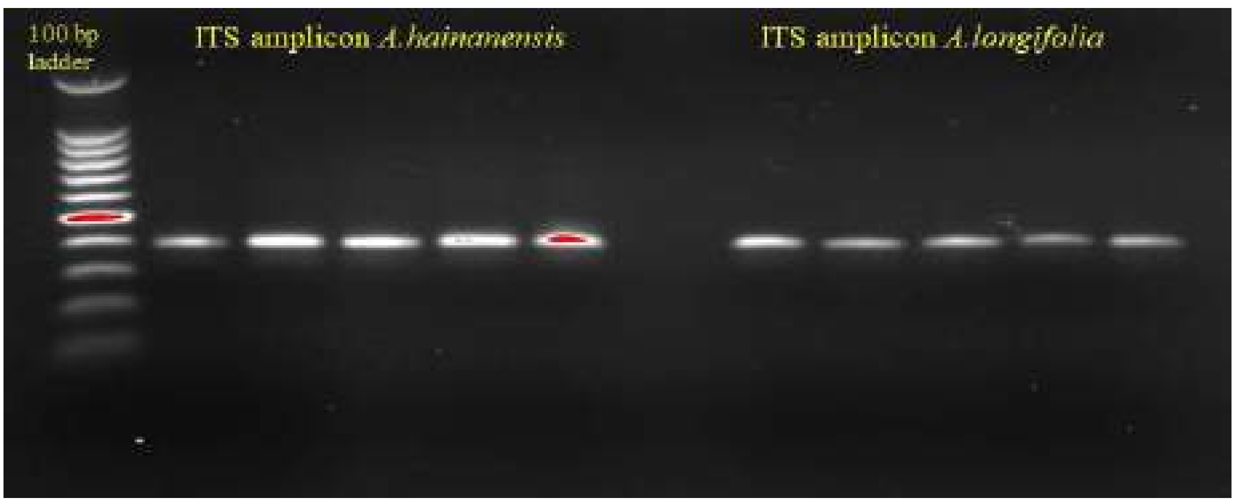


Fig:194. ITS amplicon of *Aspidistra hainanensis* and *Aspidistra longifolia*

Results

The amplified products were electrophoresed and gel images were taken using gel Documentation system. The amplicons size ranged from 300-400bp. The amplicons are ready for sequencing.

PCR amplification trnH-psbA for region:

PCR amplification for trnH-psbA region was carried out in a 20ul reaction containing 5X reaction buffer, 2mM of MgCl2, 2.5mM each dNTPs, 0.5uM forward and reverse primers and 5U/ul Taq polymerase. The PCR program for the amplification was carried with initial denaturation of 94°C for 4 mins followed by 35 cycles of denaturation at 94°C for 30 secs followed by annealing at temperature range of 55-65°C with extension time for 1 min at 72°C, followed by final extension at 72°C for 10 mins.

Results

The amplified products were electrophoresed and gel images were taken using gel Documentation system. The amplicons size ranged from 500-600bp. The amplicons are ready for sequencing.

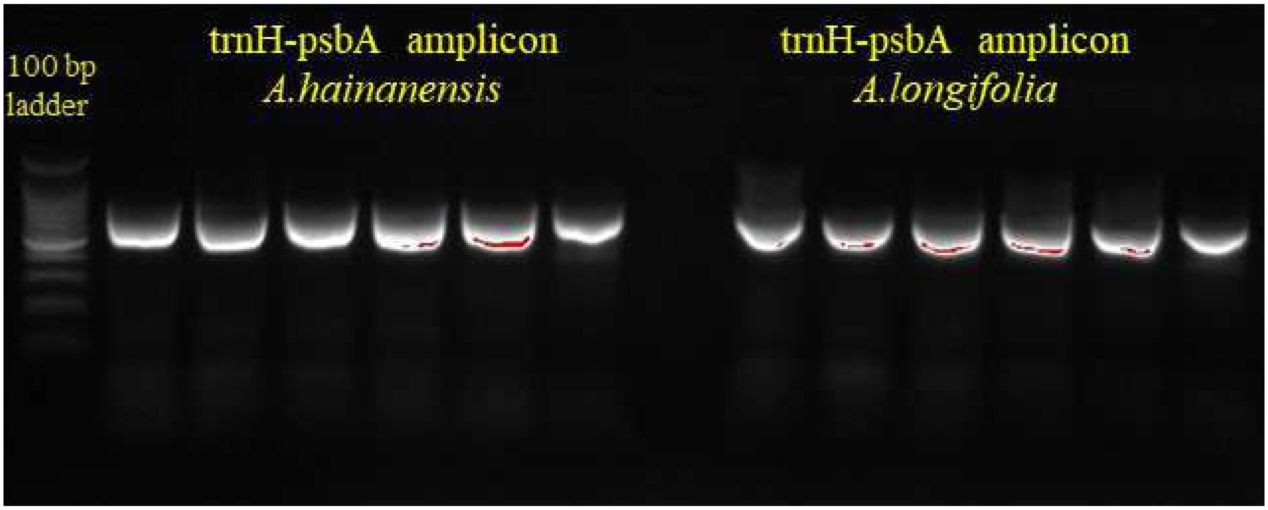


Fig:195. trnH-psbA amplicon of *Aspidistra hainanensis* and *Aspidistra longifolia*

All the amplified products will be sent for sequencing for further downstream processing and carrying out the phylogenetic studies. Further experimental set-up for the remaining markers will be carried out in the future.

Gynocardia odorata R.br. and **Aegle marmelos** (L.) Correa

Aegle marmelos is the only member of the monotypic genus *Aegle* which belong to the family Rutaceae. The leaves, roots, fruits, and seeds are used in traditional medicine to treat various illnesses. While, *Gynocardia odorata* is a species of evergreen tree belonging to the Achariaceae family. It is an important medicinal plant that has long been used in the traditional system of medicine to treat various cutaneous and subcutaneous diseases.

Both *A.marmelos* and *G.odorata* are monotypic genus with no other species have been distinguished within it. Molecular Phylogenetic studies were undertaken to understand the pattern of relatedness of these genera with other genus in their family. The proposed study is going to be carried out using sequence specific markers namely rbcL, ITS, matK and trnH-psbA.

Genomic DNA extraction and quality check of extracted DNA

DNA extraction of was carried out with CTAB method of DNA extraction described by Doyle and Doyle, 1990. The quality of isolated DNA was checked in 0.8% agarose gel for all the samples extracted and visualized in Gel Documentation System and photographed.

PCR standardisation and optimization

PCR amplification for ITS region using ITS2 and ITS4 primer pair has been successfully standardized for both *A.marmelos* and *G.odorata*. PCR amplification was carried out in a 20ul reaction containing 5X reaction buffer, 2mM of $MgCl_2$, 2.5mM each dNTPs, 0.5uM forward and reverse primers and 5U/ul Taq polymerase. The PCR program for the amplification was carried with initial denaturation of 94°C for 4 mins followed by 35 cycles of denaturation at 94°C for 40 secs followed by annealing at temperature range of 55-60°C with extension time for 1 min at 72°C, followed by final extension at 72°C for 8 mins.

The amplified products were electrophoresed and gel images were taken using gel Documentation system. The amplicons size ranged from 300-400bp.

Further experimental set-up for the remaining markers will be carried out in the future.

Results: All the amplified products will be sent for sequencing for further downstream processing and carrying out the phylogenetic studies.

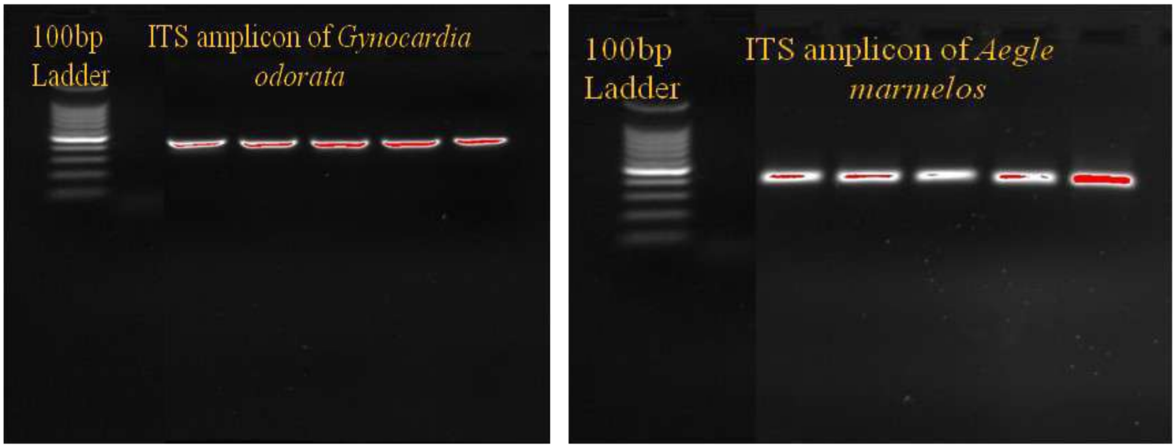


Fig:196. ITS amplicon of *Gynocardia odorata* and *Aegle marmelos*

***Dendrobium* spp.**

Within the genus *Dendrobium* three species namely: *Dendrobium fimbriatum, D. fimbriatum* var.*occulatum, D. khasianum* species are morphologically very similar and the delimitation of variety and species have been ambiguous. Therefore, a study was proposed to understand the species complexity using molecular markers such as rbcL, ITS, matK and trnH-psbA. to give a clear species identification of the three species.

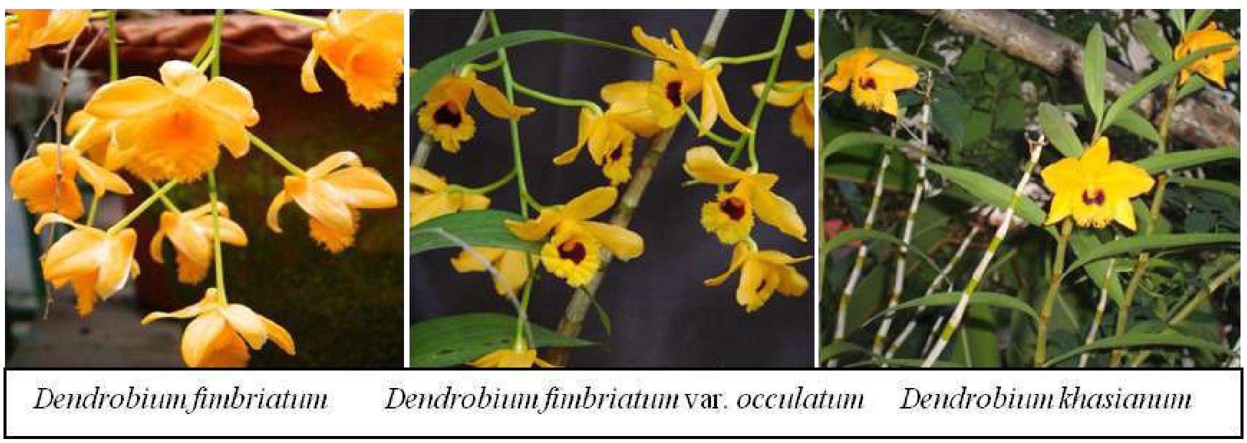


Fig:197. Flower of *Dendrobium fimbriatum, D. fimbriatum* var.*occulatum, D. khasianum*

Sample collection and DNA extraction

Plant sample collected from the garden of BSI, ERC, Shillong. Fresh fronds were used for extraction of DNA using Qiagen DNA extraction kit. Extracted DNA quality and quantity was checked using Spectrophotometer and gel electrophoresis, respectively.

Optimized PCR conditions

All extracted DNA were found to be of good quality without RNA contamination. Successful PCR reactions were performed in 25µl volume containing PCR mixture namely 50ng of template DNA, 2.5mM dNTPs mix, 10X PCR, 25mM $MgCl_2$, 3U Taq DNA polymerase 10pmol of primer

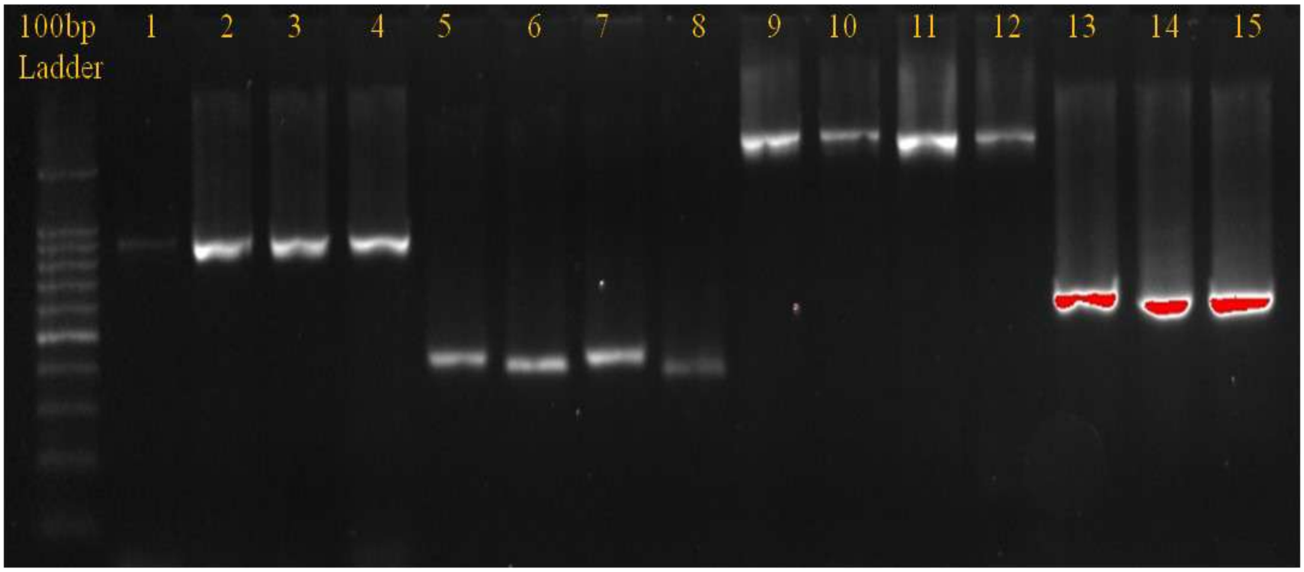


Fig:198. 1-4 well (matK KIM1R/3F):1. *Diplazium nagalandicum,* 2. *Dendrobium fimbriatum,* 3. *D. fimbriatum* var. *occulantum,* 4. *D. khasianum;* 5-8 well (ITS): 5. *Dendrobium fimbriatum,* 6. *D. fimbriatum var. occulantum,* 7. *D. khasianum*, 8. *Diplazium nagalandicum;* 9-12 well (matK 19F/1867R): 9. *Dendrobium fimbriatum* var. *occulantum,* 10. *Diplazium nagalandicum,* 11. *Dendrobium fimbriatum,* 12. *D. khasianum;* 13-15 well (rbcL): 13. *Dendrobium fimbriatum* var. *occulantum,* 14. *D. khasianum*, 15. *Dendrobium fimbriatum.*

Reaction program for ITS and rbcL was set at 94°C for 4min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 40sec, annealing at 55°C - 60°C for 40sec and extension at 72°C for 1min, and finally 7 min for extension at 72°C. The amplicon size was found to be 400bp for ITS region and for rbcL the amplicon size ranges between 500-600bp. Reaction program for matK (19F/1867R and 1R KIM/ 3F KIM) was set at 94°C for 1min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 30sec, annealing temperature 50°C - 57°C for 20sec and extension at 72°C for 50sec and finally 5min for extension at 72°C. The amplicon size ranged between 1.5kb-2kb.

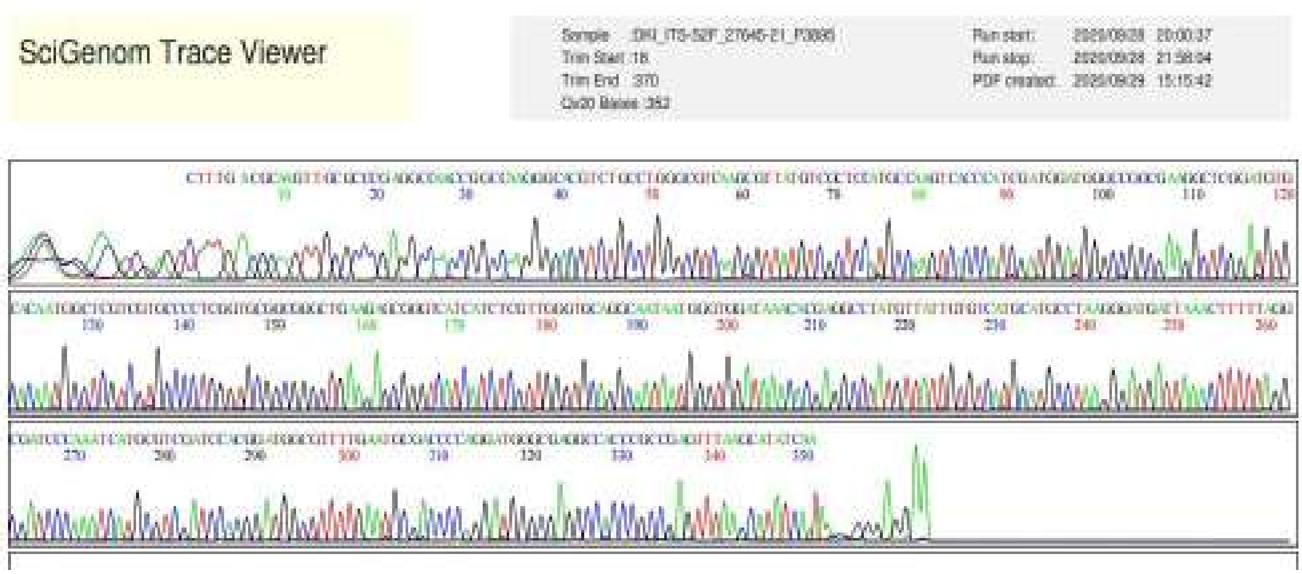


Fig:199. Electropherogram of ITS DNA sequence of *D.khasianum*

Fig:200. Electropherogram of ITS DNA sequence of *D.fimbriatum*

Results:

BLAST analysis Nuclear ITS DNA sequenced for *Dendrobium khasianum* showed uniqueness among other species of *Dendrobium.* BLAST analysis of nuclear ITS DNA sequenced for *Dendrobium fimbriatum* and *Dendrobium fimbriatum* var. *occulatum* confirmed the identity of *Dendrobium fimbriatum* but for the later one showed similarity with *Dendrobium fimbriatum*.

Dendrobium dantaniense **Guillaumin and** ***Dendrobium tuensangense*** **N. Odyuo & C. Deori**

These two orchid species was taken up to study the species complexity among three morphotypes of *Dendrobium dantaniense* at genetic level and to study the phylogenetic relationship between already studied *Dendrobium* spp. and with *Dendrobium tuensangense*, newly discovered species, using sequence specific molecular markers namely rbcL, ITS, matK and trnH-psbA.

Materials and Method:

Sample collection and DNA extraction

Plant sample collected from the garden of BSI, ERC, Shillong. Fresh leaves were used for extraction of DNA using CTAB method and Qiagen DNA extraction kit. Extracted DNA quality and quantity was checked using Spectrophotometer and Gel electrophoresis, respectively.

Optimization of PCR protocol for rbcL, ITS (ITS2-ITS4), matK and trnH-psbA region

Different genomic DNA concentrations (50, 80 and 90ng), $MgCl_2$ concentrations (1, 1.5, 2 and 2.5mM) and Taq DNA polymerase (0.3, 0.5, 0.6 and 0.8U) were tested in multiple combinatorial approach to precisely identify the most preferable PCR optimization conditions along with annealing temperature gradient setting from 55ºC-60 ºC.

All the PCR reactions were performed in 20µl volume containing PCR mixture namely 30-50ng of template DNA, 200µM of each of the four dNTPs, 5X PCR buffer, 1.5mM MgCl2, 0.6U Taq DNA polymerase and 10µmol of respective primer.

Reaction program for rbcL and ITS primer pair, PCR was set at 94°C for 4min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 40sec, annealing at different temperature range for 40 seconds and extension at 72°C for 1min and finally 7min for extension at 72°C.

Reaction program for matK KIM1F/3R primer pair, PCR was set at 94°C for 1min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 30sec, annealing at different temperature range for 20 seconds and extension at 72°C for 50 sec, and finally 5min for extension at 72°C. Reaction program for psbA-trnH primer pair, PCR was set at 94°C for 4mins (initial denaturation) followed by 35 cycles of denaturation at 94°C for 30sec, annealing at different temperature range for 30 seconds and extension at 72°C for 1min and finally 10mins for extension at 72°C.

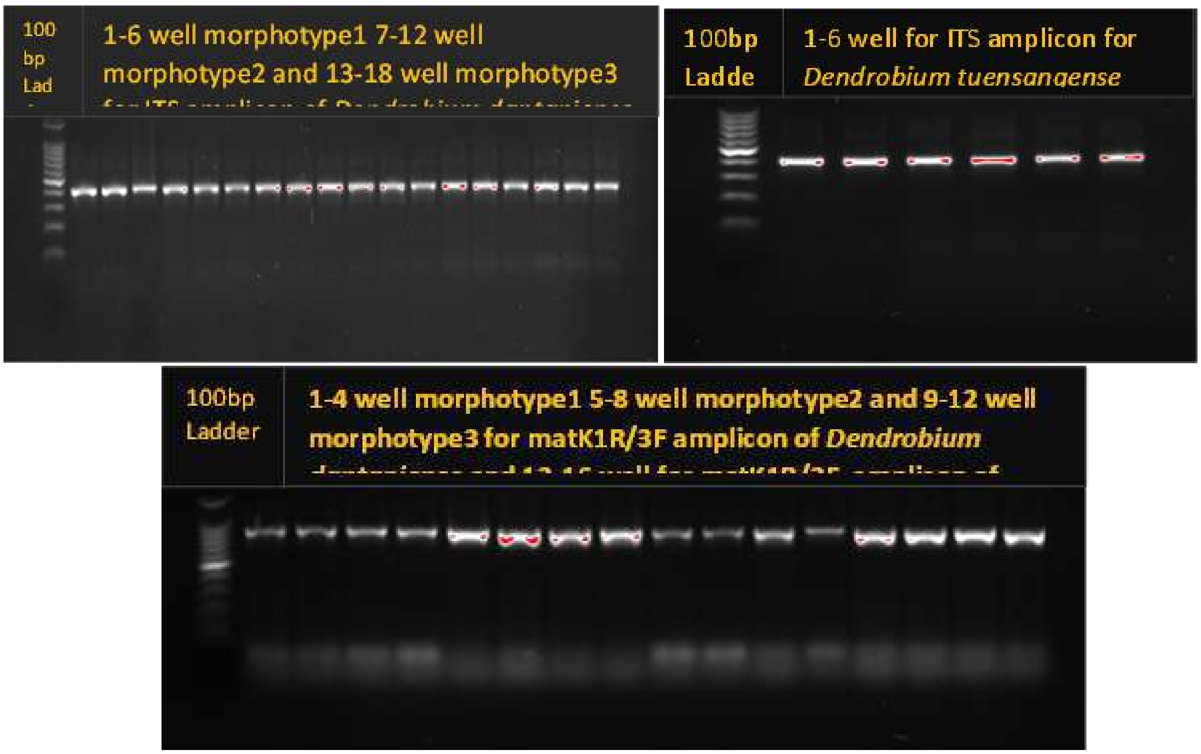


Fig:201. Electropherogram of ITS sequence of *Dendrobium dantaniense* morphotype 1.

Fig:202. Electropherogram of ITS sequence of *Dendrobium dantaniense* morphotype 2.

Fig:203. Electropherogram of ITS sequence of *Dendrobium tuensangense*.

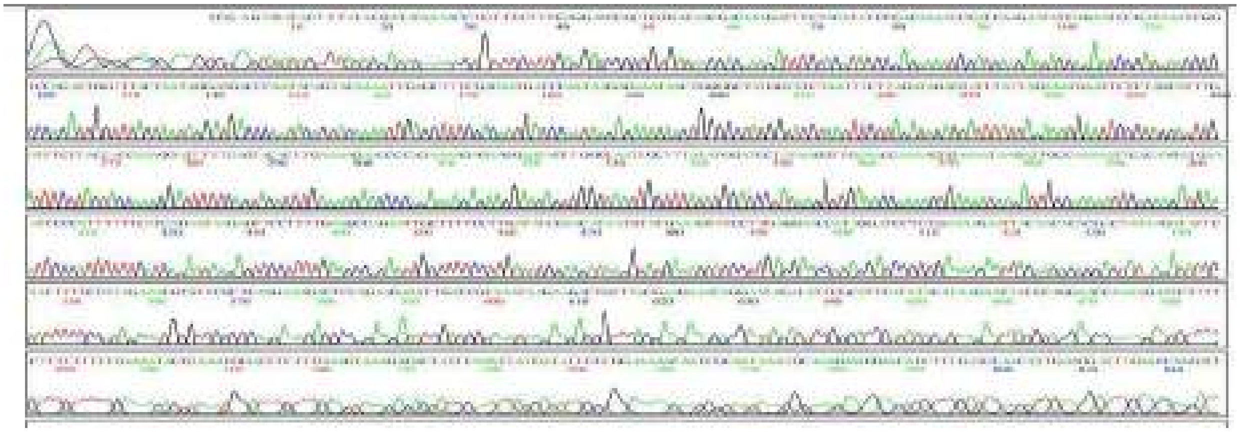


Fig:204. Electropherogram of MatK sequence of *Dendrobium tuensangense*.

Results

- BLAST analysis of nuclear ITS DNA sequence of *Dendrobium dantaniense* morphotype 1 showed species uniqueness among other related species but chloroplast matK DNA sequence confirmed the species for morphotype 1
- BLAST analysis of nuclear ITS DNA sequence of *Dendrobium dantaniense* of morphotype 2 showed species uniqueness among other related species.
- BLAST analysis of nuclear ITS DNA sequence of *Dendrobium tuensangense* showed species uniqueness among other related species.
- BLAST analysis of nuclear matK DNA sequence for *Dendrobium tuensangense* showed species uniqueness among other related species.

***Myrica esculenta* Buch. Ham**

M. esculenta is one of the most economically important fruits in Meghalaya. For analysis of genotypes with higher variability in terms of fruit quality, genetic variability studies using ISSR markers have been taken up.

Sample collection: Plant samples from Mairang, Lad Mawphlang, Jarain, Chyrmang and Laitkynsew have so far been collected. Fresh leaves were used for extraction of DNA using CTAB method. The quality of isolated DNA was checked in 0.8% agarose gel for all the samples extracted and visualized in Gel Documentation System and photographed.

PCR standardisation of ISSR primers (ISSR 1,4,8,10,14,16,17,18 and 19)

PCR cycles and reaction have been standardized for ISSR 1,4,8,10,14,16,17,18 and 19. The reaction was carried out in a 25µl volume containing PCR mixture namely 30-50ng of template DNA, 300µM of each of the four dNTPs, 5X PCR buffer, 200µM $MgCl_2$, 0.05U Taq DNA polymerase and 10µmol of both the forward and reverse primer. The reaction program for PCR was set at 95°C for 5min (initial denaturation) followed by 35 cycles of denaturation at 94°C for 45sec, annealing at temperature gradient ranging from 45°C-55°C for 1min and extension at 72°C for 2min, and finally 7min for extension at 72°C.

Note: Further screening and comparison studies have to be carried out to get a better understanding of the genetic diversity of the species.

Prunus nepaulensis Ser. (Steud)
P. nepaulensis is an economically important fruit tree species of Meghalaya. Study was undertaken to assess the genotypic variability of populations from various localities for identification of populations with higher variation.
Plant sample collection: Leaf samples were collected from BSI, Shillong and Jarain, Meghalaya. DNA extraction from young leaves was carried out using CTAB method.
Note: Field tours need to be carried out for increasing the sample size in the study.

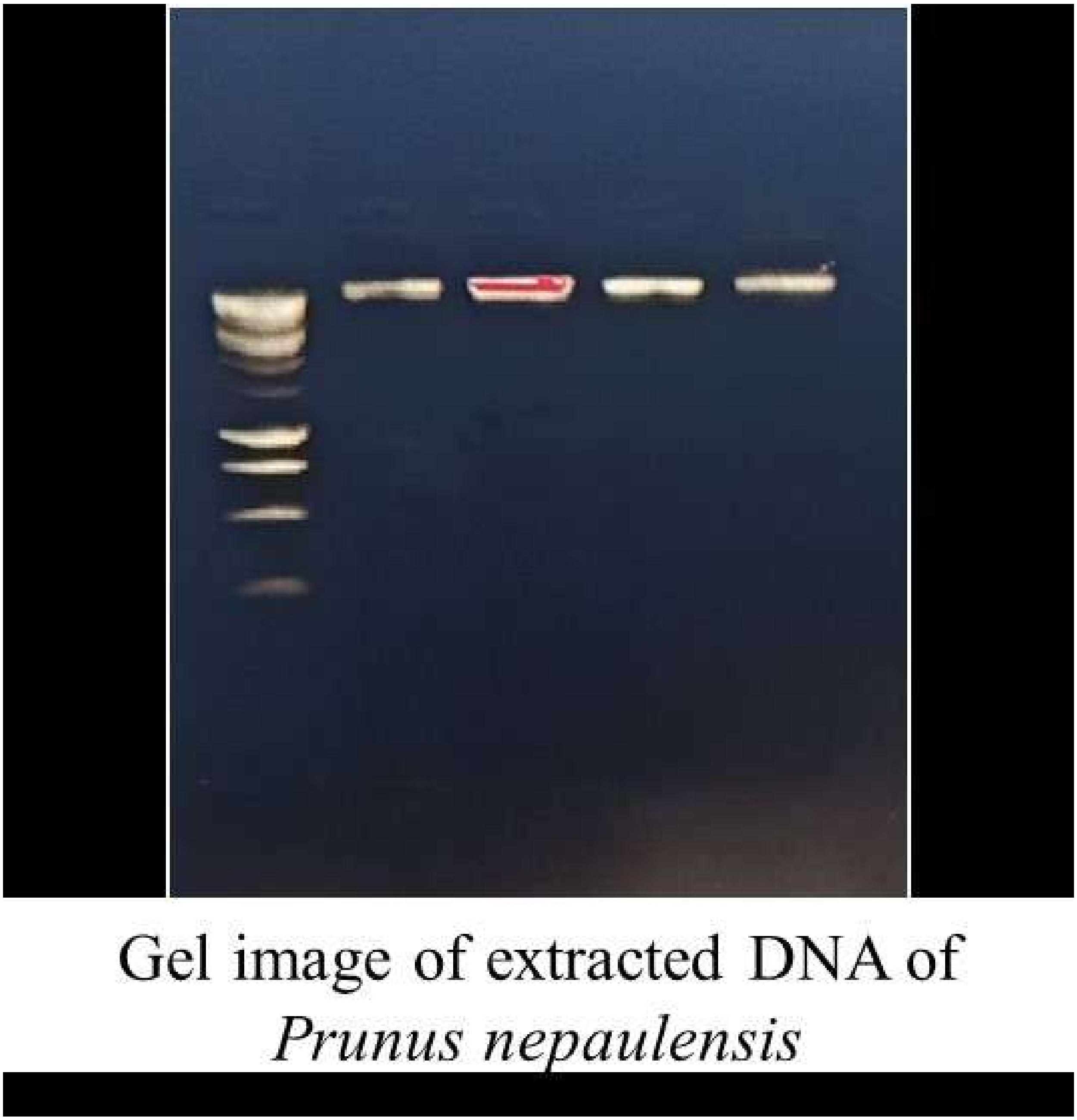


Fig:205. Gel image of extracted genomic DNA of *Prunus nepaulensis*

PUBLICATIONS

BOOK (PUBLISHED)

Dash, S.S., S. Lahiri, A.S. Chauhan 2023. Flora of Kyongnosla Alpine Sanctuary, Sikkim. [Dash, S.S, Mao, A.A. (Eds)]. Botanical Survey of India, Kolkata. pp 1–322. ISBN:978-81-958726-5-7

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2. Lahiri, S., Dash, S.S., Ghosh, A. & Sinha, B.K. 2019. Plant Diversity of Dzongri-Goecha La Region in Sikkim Himalaya**.** *In:* Annual Conference of Indian Association for Angiosperm Taxonomy & National Symposium on Modern Trends in Biosystematics of Angiosperms.11-13th November. Organized by KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute in collaboration with Birbal Sahni Institute of Palaeosciences, Lucknow, UttarPradesh. Pp. 40.
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POPULAR HINDI ARTICLES:

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3. मयंक धर देवेदी. भारत में कुकुर्बिटेसी कुल की विविध्ता - एक अवलोकन.

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1. Sharma, D., Dwivedi M.D., Dash S.S., Chauhan S.K. and Pandey A.K. 2022 Lectotypification of Allium Blandum Wall. (Amaryllidaceae). Rheedea (Accepted for publication)
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Reassessment of threat status of *Allium carolinianum* Redouté (Amaryllidaceae)

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Abstract

The present communication reassessed the threat status of *Allium carolinianum* Redouté (Amaryllidaceae) as its population is continuously declining due to different natural and anthropogenic pressures. Geocat online tool was used for the study of the geographical distribution of the species. The species is known to be distributed from Central Asia to Mongolia, and Trans Himalayan countries including India, which is less than five locations of occurrence all around the world (criteria B2(a), IUCN Red list). Present study revealed the Area of occupancy (AOO) to be 284 Km² and, hence, the threat status of the species has been upgraded to Endangered (EN) category from Vulnerable (VU) (<500 Km², B2 criteria) following IUCN recommendations. Additional measures such as land use land cover changes (LULC) were recorded as the studied land at many places have been converted to the agricultural land destroying the original habitat of the species (Criteria B2(b3)).

Key words: *Allium carolinianum*, Endangered, Himalaya, IUCN, AOO, EOO, GeoCat

INTRODUCTION

The threat reassessment of vascular plants is essential for conservation and maintenance of biodiversity (Mora *et al.* 2011; Trias-Blasi *et al.* 2017). Till date, 61,914 out of the 8.7 million species (<1%) have been evaluated for their conservation status following Red List criteria (Bachman *et al.* 2011). Re-evaluation of the taxa is crucial as it keeps on changing in due course of time.

Trans-Himalaya is one of the most remote and inaccessible regions of the world. Biogeographically, the Indian Trans-Himalayan zone is classified under 1A, 1B, 1C and 1D provinces (Kumar *et al.* 2017). Cold desert Trans-Himalaya of India occupies 98,980 sq Km (Srivastava 2010). It majorly includes Ladakh, Lahaul-Spiti valley and Kinnaur in Himachal Pradesh, Nelang and Mana Niti valley in Uttarakhand. The mesophytic and xerophytic patchy vegetation of this region mainly comprised of the plants with prostrate, thick, woolly, cushion-like, spiny plants with deep penetrating long roots and small and thick leaves (Srivastava & Shukla 2015).

Allium carolinianum Redouté (Amaryllidaceae) is known to be distributed in Central Asia. This species is restricted to the mountains of the cold desert region with an altitude of 3000 – 5000 m amsl (Figure 1). In 2015, the conservation status of this species was assessed as threatened (Srivastava & Shukla 2015). However, it was not assigned any threat status by IUCN (2012) and, therefore, remained under the category "Not evaluated".

Moreover, the local people of Lahaul-Spiti valley and Ladakh harvest *A. carolinianum* for cooking purposes (Singh *et al.* 2007). Its leaves and bulbs are cooked as vegetable or used as a condiment (Murti 2001; Pandey *et al.* 2008; Singh *et al.* 2015; Aziz *et al.* 2020). Due to

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ORIGINAL ARTICLE

Phylogenetic relationships in Indian *Daphne* (*Thymelaeaceae*) based on nuclear ITS and cpDNAdata

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Abstract
Daphne (*Thymelaeaceae*) is a small group of shrubby plants mainly distributed in subtropical and temperate regions of the world with a few species also occurring in alpine habitats. Of *ca.* 95 species in the world, six species and one variety are reported from India. Phylogenetic relationships of the Indian *Daphne* were investigated based on nuclear (ITS) and plastid (*rbc*L and *trn*L-F) regions. A total of 21 sequences representing five taxa of the six species reported from India were newly generated for the present study. The phylogenies using ML and Bayesian analyses obtained from individual and combined datasets were congruent and strongly supported the monophyly of the genus *Daphne*. Combined analyses revealed two major well-supported clades. The systematic relationship of the narrow endemic species, *D. shongensis* was also confirmed as sister to the morphologically similar *D. tangutica*. The study supports the independent species status of *D. retusa* and *D. tangutica*. Ancestral state reconstructions were done using two major features, viz. presence or absence of indumentum on calyx and colour of the calyx occurrence of species. A taxonomic key has also been provided for the Indian taxa. This is the first comprehensive molecular study on the Indian *Daphne*.

Keywords Character evolution · Daphne · ITS · Phylogeny · *Rbc*L · *Trn*L-F

Introduction

The genus *Daphne* L. includes approximately 95 species distributed in Europe, Asia, Australia and N. Africa (Halda 2001; Herbada 2006; Mabberley 2017). The primary centre of origin of the genus *Daphne* is South-West China (Halda 1998). In India, the genus is represented by six species and one variety (Sinha et al. 2019). *Daphne tangutica* Maxim. as enumerated by Sinha et al. (2019) is not supported by any specimen collected from Indian territory and thus, not considered under Indian species in this study. All the species of *Daphne* are distributed in the Himalayas and North Eastern states (Fig. 1). Among these, only *Daphne mucronata* Royle is restricted to the Western Himalaya (Himachal Pradesh, Jammu Kashmir and Ladakh, Uttarakhand) (Smith and Cave 1913; Sinha et al. 2019) whereas *Daphne sureil* W.W.Sm. & Cave has been reported only from the Eastern Himalaya and North East India (Smith and Cave 1913; Ghosh and Mallick 2014; Sinha et al. 2019). *Daphne oleoides* Schreb. was reported from Western Himalayan region of India by Hooker (Fl. Brit. India 5: 193. 1886). However,

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RESEARCH Open Access

In vitro propagation and cytological analysis of *Sophora mollis* Royle: an endangered medicinal shrub

Aakriti Bhandari[1], Harminder Singh[1,2], Amber Srivastava[1], Puneet Kumar[1], G. S. Panwar[1*] and A. A. Mao[3]

Abstract

Background: *Sophora mollis* Royle (family Fabaceae, subfamily-Papilionaceae) is a multipurpose legume distributed in plains and foothills of the North West Himalaya to Nepal and is facing high risk of extinction due to habitat loss and exploitation by the local people for its fuel and fodder values. Therefore, the present study was conducted to standardize a micropropagation protocol for *Sophora mollis* by using shoot tip explants and to study the meiotic chromosome count in the species.

Results: Multiple shoots were induced in shoot tip explants of *Sophora mollis* in Murashige and Skoog medium supplemented with different concentrations of cytokinins alone (BAP, TDZ, and Kinetin) and in combination with varying concentrations of NAA. MS medium supplemented with BAP (8.9 μM) was observed to be the optimal medium for multiple shoot induction and maximum 25.32 shoots per explant was obtained with average length of 4.5 ± 0.8 cm. In vitro developed shoots were transferred onto rooting media supplemented with different concentrations of auxin (IAA, IBA, and NAA). Maximum 86% rooting was observed in half strength MS medium supplemented with 21.20 μM NAA with an average of 21.26 roots per culture. In vitro raised plantlets were adapted to greenhouse for better acclimatization and 60% plants were successfully transferred to the open environment. Based on the chromosome counts available from the literature and the current study, the species tend to show a basic chromosome number of $x = 9$.

Conclusion: The micropropagation protocol standardized can be helpful for the ex situ mass multiplication and germplasm conservation of the endangered species. Moreover, the ex situ conservation approach will be helpful in actively bridging the gap between ex situ and in situ approaches through the reintroduction of species in the wild. The cytological studies revealed the basic chromosome number $x = 9$ of the species.

Keywords: Micropropagation, Shoot tip culture, Plant growth regulators, *Sophora mollis*, Chromosome number

Background

Sophora mollis (Royle) Baker belongs to family Fabaceae (subfamily-Papilionaceae) is a small deciduous perennial shrub with dense hairy twigs and yellow flowers generally blooms in the month of March to May [1]. It is commonly known as peeli sakina, and distributed to semi-exposed to shaded moist slopes of forest edges in the Western Himalaya at an altitude range of 700-1500 m in India (Jammu and Kashmir, Himachal Pradesh, and Uttarakhand), Pakistan, Afghanistan, and China [2]. Due to its continuous exploitation from wild habitats by the local people to fulfill their needs, embark it into endangered category as per its conservation status [3].

Previous studies revealed various pharmacological and therapeutic properties of this genera and extensively being used in traditional Chinese drugs since time immemorial. Genus *Sophora* is a source of more than 300 compounds such as quinolizidine alkaloids (matrine and

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SHORT COMMUNICATION

An enumeration of the flowering plants of Kyongnosla Alpine Sanctuary in eastern Sikkim, India

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Abstract: The present paper is the outcome of an extensive floristic survey conducted in two phases by the authors in Kyongnosla Alpine Sanctuary, East Sikkim, India. During the study 411 taxa (400 species, 04 subspecies and 07 varieties) belonging to 178 genera and 54 families were recorded. The most dominating family was Asteraceae with 44 species followed by Ericaceae 28 species, Ranunculaceae 26 species, Polygonaceae 24 species and Rosaceae 20 species. These five families represent 34.13% of the total taxa recorded from the sanctuary. About 12 families were represented by only one species each. The most dominating genus was *Rhododendron* (18 species) followed by *Primula* (16 species), *Pedicularis* (15 species), *Gentiana* (11 species), and *Impatiens* (10 species). Among the different growth forms, herbs contributed the maximum (86.61 %) followed by shrubs (7.79%), trees (4.87%), climbers 0.49% and epiphyte (0.24%).

Keywords: checklist, eastern Himalaya, floristic survey, growth form, Himalayan forest types.

Comprehensive documentation and identification of plant diversity is one of the targets of Global Strategy for Plant Conservation (GSPC). Being a signatory of the Convention on Plant Diversity (CBD), India is committed towards achieving a complete inventory of plant diversity of all the protected and nonprotected areas (Singh & Dash 2015). India is endowed with diverse ecosystems ranging from high altitude cold deserts to hot and humid coastlands which show rich floral diversity. Continuous survey and exploration in different habitats have facilitated an updated inventory of plants, which opens up different potential linkages among various sectors and implementation of appropriate action on management and sustainable conservation.

Kyongnosla Alpine Sanctuary (KAS) situated in the East district of Sikkim (Figure 1) between 27°22'33"N latitude and 88°44'13"E longitude covers an area of 31 km² between the elevation ranging from 3,000–4,500 m. In the initial notification 45/WL/83/625 dated 29.viii.84, the area demarcated was 4.5 km², however in the second and final notification 45/WL/F/92/1585/F&WL dated 12.v.92 the area of the sanctuary extended to 31 km². The vegetation of the KAS comprises different ecological zones depending upon the elevation, viz., mixed *Rhododendron* temperate forest, coniferous forest along open slopes and ridges and alpine scrubs on upper reaches. Though it encompasses a small area, the sanctuary supports a luxuriant temperate and alpine vegetation owing to its unique topography, variation of altitudes and high annual precipitation. All representative Himalayan forest types (Champion

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Threat Assessment of Two Himalayan Endemic Alpine Plant Species and Conservation Implications

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ABSTRACT

Aconitum novoluridum Munz (Ranunculaceae) and *Bistorta longispicata* Yonek. & H. Ohashi (Polygonaceae), a narrow endemic plant species confined to the Himalayas. The present study assesses the threat status of these species using the criteria of the IUCN Red List of Threatened Species based on the available occurrence records, and both of the species currently categorized as the "Endangered". As the species is simultaneously experiencing various threats and the known distribution range is relatively more narrow, it is the right time to develop conservation strategies for the sustainable utilization of these narrow endemic alpine plant species of the Himalayas.

HIGHLIGHTS

- Three subpopulation of *Aconitum novoluridum* Munz. and two subpopulations of *Bistorta longispicata* Yonek. & H. Ohashi has been recorded.
- Both *A. novoluridum* Munz. and *B. longispicata* Yonek. & H. Ohashi were classified as 'Endangered'.

Keywords: *Aconitum novoluridum*, *Bistorta longispicata*, conservation, Himalaya, Sikkim

Catastrophe is a natural process that has always been essential to the evolution of life. Recent historical period has had a persistently catastrophic impact on biodiversity, both loss of species and the integrity and operation of larger ecosystems (Turvey and Crees, 2019). Furthermore, many species are rapidly going to be extinct because of factors including high population growth, urbanization, habitat loss, changes in microhabitats, climate, and greater reliance of the global population on non-renewable resources (Woodruff, 2001). The rate of species extinction peaked in the second half of the 20th century, nearly unheard of in Earth's history (Frankham, 2003). However, biodiversity has been a vital source of livelihood since the beginning of human civilization because it provides distinct types of ecological services. (Costanza *et al.* 1997). The Indian Himalayan Region (IHR) contains more than 30% of India's total endemic flowering plants (Singh *et al.* 2015). The IHR is under extreme anthropogenic strain while supporting such rich biodiversity because of overexploitation, urbanization, alien species invasion, illegal trafficking in precious and therapeutic plants, deforestation, and construction operations like roads and dams. Due to the severity of the present extinction crisis, a significant amount of effort has been put into determining and monitoring the threat of extinction to the distinct species across the globe. As a result, during the past forty years, lists of threatened species on a global, regional, national, and local level have expanded (Burton, 2003). Finding populations or species that are in decline or are in danger of extinction is the first step in beginning conservation efforts

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Reassessment of threat status of *Allium carolinianum* Redouté (Amaryllidaceae)

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Abstract

The present communication reassessed the threat status of *Allium carolinianum* Redouté (Amaryllidaceae) as its population is continuously declining due to different natural and anthropogenic pressures. Geocat online tool was used for the study of the geographical distribution of the species. The species is known to be distributed from Central Asia to Mongolia, and Trans Himalayan countries including India, which is less than five locations of occurrence all around the world (criteria B2(a), IUCN Red list,). Present study revealed the Area of occupancy (AOO) to be 284 Km^2 and, hence, the threat status of the species has been upgraded to Endangered (EN) category from Vulnerable (VU) (<500 km^2, B2 criteria) following IUCN recommendations. Additional measures such as land use land cover changes (LULC) were recorded as the studied land at many places have been converted to the agricultural land destroying the original habitat of the species (Criteria B2(b3)).

Key words: *Allium carolinianum*, Endangered, Himalaya, IUCN, AOO, EOO, GeoCat

INTRODUCTION

The threat reassessment of vascular plants is essential for conservation and maintenance of biodiversity (Mora *et al.* 2011; Trias-Blasi *et al.* 2017). Till date, 61,914 out of the 8.7 million species (<1%) have been evaluated for their conservation status following Red List criteria (Bachman *et al.* 2011). Re-evaluation of the taxa is crucial as it keeps on changing in due course of time.

Trans-Himalaya is one of the most remote and inaccessible regions of the world. Biogeographically, the Indian Trans-Himalayan zone is classified under 1A, 1B, 1C and 1D provinces (Kumar *et al.* 2017). Cold desert Trans-Himalaya of India occupies 98,980 sq Km (Srivastava 2010). It majorly includes Ladakh, Lahaul-Spiti valley and Kinnaur in Himachal Pradesh, Nelang and Mana Niti valley in Uttarakhand. The mesophytic and xerophytic patchy vegetation of this region mainly comprised of the plants with prostrate, thick, woolly, cushion-like, spiny plants with deep penetrating long roots and small and thick leaves (Srivastava & Shukla 2015).

Allium carolinianum Redouté (Amaryllidaceae) is known to be distributed in Central Asia. This species is restricted to the mountains of the cold desert region with an altitude of 3000 – 5000 m amsl (Figure 1). In 2015, the conservation status of this species was assessed as threatened (Srivastava & Shukla 2015). However, it was not assigned any threat status by IUCN (2012) and, therefore, remained under the category "Not evaluated".

Moreover, the local people of Lahaul-Spiti valley and Ladakh harvest *A. carolinianum* for cooking purposes (Singh *et al.* 2007). Its leaves and bulbs are cooked as vegetable or used as a condiment (Murti 2001; Pandey *et al.* 2008; Singh *et al.* 2015; Aziz *et al.* 2020). Due to

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Reinstatement of *Alysicarpus pokleanus* (Leguminosae, Papilionoideae: Desmodieae) based on ITS sequences of nuclear ribosomal DNA

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In the present communication, we evaluated the taxonomic status of *Alysicarpus pokleanus* Gholami & Pandey using nrDNA ITS sequences. Molecular and morphological diagnosis are provided which suggest reinstatement of *A. pokleanus* from the synonymy of *A. hamosus*.

Keywords: *Alysicarpus*, nrDNA, synonymy

Introduction

Alysicarpus Necker ex Desvaux (1813: 120) belongs to tribe Desmodieae of the subfamily Papilionoideae, family Leguminosae. It comprises of about 35 species and nearly 20 infraspecific taxa distributed in Africa, Asia, Australia, Polynesia and tropical America. In India, the genus is represented by 18 species and nine infraspecific taxa (Pokle 2017; Gholami *et al.* 2020).

Alysicarpus pokleanus A. Gholami & A.K. Pandey (2016: 119) was first collected from Sinhgarh, Maharashtra and described as a new species endemic to Maharashtra. Tiwari (2020) synonymized this species under *A. hamosus* based on some overlapping morphological characters and on the assumption that the absence of pods from the type specimen of *A. hamosus* are due to easily separable pods from the joints. As the genus *Alysicarpus* is known to exhibit high morphological plasticity (Sanjappa 1992; Pokle 2002, 2017; Gholami *et al.* 2017, 2020), in the present communication we evaluated the morphological variations in the species to understand if the variation is also present at molecular level.

Material and methods

We obtained 41 ITS sequences of *Alysicarpus* spp. including three outgroups. The leaf sample for *A. pokleanus* was taken from the type specimen deposited in Delhi University Herbarium (DUH) and the remaining sequences (including outgroups) were retrieved from our earlier publication (Gholami *et al.* 2017) and sequences submitted by others.

Genomic DNA extraction, PCR amplification, Sanger sequencing, sequence editing, multiple sequence alignment and ML tree building follows after Gholami *et al.* (2017), and Kasana *et al.* (2020).

Results

In the present study, a total of 41 sequences with 607 characters were analyzed. The alignment of ITS region consists of 186 distinct patterns, 143 parsimony-informative, 51 singleton sites and 413 constant sites. The Best Fit Model chosen according to the Bayesian Information Criterion (BIC) was TN+F+G4 as evaluated in jModeltest (Posada 2008). The rate parameters were A-C: 1.00000; A-G: 2.09676; A-T: 1.00000; C-G: 1.00000; C-T: 4.20398; and G-T: 1.00000. The base frequencies were A: 0.189; C: 0.303; G: 0.308; and T: 0.200.

The tree topology (ML tree) was similar to previous study by Gholami *et al.* (2017). The genus is recovered monophyletic and supports the previous findings of Gholami *et al.* (2017, 2020). The molecular analysis using ITS sequences of *Alysicarpus* species revealed that the two accessions of *A. pokleanus* group together as a sister clade to *A. hamosus* (Fig. 1). There is a robust difference between *A. pokleanus* and *A. hamosus* which suggests that *A. pokleanus* is a distinct species. The analysis of morphological and molecular characters confirms reinstatement of *A. pokleanus* from the synonymy of *A. hamosus*.

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An updated circumscription of *Saussurea* (Cardueae, Asteraceae) and allied genera based on morphological and molecular data

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Abstract

The temperate Asteraceae genus *Saussurea* displays much morphological variation. Recent and previous taxonomic revisions have led to redefinition and later lumping of several additional genera. This study made use of morphological and molecular data to answer questions related to smaller split genera from *Saussurea*. The result indicates that the genus *Lipschitziella*, split from *Saussurea*, is monophyletic after the inclusion of *Himalaiella*. Another closely allied genus *Dolomiaea* is also recovered monophyletic after the inclusion of *Saussurea costus* and *Frolovia frolowii*. Nine possible new combinations are established.

Keywords: Cardueae, *Dolomiaea*, *Himalaiella*, *Lipschitziella*, New combinations, nrDNA ITS

Introduction

The genus *Saussurea* Candolle (1810: 135) includes ca. 493 species (Raab-Straube 2017) with a geographic range that encompasses temperate areas of Asia, Europe, America and Australia (Lipschitz 1979, Dickoré 2001, Barres 2013, Chen 2015). The center of origin for this genus is in Central and Eastern Asia, which is also the center of species diversity as most of the species occur in that region (Dickoré 2001, Butola & Samant 2011, Gailite & Rungis 2012). In India, the genus is represented by ca. 62 species commonly found in the Himalayan regions of Arunachal Pradesh, Assam, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Nagaland, Sikkim and Uttarakhand (Hajra 1988, Butola & Samant 2011). Members of genus *Saussurea* are perennial herbs, found in stony places, open slopes, forest clearings or waste land and occur at high elevations up to 6000m. The genus is characterized by unarmed leaf margins, entire to pinnately divided leaves, which are usually lanuginose, dimorphic pappus bristles, recurved apex of phyllaries, linear style branches and basally connate pappus (Bremer 1994, Häffner 2000, Shi & Raab-Straube 2011).

The genus *Saussurea* has been split variously based on morphological and molecular data but still the monophyly of various infrageneric groups could not be ascertained due to unclear generic boundaries between *Saussurea*, *Jurinea* Cassini (1821: 140), *Dolomiaea* Candolle (1833: 330) and other related members of the subtribe Carduinae (Figure 1). Various genera are recognized in the *Saussurea* group based on morphological characters and standard barcode markers like *Hemistepta* Fischer & Meyer (1836: 38), *Polytaxis* Bunge (1844: 156), *Jurinea*, *Himalaiella* Raab-Straube (2003: 390), *Lipschitziella* Kamelin (1993: 632), *Dolomiaea* and *Frolovia* (Candolle) Lipschitz (1954: 461). There are two extremes of classification for the *Saussurea* group, either four genera as recognized by Susanna & Garcia-Jacas (2007, 2009) or 15 genera as recognized by Shi & Raab-Straube (2011). Some of the genera in this group are extremely species rich (e.g., *Jurinea* and *Saussurea*) whereas others have fewer species (e.g., *Dolomiaea*, *Frolovia*, *Himalaiella*). Even though many molecular studies have been performed to analyze the systematic position of members of the *Saussurea* group, the clear generic boundaries could not be ascertained due to selection of only a few members of the group in the analysis.

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A Brief Analysis of IUCN Red listed threatened Plants of India

The newest assessment of Indian plant richness stands at 54733 taxa which include 21849 angiosperms, 15504 fungi, 8979 algae, 2791 bryophytes, 2961 lichens, 1257 microbes, 1310 pteridophytes and 82 gymnosperms. Of these, the IUCN Red List for Indian plants includes 416 angiosperms, 12 gymnosperms, 2 pteridophytes, 7 bryophytes and 1 fungal species under various threat categories. In current communication, the authors discuss various IUCN threat categories and analyse in brief the Red listed threatened plants of India.

Key words: Biodiversity, Hotspots, Endemic, Endangered

India is one of the biodiverse countries with 54733 plant species. Out of which 438 has been categorised into different threat categories of the IUCN.

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Introduction

In a time when anthropogenic activities, global climate changes, habitat destruction and species loss are on rise at an alarming rate, conservation policies play pivotal role towards curtailing biodiversity loss (Marchese, 2015). The idea of biodiversity or biological diversity has been known to mankind ever since he started to observe carefully the living things in its surroundings. The term biodiversity became a popular term to general public only after the United Nations Conference on the Environment and Development (UNCED), also recognized as the 'Earth Summit' organized at Rio de Janeiro, Brazil, 3-14 June 1992. The Conference brought biodiversity to the forefront, and since then immense stress laid to save our earth planet and its biological diversity. Subsequently, many research organizations have adopted biodiversity as their central focus and countless agreements, strategies had been made to save the biodiversity. Thus, there is tremendous interest among scientists, policy makers, and general community in understanding the causes of loss of biodiversity. The main reason that stands behind the conservation is fear of graveyard consequences of biodiversity loss that can ultimately result into loss of benefits from nature, such as clean water and air, food and fiber and many other vital things (Reid *et al.*, 2005). In this communication, the authors analyse in brief the threatened plants of India.

Red Listing at Global Level

A threatened species is determined on the basis of the amount of risk of extinction which it faces within a part or the whole of its geographic range. However, the concept of endangered species is a human idea and often subjected to debate and varied interpretation. Many organizations practice variable criteria for listing a species as endangered. The most familiar and widely accepted organization is the International Union for Conservation of Nature and Natural Resources (IUCN). This organization included members from both government and civil society organisations. It offers scientific knowledge and tools which are immensely helpful in conservation of biodiversity along with sustainable development. IUCN has developed an assessment system that prepares global Red List of threatened species. Now it is over more than five decades it has been continuously helping in nature conservation. The IUCN maintains the

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Diversity of *Rhododendron* L. (Ericaceae) in the Dzongri Goecha La trekking trail of Khangchendzonga Biosphere Reserve, Sikkim, India

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Abstract

Seventeen species of *Rhododendron* L. (Ericaceae) were recorded from Dzongri Gocha La region of Kanchendzonga Biosphere Reserve a UNESCO world heritage site. A brief description, information on phenology and altitudinal distribution of each of these species has been provided here along with a key for easy identification.

Key words: *Rhododendron*, Dzongri Gocha La, Kanchendzonga Biosphere Reserve, Diversity

INTRODUCTION

The genus *Rhododendron* L. (Ericaceae) is represented by about 132 taxa in India and distributed in mostly sub-tropical to alpine regions of Himalaya with few speceis in Western Ghats (Mao *et al.* 2017). It is the largest genus of the family Ericaceae as well as among one of the largest flowering plant genera in Asia (Cullen & Chamberlain 1978). Most *Rhododendrons* are found in fragile habitat of eastern Himalaya. In Sikkim, *Rhododendron* speceis distributed in higher altitudes preferable within protected areas. Members of this genus play a considerable role in maintaining ecological stability in higher ecosystems and known for their phenological sensitivity. Therefore, a good number of *Rhododendron* species have been recognized as indicators species of forest health as well as for climatic change (Chettri *et al.* 2018). *Rhododendron* species also act as a keystone species in the fragile ecosystem of Himalayas since they provide niche for several plant and animal speceis (Menon *et al.* 2012). J.D Hooker's was reported the occurrence of *Rhododendrons* rom Sikkim during his visit on 1849 and he described 34 new species of *Rhododendrons* from the Sikkim Himalaya in his monograph '*The Rhododendrons of Sikkim-Himalaya*'.He described 34 new species of Rhododendrons from the Sikkim Himalaya in his monograph '*The Rhododendrons of Sikkim-Himalaya*'. Subsequent publications (Clarke 1882; Pradhan & Lachunga 1990; Long & Rae 1991; Mao *et al.* 2001, 2027; Badola & Pradhan 2010; Mao 2010, 2018; Pradhan 2010; Chettri *et al.* 2018; Pandey & Badola 2018) reveal a comprehensive account on *Rhododendrons* of Sikkim Himalaya. Altogether 46 taxa of *Rhododendrons* have been reported from Sikkim state (Mao *et al.* 2017).

Besides aesthetic and sacredness, the members of *Rhododendron* have ethnomedicinal, commercial and social importance in Sikkim. Due to heavy anthropogenic disturbance, deforestation, over-exploitation and unscientific expansion of agricultural fields, roads the natural habit of *Rhododendrons* are dwindling; as a result, many species have become vulnerable and threatened. Therefore, record of different species of *Rhododendrons* and understanding of their habitat, associated species in remote area like Dzongri-Goecha La region is need of the hour. Unless exact distributions of different species of *Rhododendrons*

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Lectotypification of the name *Allium prattii* (Amaryllidaceae)

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Abstract: The name *Allium prattii* C.H.Wright (Amaryllidaceae) is lectotypified here.

Keywords: *Allium*, Himalaya, isolectotype, lectotype, syntype.

Introduction

The genus *Allium* L. (Amaryllidaceae), comprising about 987 species, is one of the largest genera in monocotyledonous angiosperms distributed in the northern hemisphere (POWO, 2020). In India, over 36 species of *Allium* are reported (Karthikeyan *et al.*, 1989), of which 32 occur in the Himalaya (Sinha *et al.*, 2019). During the floristic study of the Sikkim Himalaya, *Allium prattii* C.H.Wright was collected from Dzongri area of West Sikkim. A detailed survey of the literature (Wright, 1903; Stearn, 1994; Dasgupta, 2006) revealed that a proper type was not designated for the name. After studying the type specimens at BM, CAL, G, K, MPU and P (Thiers, continuously updated) and comparison with the protologue, the lectotype is selected in accordance with the provisions in Art. 9.3 of the ICN (Turland *et al.*, 2018).

Typification

Allium prattii C.H.Wright, J. Linn. Soc., Bot. 36 (250): 124. 1903.

Lectotype (designated here): CHINA, **West Szechuen (Sichuan)** and Tibetan Frontier, chiefly near Tachienlu at 9,000–13,500 ft., *Pratt* 576 (K [K000464580 digital image!]); isolecto (BM [BM000958327 digital image!]; CAL [CAL0000001088!]). **Fig. 1**

Residual syntypes: CHINA, **Thibet (Tibet) Oriental,** Tongolo (principality of Kiala), 1893,

Fig. 1. Lectotype of *Allium prattii* C.H.Wright (*A.E. Pratt* 576, K000464580 http://specimens.kew.org/herbarium/K000464580.) © The Board of Trustees of Royal Botanical Gardens, Kew. Reproduced with permission.

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Notes on rediscovery, typification and threat assessment of *Veratrilla burkilliana* (Gentianaceae) from Eastern Himalaya, India

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भारत में पूर्वी हिमालय से ज्ञात *वेराट्रिल्ला बुर्किलियाना* (जेंशिएनेसी) के पुनःअन्वेषण, प्ररूपण एवं इसके संभावित संकट के निर्धारण पर लेख

सुभाजित लाहिड़ी, सुधांसु शेखर दास

सारांश

वेराट्रिल्ला बुर्किलियाना (डब्लू. डब्लू. स्मि.) (जेंशिएनेसी) जो अभी तक अपने मूलस्थान से ही ज्ञात है, इसे कम से कम 108 वर्षों के अंतराल के बाद पुनः अन्वेषित किया गया है। इसकी संख्या एवं संरक्षण अवस्था, संवितरण परिसर एवं नाम *स्वेर्शिया बुर्किलियाना* का प्ररूपण सहित संवितरण मानचित्र जहाँ इसके संभावित संकट अवस्था को संकटग्रस्त रूप में निर्धारित किया गया है, ये सभी चीजें प्रदान कि गई हैं। इसके सुगम पहचान हेतु इस जाति के छायाचित्र के साथ-साथ इसके पुष्पीय भागों के विच्छेदन के भी छायाचित्र प्रदान किए गए हैं। इसका पुनःअन्वेषण इस बात के महत्व को दर्शाता है कि क्योंगनोस्ला अल्पाइन अभयारण्य एवं पूर्वी सिक्किम स्थित इसके आस-पास के क्षेत्र जो त्रुटिपूर्ण रूप से प्रतिदर्शित हैं एवं उच्च जैवविविधता वाले क्षेत्र हैं, अभी भी वहाँ और भी फिल्डवर्क किया जाना है साथ ही यह पूर्वी हिमालयी फ्लोरा के उच्च संकटग्रस्त जातियों के तात्कालिक संरक्षण की आवश्यकता पर भी जोर डालता है।

Abstract

Veratrilla burkilliana (W.W. Sm.) Harry Sm. (Gentianaceae), hitherto known only from type locality has been rediscovered after at least a lapse of 108 years. Comments on its population and conservation status, distribution range and typification of the name *Swertia burkilliana* are provided, together with a distribution map where the threat status has been assessed as 'Endangered'. Field photographs of the species with dissected flowering parts are also been provided for its easy identification. This rediscovery highlights the importance of farther fieldwork in poorly sampled and highly biodiverse regions of Kyongnosla Alpine Sanctuary and its neighbouring areas of East Sikkim, as well as emphasizes the urgent need for conservation of the highly threatened eastern Himalayan flora.

Keywords: Lectotypification, rediscovery, Sikkim, threat assessment, *Veratrilla burkilliana*

INTRODUCTION

As a part of our plant exploration work in the project "Conservation of threatened plants in Indian Himalayan region: recovery and capacity building" under "National Mission on Himalayan studies" in Kyongnosla Alpine Sanctuary, East Sikkim, recently we came across seven gregarious patches of an interesting plant at an altitude of 3700–3865 m asl. On critical scrutiny of the collected specimens with literature (Smith, 1911; Smith, 1970; Aitken, 1999; Clarke, 1883; Ho & Pringle, 1995; Maity & al., 2018;

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COMMUNITY STRUCTURE AND REGENERATION STATUS OF TREE SPECIES IN KYONGNOSLA ALPINE SANCTUARY, EASTERN HIMALAYA, INDIA

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COMMUNITY STRUCTURE AND REGENERATION STATUS OF TREE SPECIES IN KYONGNOSLA ALPINE SANCTUARY, EASTERN HIMALAYA, INDIA. Habitat destruction, over exploitation, monoculture are major reasons for loss of primary forests in Himalaya. Tree population, composition and diversity particularly in the temperate Himalaya play a key role in the maintenance of many ecosystem services and natural biogeochemical cycles. The present study explores composition and regeneration status of tree species in a temperate mixed forest in Kyongnosla Alpine Sanctuary, East Sikkim, India. Two sites at an elevation range of 2800–3800 m were selected and 20 plots of 20 m × 20 m for trees, 80 plots of 5 m × 5 m for saplings, and 160 plots of 1 m × 1 m for seedlings were sampled to study the regeneration status. A total of 17 tree species belonging to 9 genera and 8 families were recorded of which Rhododendron was the most dominant genus with maximum number of species. All the phytosociological attributes, such as relative density, abundance and important value index were calculated. The average species richness of adult trees and saplings was 13.5± 0.7 and for seedlings it was 12.5 ± 0.07. The mean density of seedlings was 3609.77 ± 494.39 individuals/ ha, for saplings 1540 ± 113.13 individuals/ha and of mature trees 548.75 ± 8.83 individuals/ha. Total basal area cover ranged from 36.61 to 40.35 m^2/ha for trees, from 1.54 to 1.71 m^2/ha for saplings. Fair regeneration was observed in 64.72% of total species; good regeneration observed in 17.64% species, 11.76% species exhibited poor regeneration while 5.88% showed no regeneration. Density-diameter distribution exhibited decrease in tree densities towards higher DBH classes. The study not only provides reliable information on the ecosystem's health of the sanctuary but also will help in understanding the complexity of the ecosystem function and an approach to conservation of biota.

Keywords: Eastern Himalaya, India, *Rhododendron*, species richness, temperate mixed forest, tree diversity

STRUKTUR KOMUNITAS DAN STATUS REGENERASI SPESIES POHON DI KYONGNOSLA ALPINE SANCTUARY, HIMALAYA TIMUR, INDIA. Kerusakan habitat, eksploitasi berlebihan, tanaman monokultur adalah penyebab utama hilangnya hutan primer di Himalaya. Populasi, komposisi dan keanekaragaman pohon khususnya di Himalaya yang beriklim sedang memainkan peran kunci dalam pemeliharaan jasa ekosistem dan siklus biogeokimia alami. Penelitian ini mengeksplorasi komposisi dan status regenerasi spesies pohon di hutan campuran beriklim sedang di Kyongnosla Alpine Sanctuary, Sikkim Timur, India. Dua lokasi pada ketinggian 2800–3800 m dipilih dan 20 plot berukuran 20 m × 20 m untuk pohon, 80 plot berukuran 5 m × 5 m untuk pancang, dan 160 plot berukuran 1 m × 1 m untuk bibit diambil sampelnya untuk dipelajari status regenerasinya. Sebanyak 17 jenis pohon dan 9 genus dan 8 famili Rhododendron tercatat sebagai genus yang paling dominan dengan jumlah spesies paling banyak. Semua atribut fitososiologi, seperti kerapatan relatif, kelimpahan dan indeks nilai penting dihitung. Rata-rata keragaman jenis pohon dewasa dan anakan adalah 13,5± 0,7 dan untuk semai adalah 12,5 ± 0,07. Rerata kerapatan semai adalah 3609,77 ± 494,39 individu/ha, untuk pancang 1540 ± 113,13 individu/ha dan pohon dewasa 548,75 ± 8,83 individu/ha. Luas dasar total tutupan pohon berkisar antara 36,61 hingga 40,35 m²/ha, dari 1,54 hingga 1,71 m²/ha untuk pancang. Regenerasi yang cukup diamati pada 64,72% dari total spesies; regenerasi yang baik diamati pada 17,64% spesies, 11,76% spesies menunjukkan regenerasi yang buruk, sedangkan 5,88% tidak menunjukkan regenerasi. Distribusi kerapatan-diameter menunjukkan penurunan kerapatan pohon menuju kelas DBH yang lebih tinggi. Kajian ini tidak hanya memberikan informasi yang dapat dipercaya tentang kesehatan ekosistem suaka alam tetapi juga membantu dalam memahami kompleksitas fungsi ekosistem dan pendekatan konservasi biota.

Kata kunci: Himalaya Timur, India, Rhododendron, keragaman spesies, hutan campuran beriklim sedang, keanekaragaman pohon

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An ethnobotanical survey of useful wild plants in Dzongri-Goecha La, Sikkim, India

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भारत के सिक्किम में स्थित ज़ोंगरी-गोचै ला में उपयोगी जंगली पौधों का एक लोक वानस्पतिक सर्वेक्षण

सुभाजीत लाहिड़ी एवं सुधांशु शेखर दाश

सारांश

यह लेख सिक्किम हिमालय के ग्रामीण समुदायों के बीच 32 प्रमुख बीमारियों के इलाज के लिए 32 परिवारों से संबंधित 78 पौधों की प्रजातियों के 62 विभिन्न उपयोगों की समीक्षा से संबंधित है। सिक्किम हिमालय के ज़ोंगरी-गोचै ला क्षेत्र में पौधों की खोज के दौरान, पौधों के साथ जुड़े विभिन्न पारंपरिक उपयोगों को सूचनादाता और प्रकाशित तथ्य की मदद से एकत्र किया गया था। पारंपरिक उपयोग स्वरूप, उपयोग किए जाने वाले भाग, तैयारी की प्रक्रिया और खुराक की समीक्षा की गई और प्रलेखित किया गया है।

ABSTRACT

The paper deals with a review of 62 different uses of 70 plant species belonging to 32 families for the treatment of 32 major ailments among rural communities of Sikkim Himalaya. During the different exploration of plants in Dzongri-Goche La region of Sikkim Himalaya, the different traditional uses association with the plants were collected from selected informants and also from published literatures. The traditional uses pattern, parts used for, mode of preparation and administration of doses were reviewed and documented.

Keywords: Kanchenjunga Biosphere Reserve, Limboo, Medicinal plants, Traditional knowledge, West Sikkim

INTRODUCTION

It is critical to document the plants and their ethnobiological values to evaluate human plant relationships and understand regional human ecology relationships to their environment. Ethnomedicine is a traditional healthcare system that has been passed by words of mouth for curing of from generation to generation for curing various ailments. It is strongly linked to indigenous peoples' religious beliefs and practises (Dash & Misra, 1997; Bussmann, 2006). The culture of traditional healing of diseases using wild plants is still prevalent among aboriginal mountain communities in the Himalayas. A variety of medicinal plants with both high commercial value and use in ayurvedic or unani systems are abundant in Himalaya. Vedic literature viz. Charaka (Charak-Samhita, 100-500 AD) and Shushruta (Shushrut-Samhita, 200-500AD) represent the early phase of herbal science in India. It is a quite evident that Ayurveda, the ancient science of medicine, has its origin in India (Chauhan, 1999). While Sikkim is a densely forested region with various ethnic communities residing there, including Lepcha, Bhutia, Sherpa, Rai, Limboo, Nepali, etc., in remote and fringes areas have a good inherited rich traditional knowledge of wild plants and they are dependent on these natural resources for their uses as food, shelter, medicines, fodder, insecticides, etc. Traditional herbal healers in Sikkim are known as Lamas (monastery heads) or Jakris by the locals, and traditional use of plants is part of Sikkim's cultural heritage (Dash, 2009).

However, the traditional understanding of wild plants is rapidly lost due to the rapid urbanization. To know and document the traditional knowledge of the region, several ethnobotanical studies was carried out in Sikkim since last century. The substantial number of surveys on ethnomedicinal plants indicates that they are

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Lectotypification of three names in *Lonicera* (Caprifoliaceae) from India

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भारत से लोनीसेरा (कैप्रीफोलिएसी) में तीन नामों का लेक्टोटिपिफिकेशन

सुभाजीत लाहिड़ी, मोनालीसा दास एवं सुधांशु शेखर दास

सारांश

[illegible]

ABSTRACT

The lectotype for three names viz., *Lonicera angustifolia* Wall. ex DC., *Lonicera myrtillus* Hook.f. & Thomson and *Lonicera tomentella* Hook.f. & Thomson are designated in the current communication.

Keywords: Holotype, Kumaon, Isotype, Sikkim, syntype, *Lonicera*

INTRODUCTION

The genus *Lonicera* L. (1753: 173) (Caprifoliaceae) comprises 180 species mainly distributed throughout the temperate and subtropical regions of the world. Several species extend their distribution in the tropical regions of India, Malaysia, and the Philippines (Mabberley, 2018). In India, 26 taxa of *Lonicera* have been reported mainly from tropical to temperate regions (Gangopadhyay & al., 2020). During the field work of project entitled "Conservation of Threatened Plants in Indian Himalayan Region: Recovery and Capacity Building" we have collected some specimens of *Lonicera* from Sikkim Himalaya. In course of identification, a detailed study of the literatures (Rehder, 1903; Acharya, 2016) revealed that, the names *Lonicera angustifolia*, *L. myrtillus* and *L. tomentella* were not finally typified. Consequently, all the specimens cited in the protologue are syntypes (Art. 9.6, Shenzhen Code, Turland & al. 2018). Therefore, the terms 'holotype' and 'isotypes' used by Acharya, 2016 in his unpublished thesis (available at http://hdl.handle.net/10603/204517 is misapplied and neither can be treated as inadvertent typification nor to be corrected; eventually do not stand on any ground according to the rules of ICN (Turland & al. 2018, vide Art. 7.10). Authentic specimens, especially types deposited in national herbaria and online databases of various international herbaria (digital resources) were thoroughly checked and authentic specimens associated with Nathaniel Wallich deposited at K, A, AWH, B, BM, BR, C, G, G-DC, L, LE, LINN, whereas specimens of J.D. Hooker deposited at BM, E, GH, K, L, P were screened online and in person at BSHC and CAL (Thiers, 2022 continuously updated); online data bases such as Global Plants JSTOR (https://plants.jstor.org), GBIF (https://www.gbif.org/) also checked and thereafter the lectotypes for the aforesaid three names have been proposed here for unambiguous use in accordance with the provisions in Art. 9.3 of the International Code of Nomenclature for Algae, Fungi and Plants (Turland & al. 2018).

TYPIFICATION OF NAMES

Lonicera angustifolia Wall. ex DC., Prodr. 4: 337. 1830.

Lectotype (designated here): INDIA, Kumaon, R. *Blinkworth*,480, (K [K001111113, digital image!]). (Fig 1). *isolectotype*: E [E00265291, digital image!].

Candolle (1830) validated the name *L. angustifolia* Wall. (*nom. nud.*) based on the gathering Wallich Cat. No. 480 and cited specimens as "in Kamaon Nepaliae

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An annotated checklist to the alpine and sub alpine flowering plant diversity of Dzongri-Goecha La area, West Sikkim, India

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भारत में पश्चिम सिक्किम के जोंगरी-गोएचा ला अल्पाइन तथा सब-अल्पाइन क्षेत्र के पुष्पीय पादप विविधता संबंधी एक विस्तृत चेकलिस्ट

सुभजित लाहिड़ी, सुधांशु शेखर दाश एवं असोक घोष

सारांश

पश्चिम सिक्किम के जोंगरी-गोएचा ला क्षेत्र से कुल 254 पादप जातियों को संग्रहित किया गया है जो 151 वंशों तथा 47 कुलों से संबंधित हैं। अध्ययन क्षेत्र से संग्रहित कुल जातियों के 52.75% में प्रथम दस कुलों की बहुलता है तथा 37.74 % में प्रथम दस वंशों की बहुलता है। अध्ययन के दौरान इस क्षेत्र के लिए 22 नए टैक्सा प्राप्त किए गए हैं।

ABSTRACT

A total of 254 plant species belonging to 151 genera and 47 families were collected from alpine and subalpine regions of Dzongri Goecha La area. Of the total species collected, the first ten dominating family contributed more than 52.75% while the first ten dominating genera contributed 37.74 % of total genera of the studied area. 22 taxa have been reported new to region during the study.

Keywords: Alpine plants, Biosphere Reserve, Checklist, Flora, Khangchendzonga, Vascular plants

INTRODUCTION

One of the prerequisites for biodiversity assessments and strategy for plant conservation is to the document the plant diversity of a region. The Himalaya has a remarkable range of biodiversity in its diverse habitats and ecosystems. The distribution of plant species in fragile alpine ecosystems is dynamic and need to be recorded at different intervals to understand the pattern and potential migration of plant species to different habitats. Keeping in this in mind, this study has been carried out in the alpine and subalpine region of Dzongri-Goecha La of West Sikkim to document the plants occurring on the region. Exploration was done between July 2016 to September 2020 for collection of plant specimens along different altitudinal gradient towards the partial fulfilment of the objective of the project entitled "*Biodiversity Assessment through Long-term Monitoring Plots in Indian Himalayan Landscape*" under National Mission of Himalayan Studies.

The Dzongri-Goecha La area is well-known for its pristine natural landscapes and mesmeric meadows of alpine flowers. This is also one of the highest fragile ecosystems listed under UNESCO World Heritage Site *i.e.*, Khangchendzonga Biosphere Reserve (KBR). The vegetation of the area comprises of subalpine *Rhododendron* Forest, alpine scrubs and meadows. Though includes a smaller area, but due to high variations in elevation from 3000–4800 m asl. plant diversity of the area is remarkably high and unique. Recent study shows that, the biodiversity of this region under threat due to various factors such as heavy grazing, over exploitation of plant resources and high influx of tourist etc.

MATERIAL AND METHODS

The Dzongri Goecha La trekking starts from Yuksom, situated at an elevation of 1760 m asl. and ends at Goecha La at 5000 m asl. The trekking route considered as one

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Revisiting the typification of three names in the family Gentianaceae

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Abstract

Designated types of three pre-1958 validly published names in the family Gentianaceae are reassessed and lectotypes are designated for the names viz.: *Gentiana micans* C.B.Clarke, *Gentiana phyllocalyx* C.B.Clarke, and *Swertia hookeri* C.B.Clarke.

Keywords: *Gentiana*, *Swertia*, India, Nomenclature, Typification

Introduction

The family Gentianaceae is represented by 20 genera and nearly 170 taxa in Indian Himalayan Region (IHR) out of 21 genera and 207 taxa from overall India (Jayanthi 2020) with *Gentiana* Tourn. ex L. having the highest representatives of nearly 68 taxa in IHR out of 80 recorded from India (Jayanthi 2020), followed by *Swertia* L. with nearly 35 representatives in IHR out of 37 taxa from all over India (Jayanthi 2020). Both the genera being taxonomically critical, the taxonomy and nomenclature of the members of these genera are of great interest to plant taxonomists.

In course of identification of collected Gentianaceae specimens from Sikkim Himalaya, as part of an on-going project entitled "Conservation of Threatened Plants in Indian Himalayan Region: Recovery and Capacity Building"; thorough scrutiny of available literatures revealed, for the type of the names *Gentiana micans* C.B.Clarke, *Gentiana phyllocalyx* C.B.Clarke & *Swertia hookeri* C.B.Clarke, Ho & Liu (2001: 319, 233 & 2015: 165) stated holotype of all the three names were deposited in K. However, Clarke (1883) in the protologue of these names, indicated multiple gatherings without specifying any institute to hold the type specimen(s). Therefore, all the specimens cited in the protologue are syntypes (Art. 9.6, *Shenzhen Code*, Turland *et al.* 2018). According to the Art. 9.1 of the *Shenzhen code* (Turland *et al.* 2018), "A holotype of a name of a species or infraspecific taxon is the one specimen or illustration (but see Art. 40.4) either (a) indicated by the author(s) as the nomenclatural type or (b) used by the author(s) when no type was indicated"; but in this case, none of these two conditions was met as one already discussed above regarding the indication by the author, while regarding the point "b" in Art. 9.1 in this case, the specimens found in CAL also bear original remarks of C.B.Clarke. Therefore, it is evident that the specimens housed in K are not the only specimen used by Clarke to describe these names. Therefore, the terms 'holotype' and 'isotypes' used by Ho & Liu (2001, 2015) are misapplied and neither can be treated as inadvertent typification nor to be corrected; eventually do not stand on any ground according to the rules of ICN (Turland *et al.* 2018) vide Art. 7.11, 9.1, 9.3 & 9.10. Hence, all the aforesaid three names were till date untypified.

Typification of plant names was not practiced in pre-1st Jan., 1958 era (Art. 40.1 of *Shenzhen Code*, Turland *et al.* 2018) when the names viz. *Gentiana micans*, *G. phyllocalyx* and *Swertia hookeri*, in the family Gentianaceae, were described from Sikkim Himalaya by C.B.Clarke in 19th century. However, it is a crucial part in taxonomic studies for proper circumscription of a taxon and therefore becomes important for a better understanding of a particular one.

Authentic specimens, especially types deposited in national herbaria and online databases of various international herbaria (digital resources) were thoroughly checked and authentic specimens associated with J.D. Hooker deposited

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Lectotypification of *Medinilla himalayana* (Melastomataceae)

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Abstract: The name *Medinilla himalayana* Hook.f. ex Triana is lectotypified here.

Keywords: Himalaya, Isolectotype, Sikkim, Syntype, Typification.

Introduction

The genus *Medinilla* Gaudich. ex DC. (Melastomataceae), comprising about 375 species, is one of the largest genera in dicotyledonous angiosperms distributed in the Old World from Tropical Africa, Madagascar, to India, Sri Lanka, Myanmar, southern China and Taiwan, throughout Southeast Asia, New Guinea, northern Australia, Micronesia, Solomons, Vanuatu, Fiji, and Samoa (Bodegom & Veldkamp 2001; Fernando *et al.*, 2018). Clarke (1879) reported 11 species of *Medinilla* from the erstwhile British India, eight species from the present Indian region and three from Sri Lanka. In India, this genus is represented by eight species namely *M. erythrophylla* Lindl., *M. beddomei* C.B.Clarke, *M. himalayana* Hook.f., *M. pauciflora* Hook.f., *M. malabarica* Bedd., *M. sahyadrica* Sujanapal & Sasidh., *M. balakrishnanii* Jayanthi, Karthig., Sumathi & Diwakar and *M. anamalaiana* Sasidh. & Sujanapal distributed in the Himalayan and Peninsular regions (Sasidharan & Sujanapal, 2005; Jayanthi *et al.*, 2009). Species such as *M. himalayana* and *M. pauciflora* are confined to subtropical Himalayas. In course of study of Melastomataceae specimens from eastern Himalaya, as part of a project entitled "Conservation of threatened plants in Indian Himalayan region: recovery and capacity building", it was found that the name *M. himalayana* was not typified yet. Authentic specimens, especially types deposited in national herbaria and online databases of various international herbaria (digital resources) were thoroughly checked and authentic specimens associated with J.D. Hooker deposited at BM, E, GH, K, L, and P whereas specimens of J. Triana deposited at COL, BM, G, K, P and W and further material at many other herbaria viz. BR, DPU, E, F, FI, H, L, MANCH, MEDEL, MO, NY, US were screened online and in person at BSHC and CAL (Thiers, 2022 continuously updated). Online data bases such as Global Plants JSTOR (https:// plants.jstor.org), GBIF (https://www.gbif.org/) were also checked and thereafter the lectotypes for the aforesaid names have been proposed here for unambiguous use in accordance with the provisions in Art. 9.3 of the ICN (Turland *et al.*, 2018).

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Typification

Medinilla himalayana Hook.f. ex Triana, Trans. Linn. Soc. London 28(1): 88. 1871[1872]. *Lectotype* (designated here): INDIA, In the eastern Himalayas, Sikkim, 3000-6000 ft., *J.D. Hooker s.n.* (K [K000867099 digital image!]); isolecto (G [G006402 digital image!]; K [K000867098; K000867100 digital images!]).

The name *M. himalayana* was established by Triana in 1871 based on the specimens of Sir J.D. Hooker collected from Sikkim and Hooker and Thomson from Khasi Mountain. However, we have been unable to locate any specimens of Hooker and Thomson from Khasi Mountains. A search at various herbaria related to Hooker and Triana revealed four specimens collected by Hooker from Sikkim (G006402, K000867098; K000867099; K000867100 digital images). However, we have been unable to locate any specimens deposited at COL. Among them, the sheet K000867099 has the

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Lectotypification of Seven Names in genus *Phlogacanthus* (Acanthaceae)

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फ्लोगेकेन्थस वंश (एकेन्थेसी) में सात वानस्पतिक नामों का लेक्टोटाइपिफिकेश

रोहन मैती एवं सुधांशु शेखर दाश

सारांश

वंश फ्लोगेकेन्थस (एकेन्थेसी) की चार जातियों जिनमें फ्लोगेकेन्थस जेन्किन्साई सी बी क्लार्क, फ्लोगेकेन्थस लम्बर्टाई रायज़ादा, फ्लोगेकेन्थस पार्विफ्लोरस टी. एन्डर्स., एवं फ्लोगेकेन्थस प्यूबीनर्विस टी. एन्डर्स. को प्रस्तुत शोध पत्र में लेक्टोटाइपिफाइड किया गया है। इसके अतिरिक्त तीन अन्य नामों जस्टिसिया कर्विफ्लोरा वाल. [बेसियोनिम्स फ्लोगेकेन्थस कर्विफ्लोरस (वाल.) नीस], लोक्सेन्थस गोमेज़ाई नीस [बेसियोनिम्स फ्लोगेकेन्थस गोमेज़ाई (नीस) जे. आर. आई वुड] एवं जस्टिसिया गुटाटा वाल. [बेसियोनिम्स फ्लोगेकेन्थस गुटेटस] को भी लेक्टोटाइप किया गया है।

ABSTRACT

Four names in the genus Phlogacanthus (Acanthaceae) viz., *Phlogacanthus jenkinsii* C.B. Clarke, *Phlogacanthus lambertii* Raizada, *Phlogacanthus parviflorus* T. Anders., and *Phlogacanthus pubinervius* T. Anders. are lectotypified in the present communication. In addition, three other names i.e., *Justicia curviflora* Wall. [basionym of *Phlogacanthus curviflorus* (Wall.) Nees], *Loxanthus gomezii* Nees [basionym of *Phlogacanthus gomezii* (Nees) J.R.I. Wood] and *Justicia guttata* Wall. [basionym of *Phlogacanthus guttatus* Nees] are also lectotypified.

Key words: *Acanthaceae, Justicia, Justiceae, Loxanthus, Phlogacanthus*, India, Typification.

INTRODUCTION

The genus *Phlogacanthus* (Acanthaceae: Justiceae) with *c.* 15 species is restricted in the South-East Asian countries only (Hu, C.C. & al., 2011; Mabberley, 2018). In India the genus is represented by 13 species out of which 11 species are known from Indian Himalayan region. *P. lambertii* is the only species found in Western Himalayas (Uttarakhand) whereas the remaining 10 are found in North-East India and Eastern Himalayas (Lakshminarasimhan & al., 2020). All the taxonomic treatment or enumerations on the genus (Wallich, 1830-31, Nees, 1832, Anderson, 1867, Beddome, 1872, Clarke, 1884, Kanjilal & al., 1934, Benoist, 1935, J.R.I. Wood, 1994) from India are based on the historic collections with very limited information. In the present communication seven names under *Phlogacanthus* Nees are lectotypified strictly in accordance with the provisions in the International Code of Nomenclature for algae, fungi, and plants (Turland & al., 2018). An explanatory note for each of the species is provided to justify the need for the lectotypification.

MATERIALS AND METHODS

Few live specimens were collected recently while working on the project "Flowering plants diversity in Lal Ane hills and its surroundings (Mengio circle, Papum

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Notes on Taxonomic Status of *Phlogacanthus gracilis* (Acanthaceae) and Typification of the Name

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फ्लोगाकैंथस ग्रैसिलिस (एकैन्थेसी) के वर्गीकरण पर टिप्पणी एवं इस नाम के प्ररूपण

रोहन मैती एवं सुधांशु शेखर दाश

सारांश

इस लेख में फ्लोगाकैंथस ग्रैसिलिस टी. एंडरसन एक्स बुर्किल (एकैन्थेसी) को स्यूडरैन्थेमम लेप्टैन्थम (सी.बी. क्लार्क) लिंडाउ के विषमप्ररूपी पर्यायवाची के रूप में संक्षेपित किया गया है। इस लेख में फ्लोगाकैंथस ग्रैसिलिस टी. एंडरसन एक्स बुर्किल नाम के लिए चयनप्ररूप (लेक्टोटाइप) भी निर्दिष्ट किया गया है।

ABSTRACT

Phlogacanthus gracilis T. Anderson ex Burkill (Acanthaceae) has been reduced here as a heterotypic synonym of *Pseuderanthemum leptanthum* (C.B. Clarke) Lindau. Lectotype for the name *Phlogacanthus gracilis* T. Anderson ex Burkill is also designated here.

Keywords: Acanthaceae, Lectotype, *Pseuderanthemum*, Assam, syn. nov.

INTRODUCTION

C.G.D. Nees von Esenbeck (1832), described the genus *Phlogacanthus* (Acanthaceae) in his '*Acanthaceae Indiae Orientalis*', published in the third volume of '*Plantae Asiaticae Rariores*' edited by N. Wallich. The genus with c. 42 species worldwide (POWO, 2022) is distributed in South and South-East Asian countries (Maity & Dash, 2020; 2021). Taxonomic treatments or enumerations on Indian *Phlogacanthus* (Wallich, 1830-1831; Nees, 1832; Anderson, 1867; Beddome, 1872, Clarke, 1884, Burkill, 1925, Kanjilal & al., 1934, Benoist, 1935, J.R.I. Wood, 1994) are based on the historic collections with very limited information. In India, till date 14 taxa (13 spp. and 1 var.) were recorded among which 1 species, *Phlogacanthus gracilis* T. Anderson ex Burkill was reported as doubtful (Arisdason & al., 2020).

Phlogacanthus gracilis is an Indian endemic found in Arunachal Pradesh and Assam, which was described by Burkill (1925) in his '*The Botany of the Abor Expedition*' based on collections from multiple gatherings. In course of reinvestigation of Indian *Phlogacanthus*, authors realized the need of typifying the name *Phlogacanthus gracilis* T. Anderson ex Burkill. Further characterization of its morphology revealed its conspecificity with *Pseuderanthemum leptanthum* (C.B. Clarke) Lindau. Therefore, *Phlogacanthus gracilis* T. Anderson ex Burkill has been reduced here as a heterotypic synonym of *Pseuderanthemum leptanthum* (C.B. Clarke) Lindau and a lectotype has been designated for the name *Phlogacanthus gracilis* T. Anderson ex Burkill.

TAXONOMIC TREATMENT

Pseuderanthemum leptanthum (C.B. Clarke) Lindau ['**leptanthus**'] in Engl. & Prantl, Nat. Pflanzenfam. 4(3b): 330. 1895; Arisdason & al. in S.S. Dash & A.A. Mao (eds.), Fl. Pl. India, Dicot 2: 299. 2020. *Eranthemum leptanthus* C.B. Clarke in Hook.f., Fl. British India 4: 500. 1884. *Siphoneranthemum lepthanthum* (C.B. Clarke) Kuntze,

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the majority of the bird species described since the 1950s with eponymic names are tropical, but they are named after someone from the Global North (DuBay & al. in BioRxiv. https://doi.org/10.1101/2020.08.09.243238. 2020). Linnaeus initiated modern taxonomy and was shortly joined in his endeavour by a small group of principally European men. The names published by them reflected their interests and values. The range of people involved in taxonomy has gradually expanded over the last 250 years. It is time to go further and reflect the diversity of people who all have an interest in the scientific names of algae, fungi and plants. Taxonomy is at the heart of biodiversity research, and conservation science can greatly benefit from more inclusive approaches (Tallis & Lubchenco in Nature 515: 27–28. 2014). In New Zealand, the use of the indigenous languages te reo Māori and ta re Moriori has proved increasingly popular in constructing the scientific names of a wide range of organisms, including plants (Veale & al. in New Zealand J. Ecol. 43: 3388. 2019). Nevertheless, this practice represents only 4% of species names in New Zealand (Galbreath in New Zealand J. Ecol. 45: 3429. 2021), probably in part because the *Code* has discouraged this kind of practice for a long time.

As it is currently formulated in Rec. 20A.1 and 23A.3, the avoidance of names difficult to pronounce in Latin is a hindrance to increasing the use of vernacular names, eponyms from diverse origins, and words from indigenous languages in building epithets. It has also been applied inequitably, possibly with a greater tolerance to names derived from widespread languages (e.g. English) as illustrated with the *browne-/brownii-* example. The requirement of a Latin description or diagnosis for the valid publication of a name of a new non-fossil taxon was considered as a relict (Figueiredo & al. in Taxon 59: 617–620. 2010) and has now been removed from the *Code*. It is time to go further and remove the parts of Rec. 20A.1 and 23A.3 that recommend against forming names or epithets that are "not readily adaptable to the Latin language" or are "difficult to pronounce in Latin".

(112) In Rec. 20A.1 delete clause (b) and amend clause (c) as follows (deleted text in strikethrough):

"*20A.1.* Authors forming generic names should comply with the following:

[…]

~~*(b)* Avoid names not readily adaptable to the Latin language.~~

(c) Not make names that are very long ~~or difficult to pronounce in Latin~~."

(113) Amend Rec. 23A.3 clause (b) as follows (deleted text in strikethrough):

"*23A.3.* In forming specific epithets, authors should comply also with the following:

[…]

(b) Avoid epithets that are very long ~~or difficult to pronounce in Latin~~."

(114) Proposal to amend Article 23.2 and Recommendation 23A.3 to eliminate arbitrary formation of, and future use of hyphens in, specific epithets

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Article 23.2 of the *Shenzhen Code* (Turland & al. in Regnum Veg. 159. 2018) states: "The epithet in the name of a species may be taken from any source whatever, and may even be composed arbitrarily." The word "arbitrarily" contradicts Rec. 23A.1–3 and creates confusion. The Recommendations of Rec. 23A are useful and practical to follow by any author while coining specific epithets. However, the phrase "may even be composed arbitrarily" of Art. 23.2, which can lead to the formation of specific epithets that are very long, multi-hyphenated or sometimes unpronounceable, makes these Recommendations appear useless. Two examples are *Cycas pschannae* R.C. Srivast. & L.J. Singh (in Int. J. Curr. Res. Biosci. Pl. Biol. 2(8): 35. 2015) and *Kobresia* [illegible] Jana (in Indian J. Fundam. Appl. Life Sci. 2: 256. 2012). Similarly, Art. 23.1, stating "If an epithet consisted originally of two or more words, these are to be united or hyphenated", is implicitly in favour of formation of epithets composed of two or more words, which is also against Rec. 23A.3(d), which recommends to avoid formation of specific epithets with "two or more hyphenated words". One such example is *Henckelia collegii-sancti-thomasii* A. Joe & al. (in Phytotaxa 415: 248. 2019). Hence, to avoid such incidences in the future, it is proposed to amend Art. 23.2 by replacing the phrase "and may even be composed arbitrarily" with "may not be composed arbitrarily" and by incorporating Rec. 23A.3(d), converting it to a rule and then deleting the Recommendation. A new Example under Art. 23.2 can serve to clarify the meaning of "composed arbitrarily".

(114) Amend Art. 23.2 as follows (new text in bold, deleted text in strikethrough), add a new Example under it, and delete Rec. 23A.3(d):

"*23.2.* The epithet in the name of a species may be taken from any source whatever ~~and may even~~ **but may not** be composed arbitrarily (~~but~~ see **also** Art. 60.1). **In a name published on or after**

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Lectotypification of three names in the genus *Phlogacanthus* Nees (Acanthaceae)

Rohan Maity[1] & Sudhansu Sekhar Dash[2]

Summary. Lectotypes are designated for three names in *Phlogacanthus*: *P. albiflorus* Bedd., *P. grandis* Bedd., and *P. tubiflorus* Nees.

Key Words. *Diacanthus*, India, typification.

Introduction

The genus *Phlogacanthus* (Acanthaceae), proposed by Nees (1832), comprises c. 15 species representatives mainly restricted to South-East Asian countries (Hu *et al.* 2011; Mabberley 2008). It is represented in India by 13 species of which *P. hambotii* is only known from Western Himalaya (Uttarakhand), and *P. albiflorus* and *P. grandis* are restricted to southern India. The remaining 10 species are distributed in Eastern Himalayas and North-East India (Lakshminarasimhan *et al.* 2020). Very little information is available on the members of the genus, as the majority of the works which refer to them are restricted to enumerations based on old collections (Wallich 1830 – 1831; Nees 1832; Anderson 1867; Beddome 1872; Clarke 1884; Kanjilal *et al.* 1934; Benoist 1935; Wood 1994).

In the present communication, we discuss the lectotypification of three names placed under *Phlogacanthus* Nees from India, strictly adhering to the provisions in the International Code of Nomenclature for algae, fungi, and plants (Turland *et al.* 2018) with explanatory notes for each of the species justifying the need for the lectotypification.

Materials and Methods

As part of our on-going project "Conservation of Threatened Plants in Indian Himalayan Region: Recovery and Capacity Building" three live plants of the genus *Phlogacanthus* were collected. Authenticated collections, especially types deposited in CAL and also in ASSAM, ARUN, DD, and MH, were examined. Furthermore, digitised type images deposited in various national and international herbaria available online, were also examined. In the absence of access to the type specimens and digitised images, high resolution images were obtained from these herbaria on request. Bibliographic citations in the original publications and databases such IPNI (The International Plant Names Index; http://ipni.org/), Tropicos (http://www.tropicos.org/), and The World Flora Online, (http://www.worldfloraonline.org) were also checked.

For the lectotypification of names, we followed the provisions given in the International Code of Nomenclature for algae, fungi, and plants (Turland *et al.* 2018). Regarding the typification of pre-1990 specific and infraspecific names, Art. 40.3 second sentence applies ("For the purpose of Art. 40.1, mention of a single specimen or gathering (Art. 40.2) or illustration, even if that element is not explicitly designated as type, is acceptable as indication of the type of the name of a new species or infraspecific taxon (but see Art. 40.6)"). However, Article 40.3 applies only to post-1957 names, as made clear in the preface xxi (sub Art. 9.1): "Moreover, mention of a single specimen or illustration in the protologue is not to be interpreted as indication of the type, except under Art. 40.3, which applies only for the purpose of Art. 40.1, i.e. only to names published on or after 1 January 1958, and ceases to apply on 1 January 1990 when one must explicitly designate a type using the word "typus" or "holotypus" or an equivalent (Art. 40.6)").

All the existing syntypes deposited in different herbaria were traced, and the best-preserved original specimens which strictly adhere to the description mentioned in the protologue are designated as lectotypes. The enumeration is arranged alphabetically by the accepted names. All available homotypic synonyms are given followed by the type citations. Barcode numbers of lectotypes and isolectotypes are given (if available) following the herbarium acronym.

Typification of Names

1. Phlogacanthus albiflorus *Bedd., Icon. Pl. Ind. Or. (Beddome)* 2: 40, *t.* 180 (1872). Type: India, Tamil Nadu: "South Tinnevelly mountains 3000 – 5000 feet

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Lectotypification of the name *Ormosia fordiana* (Leguminosae: subfamily Papilionoideae) and Its Addition to Flora of Arunachal Pradesh, India

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ओरमोसिया फोर्डियाना (लेग्यूमिनोसी: उपकुल पपीलिओनोइडी) का लेक्टोटाइपिफिकेशन एवं अरूणाचल प्रदेश के वनस्पतिजात में इसका नवीन संयोजन

रोहन मैती, सुधांशु शेखर दाश एवं अशिहो असोशी माओ

सारांश

[illegible]

ABSTRACT

Ormosia fordiana Oliv. (Leguminosae subfamily papilionoideae) is reported here as a new record to Arunachal Pradesh and collected after a gap of 79 years from India. Lectotype of the name *Ormosia fordiana* is also designated here.

Keywords: Arunachal Pradesh, Lectotype, New addition, *Ormosia*, Typification

INTRODUCTION

The woody legume genus *Ormosia* of Leguminosae subfamily papilionoideae, was established by G. Jackson in 1811. The genus comprises about 132 species, geographically distributed in North Australia, tropical America and South East Asia (Mabberley, 2008; Hang and Vincent, 2010; Deng, 2014; Sinha & al., 2014). The genus is represented in India by seven species viz. *O. assamica* Yokovlev, *O. coccinea* (Aubl.) Jacks., *O. fordiana* Oliv., *O. glauca* Wall., *O. pinnata* (Lour.) Merr., *O. robusta* Baker and *O. travancorica* Bedd. (Verma and Roy, 2014; Roy and Verma, 2014; Sinha & al., 2014) among which *O. assamica* and *O. travancorica* are known to be endemic to the India (Sanjappa, 1991).

Few interesting specimens of *Ormosia* were collected from Papumpare District of Arunachal Pradesh and further identified as *Ormosia fordiana* Oliv. The present communication deals with the extended distribution of the species, lectotypification of the name *Ormosia fordiana* Oliv. and collection of the taxon after a gap of almost eight decades from India.

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(160) Proposal to convert Recommendation 40A.5 to a new Article dealing with deposition of type specimens for valid publication of names of new taxa

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According to Art. 40.7 of the *Shenzhen Code* (Turland & al. in Regnum Veg. 159. 2018), valid publication of names of new species or infraspecific taxa after 1 January 1990 requires specification of the herbarium, collection, or institution where the type is conserved. Some authors follow this Article while publishing the name of a new taxon, but fail to deposit the type material in the specified herbarium. For example, recently Bhattacharjee & al. (in Bot. Lett., published online 15 November 2021, https://doi.org/10.1080/23818107.2021.2000889) mentioned with regard to the type of *Gastrochilus corymbosus* A.P. Das & S. Chanda (in J. Econ. Taxon. Bot. 12: 401. 1989): "holotype cited as being at CAL, but actually not deposited there and could not be traced anywhere …". The present authors have confirmed with the curator at CAL that the specimen cannot be found there and is not listed in the accessions register. While this particular incident preceded 1 January 1990, some authors still fail to deposit the type, either deliberately or inadvertently.

Recommendation 40A.5 of the *Code* ("Specification of the herbarium, collection, or institution of deposition should be followed by any available number permanently and unambiguously identifying the holotype specimen") could deal with such situations if converted to a new Article under Art. 40. Because receiving such a number from the institution of deposition can sometimes take a long time, delaying publication, we propose to reword the converted Rec. 40A.5 by replacing "the holotype specimen" with "at least one of the holotype, isotype, or paratype specimens". Therefore, authors in the future will not only have to follow Art. 40.7, but practise the rule in reality by providing, for valid publication, a permanent number (e.g. accession number, barcode, or QR code) in the protologue for at least one of the type specimens, which will unambiguously identify that specimen.

(160) Convert Rec. 40A.5 to a new Article after Art. 40.7, reword it as follows, and move Rec. 40A Ex. 1 (wording unchanged) to follow the new Article:

"*40.7bis.* For the name of a new species or infraspecific taxon published on or after 1 January 2026 of which the type is a specimen, any available number permanently and unambiguously identifying at least one of the holotype, isotype, or paratype specimens in addition to its herbarium, collection, or institution of deposition must be specified (see also Art 40.7)."

"*Ex. n.* The type of *Sladenia integrifolia* Y. M. Shui & W. H. Chen (in Novon 12: 539. 2002) was designated as "*Mo Ming-Zhong, Mao Rong-Hua & Yu Zhi-Yong 05* (holotype, KUN 0735701; isotypes, MO, PE)", where KUN No. 0735701 is the unique identifier of the holotype sheet in the herbarium of the Kunming Institute of Botany (KUN)."

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Site Suitability Analysis
for the Critically Endangered *Aconitum heterophyllum* in Alpine Regions of Uttarakhand using Analytic Hierarchy Process

Aconitum heterophyllum (Ranunculaceae) is an ayurvedic medicinal plant used as a main ingredient in many Ayurvedic herbal formulations. The rising pharmaceutical demand has led to extensive exploitation of this endangered species from wild and rendered the species into miserable situation. For the effective conservation and habitat restoration of the species, the Analytic Hierarchy Process (AHP) method was used for the assessment of suitable sites in alpine region of the Uttarakhand. The AHP analysis revealed 587 km² area as highly suitable, 485 km² area as suitable and 914 km² area as moderately suitable for the growth of A. heterophyllum in the Uttarakhand. Most of the highly suitable sites are close to 3700-4000 m and lies in northern grassy slopes. The AHP analysis also exhibit that the temperature, rainfall and moisture have a high impact on the distribution of A. heterophyllum.

Key words: *A. heterophyllum*, Site suitability, Alpine regions, Analytic hierarchy process, Critically endangered.

Aconitum heterophyllum, a critically endangered medicinal plant species, can be successfully conserved in the alpine habitats of Uttarakhand which are highly suitable, moderately suitable and suitable for its growth.

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Introduction

Himalaya is well-known for its rich plant biodiversity since time immemorial and supporting the growth of umpteen number of medicinal and aromatic plant species. The wide phytogeography and peculiar climatic conditions of the area provides conducive environment for the development of myriads signature plant species endowed with lifesaving vital secondary metabolites (Singh and Hajra, 1996). Indian Himalayan Region (IHR) is one of the biodiversity hotspots with over 8000 species of vascular plants (Samant *et al.*, 1998) and out of which 1740 plant species of IHR are used in traditional and modern therapeutic system (Kala, 2010). The state of Uttarakhand endowed with rich diversity of medicinal and aromatic plants (MAPs) and around 964 species of medicinal plants are known to occur in this small Indian Himalayan state (Rau, 1975).

Plant diversity of the Himalayan region is facing surmounting threats due to various anthropogenic activities in the region and several plant species of the region are facing the risk of extinction in the imminent future (Ved *et al.*, 2003). The number of such threatened species is increasing every year due to unsustainable exploitation of the natural resources. *Aconitum heterophyllum* Wall. ex Royle is a signature species of the Himalayan region, facing various threats in the wild and has been assigned the IUCN threatened status (Kaul, 1997).

Aconitum heterophyllum Wall. is a highly medicinal herb distributed in the high-altitude regions of Western Himalayas and extended upto Eastern Himalayas at an altitude range of 2400-4500 m. The species is commonly known as 'Atees' or 'Patis' and is used for the treatment of various ailments by local people including fever, gastric disorders, general debility etc. It is also used by local inhabitants of the Himalayan region for the treatment of gastric clutters, fevers, and tooth aches. Extract of root is taken as a tonic and also as a substitute of quinine (IUCN, 1993).

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Molecular phylogeny and systematic evaluation of the *Caragana opulens* species complex (Fabaceae, Papilionoideae) based on the molecular and morphological data

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Abstract

In this study, we explored the evolutionary history and taxonomic treatment of the *Caragana opulens* complex taking information from morphological and molecular data. The complex consists of three species, *C. opulens*, *C. licentiana* and *C. kansuensis*. Moreover, the morphological characters currently used to differentiate the species present in the complex have been found insignificant and inconsistent and do not help diagnose the species. For the present study, we investigated its range and sampled 139 accessions from the different populations of the genus *Caragana* and 17 accessions of the complex. DNA sequence data from one nrDNA ITS and one cpDNA *trnH-psbA* loci were sequenced and analyzed using Maximum Likelihood and Bayesian methods. The resulting phylogenies were congruent in topologies. Based on morphological and molecular data, it is concluded that all three species of the complex are one of the same with significant morphological variations. Hence *C. opulens* is accepted as the correct name along with *C. licentiana* and *C. kansuensis* as synonyms.

Keywords: Morphological variations, *Caragana opulens* complex, nrDNA ITS, cpDNA *trnH-psbA*, *Taxonomy*

Introduction

A better understanding of the patterns of biodiversity and biogeography is essential for assessing *in situ* and *ex situ* conservation strategies of natural resources (Cano-Ortiz *et al.* 2016), which needs to become prioritized in policy and practice (Kopnina *et al.* 2020). This can be achieved by providing a description and delimiting the species in an evolutionary framework (Liu 2016, Yang 2016, Heng *et al.* 2018) and also in the context of their habitat (Perrino *et al.* 2014). However, species complexes, comprising a few distinct morphotypes with a series of intermediates at the species level, pose difficulty for taxonomists (Liu 2016). These intermediates might be produced from several processes such as intraspecies variation, interspecies hybridization, convergent evolution (Wang *et al.* 2004, Liu *et al.* 2006), including cultivation environments, evaluating their ability to hybridize with wild relatives (Perrino & Perrino 2020). Increasing studies from time to time suggest that the mechanisms responsible for the intermediate forms can be elucidated by using DNA sequences (Su *et al.* 2015, Zheng *et al.* 2017).

The genus *Caragana* Fabr. (Fabaceae: Papilionoideae) belongs to the tribe *Caraganeae*, comprises about 95 species distributed in temperate arid and semi-arid areas of the World (Polhill 1981). Approximately 80 species are distributed in Northern Eurasia, southeastern Siberia, China, Nepal, India, Afghanistan, and Turkmenistan (Lock 2005, Liu *et al.* 2010a). In Asia, China hosts the maximum number of species (*ca.* 66), with radiations in India (*ca.* 25), Nepal, and Afghanistan (*ca* 10) (Li & Ni 1985). The genus is commonly found in the montane meadows, deserts and cold-temperate dry areas. The genus is shrubby or bushy perennial and is recognised by the specific combination of characters such as stipules persistent and spinelike. Leaves paripinnate or digitate with 4-foliolate; petiole persistent on long branchlets, caducous on short branchlets; leaflet blades obovate to oblanceolate, with margin entire, apex often cuspidate. Flowers axillary, usually solitary. Pedicel articulate on the upper part to lower part. Calyx campanulate to tubular. Corolla yellow, rarely purple to whitish pink; standard sometimes reddish; wings and keel often auriculate. Stamens diadelphous (9+1). Ovary subsessile, glabrous or pubescent. Legume cylindric, pubescent/glabrous (Zhang *et*

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ORIGINAL ARTICLE

'New' species are not always new: a case study of *Ephedra sumlingensis* and *E. khurikensis* (Ephedraceae)

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Abstract
Historically, and even today, discovery of new species has remained one of the primary research activities driving the discipline of taxonomy. Discovering scientifically still unknown biodiversity is critical in addressing the taxonomic impediment which is hampering our progress to meet the challenges of global biodiversity crisis. However, in the rush to accelerate the rate of new species' discoveries, it is crucial to follow objective, stable and reproducible taxonomic criteria. Otherwise, new species' discoveries based solely on subjective, unstable and non-reproducible characters can be cause of artificial taxonomic inflation in biodiversity data with wider implications in conservation policy and practice. In this study, by integrating empirical evidences from multiple sources, we critically evaluate the validity of two recently described new species of *Ephedra* in India (*E. sumlingensis* and *E. khurikensis*) to underscore the fact that all 'new' species are not always new. Use of morphologically plastic characters in diagnosis, discrepancies in the protologues and inconsistencies with the freshly collected live specimens from the type localities clearly revealed that both these species unambiguously fall within the circumscription of already known *E. intermedia*. With further support from robust analyses of morphometric and molecular data, we recognise both the species as new synonyms of *E. intermedia*. Based on the lessons learnt from this study, we suggest recommendations to be practised by the taxonomists to avoid such pitfalls in biodiversity data due to arbitrary new species' discoveries.

Keywords Biodiversity · *Ephedra* · New species · Species discovery · Taxonomy

Introduction

Taxonomy, a discipline dealing with discovery, description, identification, naming and classification of life on the planet Earth, provides the basic scientific tools in documenting global biodiversity (Khuroo et al. 2007; Thiele et al. 2021; Richetti et al. 2022). Historically, and even today, discovery of new species has remained one of the primary research activities driving the discipline of taxonomy (Zachos 2018). In recent times, with rapid and rising rates of species extinctions, there has been a renewed research focus towards discovery of new species (Costello et al. 2015; Cornette et al. 2017; Wani et al. 2022; Pereira et al. 2022; Khuroo et al. 2022). It has been mainly spurred by the realisation that speeding up the documentation of still unknown biodiversity is crucial in addressing the taxonomic impediment which is hindering our capacity to meet the global biodiversity goals (Valdecasas and Camacho 2003; Dar and Khuroo 2013, 2020; Engel et al. 2021). At present, majority of the new species discovered are still based on morphological description with molecular and allied biological data serving as significant supplementary sources (Islam et al. 2021; Lee et al. 2021). However, in the rush to speed up the discovery rate of new species, it is crucial to follow objective, stable and reproducible taxonomic criteria (Fraser-Jenkins 1997; Ickert-Bond and Renner 2016). New species' descriptions

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Gentiana ranae (Gentianaceae), a new species from India revealed by morphology and molecular phylogenetic analyses

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Abstract: A new species of the genus *Gentiana*, *G. ranae* sp. nov., from Rohtang Pass in Himachal Pradesh (India) is described here. The species shows morphological resemblances with *G. glauca* Pall. and *G. venusta* Wall. of sect. *Monopodiae*, but differs in key morphological characters such as a stem with 4–6 fine lines, upper stem leaves more densely enveloping the inflorescence, a light blue corolla with margins of the corolla lobes scabrous to crenulate, horizontally truncate plicae, dentate to erose margins, and ovate to sub-orbicular seeds. Along with the morphological characters the species is supported as a new member of sect. *Monopodiae* in a molecular phylogenetic analyses using the nuclear ribosomal DNA internal transcribed spacers (ITS) and chloroplast *trn*L-F intron-intergenic spacer regions. This new species is described, illustrated and discussed.

Keywords: cpDNA *trn*L–F, *Gentiana glauca*, nrDNA ITS, sect. *Monopodiae*, western Himalaya.

Introduction

The genus *Gentiana* L. (Gentianaceae) belongs to the monophyletic subtribe Gentianinae along with *Crawfurdia* Wall., *Kuepferia* Adr.Favre, *Metagentiana* T.N.Ho, *Sinogentiana* Adr.Favre & Y.M.Yuan, and *Tripterospermum* Blume, consisting of about 362 species (Ho & Liu, 2001; Struwe & Albert, 2002; Favre *et al.*, 2014, 2016). *Gentiana* finds its ecological optimum between 3500–4500 m and is found distributed in the meadows of temperate, sub-alpine and alpine regions around the globe. In India, the genus comprises *c.* 68 species largely distributed in the Indian Himalayan region (Grag, 1987; Gupta *et al.*, 2012; Shabir *et al.*, 2018).

During a field collection trip to the Rohtang Pass of Himachal Pradesh (India) in October 2017, MS located a population of a species of *Gentiana* growing on the south-facing slope at about 4200–4400 m asl., near the Rohtang temple. Three mature individuals were collected from this population for taxonomic studies. After a critical examination of the specimens, the plants were found to represent a species without any resembling description in the available literature under sect. *Monopodiae*. Therefore, a detailed study was made using molecular and morphological methods in support of its taxonomic status and affinities with *Gentiana*, and the discovered new species is described and illustrated herewith as *Gentiana ranae* sp. nov.

Materials and Methods

Field trips and herbarium visits: Accessions of *Gentiana* specimens were collected from a single population in Rohtang Pass of Himachal Pradesh in western Himalaya. The determination of the collected specimens down to genus level was made after consulting the relevant taxonomic literature (Garg, 1987; Ho & Pringle, 1995; Halda, 1996; Ho & Liu, 2001; Gupta, 2009; Shabir *et al.*, 2017), and consultation of herbarium specimens housed at BSD, CAL, DD, KASH, and LWG and digital images of specimens deposited in BM, E, and K. The holotype (*Shabir* 308822) was deposited in

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Typification of *Allium carolinianum* (Amaryllidaceae)

Damini Sharma[1,2], Mayank D. Dwivedi[2], Kusum Upadhyay[1,2] & Arun K. Pandey[1]

Summary. Lectotypification of the name *Allium carolinianum* Redouté is discussed. An illustration from the protologue has been designated as the lectotype. The plate fulfils the requirement of an illustration with analysis. As no cited isotype, syntype, iso-syntype or paratype exist, the name is lectotypified to the published plate.

Key Words. Illustration, L. A. G. Bosc, lectotype, nomenclature, P. J. Redouté.

Introduction

The genus *Allium* L. (Linnaeus 1753: 294) is represented by c. 1000 taxa which make it one of the largest petaloid monocotyledon genera (Li *et al.* 2010; Herden *et al.* 2016). In early classifications, *Allium* was placed in the Liliaceae (Melchior 1964). Takhtajan (1997) recognised *Allium* and its close relatives as a distinct family, Alliaceae (Fritsch & Friesen 2002). More recently, APG III (Angiosperm Phylogeny Group 2009; Chase *et al.* 2009) have transferred *Allium* to the family Amaryllidaceae, based on molecular data.

Allium carolinianum was published based on an illustration drawn by Redouté and Bosc's collection from Carolina, USA. L. A. G. Bosc collected about 1600 species of grasses and cryptogam plants from North America mainly Wilmington, North Carolina and Tennessee from 1798 – 1800. His specimens are found in the herbaria of Ventenat, Martius, Moretti and de Candolle (Brendel 1879). Pierre-Joseph Redouté was a very well-known plant illustrator, who became famous as "Raphaël des fleurs" (Lawalrée 1996). Most of his watercolour paintings are of roses and lilies (Lack 2018). The author citation of *A. carolinianum* is confused between Redouté and de Candolle but no internal evidence was found for providing the name and description by de Candolle. Therefore, authorship of the name *A. carolinianum* is attributed to Redouté (Art. 46.9 of ICN, Turland *et al.* 2018). In "Les Liliacées", two illustration plates for the name *Allium carolinianum* were provided, of which one image is monochromatic and the other is coloured. In the illustration, two important morphological features i.e., scapes bearing globose inflorescences and a cluster of dark brown tunicated bulbs are clearly visible. The illustration was annotated by Redouté in his own handwriting. It was drawn by Redouté possibly based on the plant cultivated in Cels's garden at Montrouge, Paris, brought from North Carolina, USA by Louis Augustin Guillaume Bosc (Redouté 1804). On the lower right-hand side of the illustration, the illustrator has written 'garlic from Caroline' in French. However, clarification on the origin (North America?) of the material was provided by Watson (1879). As no original material (isotype, syntype, iso-syntype or paratype) could be traced for this species, the illustration available in the protologue is the best representative specimen that can be used as a nomenclatural type (Art. 38.7 of ICN, Turland *et al.* 2018). However, one specimen of *A. carolinianum* (Barcode number: G00165359) deposited at CJBG had an initial element of doubt which was cleared by an annotation label on the collection (Fig. 1). It is not clear where the author submitted the original specimen or which specimen was used to draw the illustration. During the revision of the genus *Allium* in India, it was found that no type was assigned to *A. carolinianum* Redouté (Fig. 2) and nor was typification attempted previously. Hence, the name *A. carolinianum* has been lectotypified here.

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Damini Sharma, Mayank D. Dwivedi and Arun K. Pandey contributed equally to this work.

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Orthographic Corrections of the Five Names in the Genus *Allium*

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Abstract: In this study orthographic corrections have been made in the names of five species of *Allium* i.e. *Allium carolinianum, Allium apolloniensis, Allium gilgiticum, Allium stoliczki* and *Allium barszczewskii*.

Keywords: Orthographic corrections, *Allium carolinianum, Allium apolloniensis, Allium gilgiticum, Allium stoliczki, Allium barszczewskii*

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Introduction

The five names *Allium carolinianum, Allium apolloniensis, Allium gilgiticum, Allium stoliczki* and *Allium barszczewskii* were published however, the authors did make orthographic errors in specific epithets when publishing the name of new species. Later, the genus was revised by the workers (Biel *et al.*, 2006, Dasgupta, 2006) but the epithets errors did not corrected by them. Thus, the specific epithets are being corrected here as follows:

The construction is with an orthographic error in an adjectival epithet of *Allium carolinianum* giving city name i.e. Carolina (United States) which is ending with letter 'a' should be latinized by adding 'ense' in suffix as the generic name in neuter gender (Art. 60.0.1). Thus, the corrected name would be *Allium caroliniense* Redouté, Liliac 2: 101. (1804).

Orthographical error is acknowledged in *Allium apolloniensis* because if the generic name is of neuter gender, then its epithet will also be kept in neuter gender. This epithet refers to the place where this species was found for the first time i.e. Apollonia in Greece (Biel *et al.*, 2006). Apollonia ends with 'a' vowel where before adding suitable suffix of neuter case 'a' has to be removed. Therefore, the species should be written as *Allium apolloniense* B. Biel, Kit Tan and Tzanoud., Willdenowia 36.1:367-372 (2006).

Othographical error is found in *Allium gilgiticum* as the specific epithet derived from the geographical name i.e. Gilgit which is an abbreviated form of Gilgit mountains that comes under LOC part of India. According to Art. 32.2 and Rec. 60D.1 of the ICN, it was not correctly constituted (Shenzhen Code; Turland *et al.*,

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ORIGINAL ARTICLE

Molecular systematics of the genus *Musa* L. (Zingiberales: *Musaceae*) in Andaman and Nicobar Islands

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Abstract
In the present study, we have re-visited *Musa* taxonomy based on morphological and molecular data. DNA sequence data (ITS, *trn*L-F) and population assessment reveal that *Musa balbisiana* var. *andamanica* and *Musa sabuana* should be synonymized under *Musa balbisiana*. Based on the present work, we recognize four species of *Musa* namely *M. acuminata*, *M. balbisiana*, *M. indandamanensis*, and *M. paramjitiana* in Andaman and Nicobar Islands.

Keywords Andaman and Nicobar · *Musa* · Molecular markers · Synonymies

Introduction

Andaman and Nicobar Islands are the largest archipelago system in the Bay of Bengal. It constitutes a unique flora and a high level of endemism (Singh et al. 2014). The Nicobar Islands constitute one of the hotspots of biodiversity with a variety of ecosystems (Myers et al. 2010). Approximately 10% of the angiosperm flora of these islands are endemic and taxonomy of several species of the archipelago is poorly known (Singh 2014, 2017; Murugan et al. 2016).

Of all the taxa occurring on the Andaman and Nicobar Islands, banana family (*Musaceae* Jussieu) is one of the taxonomically difficult plant groups. Globally, the family is represented by three genera viz., *Ensete* (8 spp.), *Musa* (70 spp.), and *Musella* (1 sp.) (Table 1). The largest genus *Musa* is mainly distributed in the tropical Asia from Himalaya to northern Australia (Kress 1990; Liu et al. 2010; Hareesh et al. 2017).

Since time immemorial, the cultivated banana fruits (berries) have been consumed raw/ ripened. Other parts of the plant like, pseudostem and leaves have been used by the local tribal people and by settlers for various purposes (Roux et al. 2008; Singh 2014, 2017; Singh et al. 2018). The economic utility of banana has attracted several plant breeders and researchers to develop new varieties (Liu et al. 2010).

Taxonomy of the wild *Musa* species is complex (Argent 1976; Simmonds and Weatherup 1990; Gawel et al. 1992; Liu et al. 2002, 2010; Häkkinen and Väre 2008; Joe and Sabu 2016, 2019). Based on molecular phylogenetic studies on the genus *Musa*, two sections viz., *Musa* sect. *Musa* and *Musa* sect. *Callimusa* have been recognized (Nayar 1952; Li et al. 2010; Liu et al. 2010; Christelová et al. 2011; Häkkinen 2013). In India, all the species of the genus *Musa* belong to the *Musa* sect. *Musa*. This section comprises of ca. 32 species, of which 20 species are endemic (Joe and Sabu 2019). In India, wild species are distributed mainly in Eastern Ghats, Western Ghats, North Eastern India and in Andaman and Nicobar archipelago.

In Andaman and Nicobar Islands, the family *Musaceae* is represented by a single genus, *Musa* (Fig. 1). Based on earlier taxonomic studies, the genus is represented by six wild taxa viz., *M. acuminata* Colla, *M. balbisiana* Colla, *M. indandamanensis* L.J. Singh, *M. paramjitiana* L.J. Singh, *M. sabuana* K. Prasad et al. and *M. balbisiana* Colla var. *andamanica* Singh et al. (Singh 2014, 2017; Singh et al. 2014, 2018). Also, two cultivated forms of *Musa*

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RESEARCH ARTICLE

Phylogenetic relationships of Indian *Memecylon* L. (Melastomataceae) based on nrDNA ITS and cpDNA *rbc*L sequence data

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Abstract. *Memecylon* (Melastomataceae) is a large genus of the Old-World predominantly woody species. Many species of *Memecylon* are used for timber, ornamental and medicinal purposes. The objective of the present study was to undertake a phylogenetic analysis of Indian *Memecylon* based on nuclear ribosomal DNA internal transcribed spacer (nrDNA-ITS) and *rbc*L sequence data. Sampling included 26 species and one variety (20 endemics) representing 67% of the total Indian species. Molecular phylogeny data for analysed species revealed that the Indian *Memecylon* is monophyletic. Monophyly is strongly supported in the ITS, *rbc*L and ITS + *rbc*L combined analyses. *Memecylon* species are grouped in a major clade with strong support in ITS sequence data and moderate support in combined ITS + *rbc*L analyses.

Keywords. India; *Memecylon*; phylogenetic relationships; monophyly.

Introduction

The genus *Memecylon* L. (Melastomataceae) is confined to the Old-World tropics, and comprises ~ 300 species (Bremer 1979; Stone 2014). In India, the genus is represented by *ca.* 53 species (Das *et al.* 2016, 2018a, b), of these, 37 are found in peninsular India (Andhra Pradesh, Karnataka, Kerala and Tamil Nadu) and 16 including three varieties occur in Andaman and Nicobar Islands. Two species, namely *M. edule* and *M. ovatum* are widely distributed in different parts of India (Das *et al.* 2018a, b). The genus *Memecylon* was proposed by Linnaeus based on *M. capitellatum* as type species, the specimen of which was collected from Sri Lanka (Ceylon). *Memecylon* is a Greek word meaning 'edible fruit' of strawberry trees. The members of the genus are evergreen and predominantly woody shrubs and some of them are small to medium sized trees (figure 1). The flowers are characteristically coloured from white to blue and hence *Memecylon* is called as 'blue-mist' genus.

Memecylon species are generally distributed in all types of habitats ranging from deciduous, semi evergreen, evergreen and montane sholas with a wide range of altitude from sea level to 2500 m. Several species are economically important as they are used for timber, ornamental, and medicinal purposes (Sivu *et al.* 2012; Stone 2014). The species are variable in nature and often the morphological key developed by the conventional taxonomy is of limited use in determining the species resulting in taxonomic ambiguity in many taxa.

The characters which have been used by the traditional taxonomists like floral characters are not much variable and

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VIEWS AND EXPRESSIONS

Ornamental potential of *Gentiana kurroo* could be a Boon for its survival: a Critically Endangered species

Gentiana kurroo Royle is one of the highly medicinal and threatened plants of Western Himalaya with its restricted distribution in few localities of India, Pakistan and Afghanistan. In India, the species is reported from a very few disjunct populations in Uttarakhand, Himachal Pradesh and Jammu & Kashmir (Garg, 1987; Ved *et al.*, 2015). The species is mainly being exploited for its medicinal roots and marketed by the trade name "Indian Gentian". It is used in the treatment of cough, stomach disorders, jaundice, fever, etc. and is the source of bitter glycosides (gentiopicrin and gentianin) and alkaloids (gentiomarin) (Sharma *et al.*, 2014). It is medicinally used as an antiperiodic, expectorant, antibilous, astringent, stomachic, anthelminthics, blood purifier and carminative (Kirtikar and Basu, 1935) besides this it is also used as veterinary medicine (Kaul, 1997).

Earlier the species was reckoned as common in the Western Himalayas, but in the recent few decades populations of the species are dwindling from its natural habitats and consequently became extremely rare (Clarke, 1883; Sastri, 1962). The unabated exploitation of species from wild has rendered the species near to extinction vortex (Garg, 1987). Considering the magnitude of threats on its natural population, *G. kurroo* has been listed as 'Critically Endangered' by IUCN (Ved *et al.*, 2015).

Gentiana kurroo is a microclimatic species and grows only on exposed, dry, barren and calcareous rocky slopes. The specialized habitat requirement of the species further increases the magnitude of threats manifold and decreases the regeneration potential of the species. Habitat destruction of *G. kurroo* is also one of the prominent causes for its population shrinkage. It was personally observed during the field surveys that the rocky habitats of species are illegally being mined as a raw material for the cement industries. Situation further becomes grim when it was observed during the field surveys that the species has been completely wiped out from some of the earlier reported localities in Uttarakhand, including the type locality near Mussoorie.

Fig. 1: Rhizome size of *Gentiana kurroo* plants after 3-years of growth: (a) wild plant (b) cultivated plant.

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JARMAP

Applicability of Start Codon Targeted (SCoT) and Inter Simple Sequence Repeat (ISSR) markers in assessing genetic diversity in *Crepidium acuminatum* (D. Don) Szlach.

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ABSTRACT

Crepidium acuminatum is extensively used in the Indian traditional system of medicine and being over-harvested from natural habitats which have caused great damage to its population and species diversity. Despite its high medicinal importance, not much information is available on its genetic and conservation studies. The present study focuses on assessing the genetic diversity and population structure of *C. acuminatum* from the Middle and Lower Himalayas. Start Codon Targeted Polymorphism (SCoT) and Inter Simple Sequence Repeats (ISSR) markers were used to assess the diversity within and among all the populations. Thirteen SCoT primers amplified 73 fragments with 97.26 % polymorphism, whereas, 10 ISSR primers amplified 45 fragments with 91.33 % polymorphism. Analysis of Molecular Variance (AMOVA) revealed higher intra-population (SCoT = ISSR = 61 %) than inter-population diversity (SCoT = ISSR = 39 %). Maximum diversity was observed using SCoT and ISSR markers in the populations from Uttarakhand (Tehri and Gothara respectively) and the least diversity was recorded in populations from Himachal Pradesh (Solan and Kasauli respectively). Grouping patterns obtained by STRUCTURE analysis separated populations collected from North and Northeast India into different groups. Genetic diversity and population structure were found to be directly correlated to the altitudinal range and anthropogenic activities. The results showed usefulness of dominant markers in genetic diversity assessment and conservation of *C. acuminatum*.

1. Introduction

Crepidium acuminatum (syn. *Malaxis acuminata* D. Don), commonly known as Jeevak, is a perennial terrestrial orchid that occurs in a temperate climate. The species is reported from Australia, Bhutan, Cambodia, China, India, Indonesia, Java, Malaysia, Myanmar, Nepal, Philippines, Thailand, and Vietnam (Seth and Kandel, 2020). In India, it is mainly present in north-eastern and north-western Himalaya at a varying elevation of 1500–2400 m (Chauhan, 1999; Balkrishan et al., 2012; Thakur et al., 2018).

C. acuminatum is a significant component of a polyherbal formulation 'Astavarga' (Singh et al., 2017). Astavarga is a group of eight medicinal plants, used in Ayurveda for preparing Chyawanprash. It is sold in the market and used against cough, cold and other infections and it re-vitalizes the body's natural immunity. Chyawanprash is proved to have radioprotective, cytoprotective, genoprotective, antimutagenic and anticarcinogenic effects (Sharma et al., 2019). The plant is known to treat tuberculosis and is also used as an aphrodisiac (Sharma et al., 2014). Its pseudobulbs are sweet and refrigerant, which aids in the smooth functioning of the circulatory, digestive nervous, and respiratory systems (Sharma et al., 2011). Pseudobulbs contain alkaloids, glycoside, flavonoids, β-sitosterol, piperitone, methylbetanin, 1,8-cineole, citronellal, eugenol, glucose, rhamnose, citral, limonene, p-cymene and cetyl alcohol which are useful for curing haematemesis, seminal weakness, burning sensation, dipsia and emaciation (Sharma et al., 2011; Balkrishan et al., 2012; Deb and Arenmongla, 2013). The decoction of

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A new species of *Sauromatum* (Araceae) from North-East India

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पूर्वोत्तर भारत से *सौरोमेटम* (एरेसी) की एक नवीन जाति का अन्वेषण

उमेशकुमार एल. तिवारी, रोहन मैती एवं सुधांशु शेखर दास

सारांश

भारत के अरुणाचल प्रदेश से सौरोमेटम (एरेसी – एरिई) की एक नवीन जाति को अन्वेषित एवं वर्णित किया गया है। इसकी सही एवं सरल पहचान हेतु विस्तृत वर्णन, डिजिटल छायाचित्र, निकट समवर्ती जातियों से इसके आकारिकीय लक्षणों की तुलना एवं वैश्विक स्तर पर पाये जाने वाली जातियों पर आधारित कृत्रिम कुंजी भी दी गई है।

ABSTRACT

A new species of *Sauromatum* (Araceae: Areae) is described here from Arunachal Pradesh, India. Detailed description, digital photographs, comparison of morphological characters with closely allied species and artificial key for globally found species is provided for easy identification.

Keywords: Areae, Arunachal Pradesh, Eastern Himalaya, *sp. nov.*

INTRODUCTION

The genus *Sauromatum* Schott (1832: 17) of family Araceae comprises of *c.* 10 species (POWO, 2021) distributed in Tropical Africa, Tropical & Subtropical South-East Asia—Bangladesh, Bhutan, China, Combodia, India, Indonesia, Myanmar, Nepal, Thailand and Vietnam (Hooker 1893; Hetterscheild & Boyce 2000; Hetterscheild & al., 2001; Heng & Hetterscheild 2010; Cusimano & al., 2010; Boyce & al., 2012). Since the publication of Flora of British India (Hook.f., 1893), no significant additions have been made on the genus *Sauromatum* from Indian perspective till last decade. During the past one decade one new species *Sauromatum meghalayense* D.K. Roy & al. has been described from Meghalaya, India (Talukdar & al., 2014) and one new distributional record (*Sauromatum horsfieldii* Miq. (1856: 196) is from Nagaland (Odyuo & al., 2015) has been made for Indian flora. *Sauromatum diversifolium* (Wall. ex Schott) Cusimano & Hett. (2010: 445) and *Sauromatum venosum* (Dryand. ex Aiton) Kunth (1841: 281) are reported from Arunachal Pradesh (Nangkar & Tag 2018, 2019; Roy 2018) as new addition for the state flora. Sasikala & al. (2019) reported 50% worldwide representative of the genus *Sauromatum* are occurring in India.

During our recent field exploration in Papum Pare district of Arunachal Pradesh, India, an interesting plant of the genus *Sauromatum* Schott (1832) was collected.

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Revisiting the systematics of sect. *Butomissa* (genus *Allium*, subgenus *Butomissa*) based on morphological and molecular evidences

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Abstract

The subgenus *Butomissa* (Salisb.) N. Friesen of the genus *Allium* L. is consisting of two sections, *Butomissa* and *Austromontana*. The subgenus is represented by four species. Present study derives results from morphology and molecular phylogenetic analyses to test the relationship between *Allium ramosum* and *A. tuberosum* of the section Butomissa. Results reveal that *Allium ramosum* and *A. tuberosum*, found to be in polytomy using molecular markers *trnL-F* and ITS in individual as well as combined analysis. Morphological results also reveal little to no variation. Based on the results obtained we propose that *A. tuberosum* may be treated as synonym of *A. ramosum*.

Key words: *Allium tuberosum, A. ramosum*, Subgenus *Butomissa*, Synonymisation

INTRODUCTION

The genus *Allium* L. (Amaryllidaceae) includes *ca.* 10 subgenera and 850 species (Khassanov & Yusupov 2022) and is one of the largest petaloid monocotyledonous genera (Herden *et al.* 2016; Fritsch *et al.* 2010). In India the genus is represented by *ca.* 42 species which are distributed in western Himalayan region as well as in eastern Himalayan region. In the western Himalayan region *Allium* is represented by *ca.* 19 species (Murthi 2001) distributed in Jammu & Kashmir, Ladakh, Himachal Pradesh and Uttarakhand. *Allium* species are well known for their pungent odor and flavor which are due to the presence of Cysteine sulfoxides (Friesen *et al.* 2006).

The genetic diversity among different species within the genus is demonstrated through many morphological, physiological, genetic and reproductive adaptations (McNeal & Ownbey 1973; Ernst 1979; Nault & Gagnon 1988; Kamenetsky & Gutterman 2000; Kamenetsky & Rabinowitch 2006; Phillips *et al.* 2008).

The taxonomy of *Allium* is controversial in having a large number of synonyms and infra-generic groupings (Klaas 1998). The infra-generic classification in *Allium* was given by Linnaeus (1753) in which he accepted 30 species in three alliances. Based on phylogenetic data, Friesen *et al.* (2006), proposed a new classification of *Allium* which consists of 15 subgenera and ca. 780 species. During past three decades, several attempts have been made to utilize the morphological and anatomical data to infer evolutionary relationships in the genus *Allium* (Hanelt *et al.* 1992; Khassanov & Fritsch 1994; Khassanov 1997; Mes *et al.* 1997; Gregory *et al.* 1998).

Molecular approaches using plastid DNA and nuclear ribosomal DNA sequences are emerging as a most reliable study in understanding the evolutionary as well as taxonomic details within a genus (Li *et al.* 2010). A first step in this field for *Allium* was undertaken by Linne von Berg *et al.* (1996). Later on, molecular studies in the genus *Allium* was focused on classification and phylogeny by Mes *et al.* (1997); He *et al.* (2000); Fritsch & Friesen (2002) and Friesen *et al.* (2006).

Conference papers Abstract 1

AP/P-17

Multiple Shoot Induction in Shoot Tip and Axillary Bud Explants of *Sophora mollis* (Royle) Baker

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Sophoramollis (Royle) Baker (Fabaceae) is a multipurpose legume distributed in plains and foothills of the North West Himalaya to Nepal Himalaya and is facing high risk of extinction due to habitat loss and exploitation by the local people for its fuel and fodder values. The situation is further aggravated by the poor seed germination and regeneration potential of the species. Therefore, to overcome this problem advance method of micropropagation is considered as an effective tool for the conservation and consequently to reduce the pressure on natural stock. The present study was conducted to standardize the micropropagation protocol for *Sophoramollis* by using shoot tip and axillary bud as an explants. Multiple shoots were induced in shoot tip and axillary bud explants in Murashige and Skoog (MS) medium fortified with different cytokinins alone (BAP, TDZ & Kinetin) and in combination with varying concentrations of NAA. Axillary bud inoculated onto MS medium fortified with BAP (8.80 µM) was observed as the most suitable explant for the multiple shoot induction and maximum 55 shoots per explant was obtained with average length of 4.5 cm.

Keywords: Axillary buds; Micropropagation, Shoot tip, *Sophoramollis*, Threatened.

Abstract 2

PP-T4-30

Rhododendron diversity along altitudinal gradient of Dzongri Gocha La Landscape, Sikkim

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In Sikkim, *Rhododendron* speceis distributed in higher altitudes preferable within protected areas. Members of this genus play a considerable role in maintaining ecological stability in higher ecosystems and known for their phenological sensitivity. The present study highlights the Rhododendron diversity in the Dzongri Gocha La landscape of eastern Himalaya in India along altitudinal range from 3000 to 4500 m asl. Altitude regulate the pattern of biodiversity elements, and provides very effective natural experimental circumstances to understand ecological and evolutionary responses of a species to environmental changes. In case of the Eastern Himalayan, vegetation and microclimatic condition varies significantly from low to high altitude zone that also affect the population structure of tree speceis. Present day many of the *Rhododendrons* speceis declining in their natural habitat due to high tourist influx and habitat fragmentation in Dzongri-Gocha La landscape. Therefore, an urgent attention is needed for conservation of this beautiful species for livelihood generation through eco-tourism in high altitudes. Hence, the present study was targeted to understand the pattern of Rhododendron diversity along representative altitude transects (3000 to 4500 m asl) in Dzongri-Gocha La landscape of West Sikkim. By following the methodical approach, sample sites were alienated at each 300 m interval (altitude bands). A total 50 plots (20 m x 20 m; containing 200 random quadrats for saplings and undershrub, 400 quadrats for seedlings) were assessed using standard phytosociological methods. A total 17 species of *Rhododendrons* were recorded of which two species *R. grande* Wight and *R. lanatum* Hook. f. are endemics to eastern Himalaya. The tress density tended to decrease with increasing altitude (range varied from 87.5 ind/ha to 227.5 ind /ha, recorded lowest at 4100–4400 m asl. (Treeline) and highest at 3000–3300 m asl.). Total basal cover ranges from 3.10 (4100–4400 m asl.) to 15.23 m^2/ha (3000–3300 m asl.).

Abstract 3

APSC-O | 14

Structural and floristic diversity of two alpine landscape of Eastern Himalaya in special reference to threat assessment of selected floristic elements

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The study was undertaken to assess the structural and floristic diversity in selected landscape i.e., Dzongri Goecha La area of west Sikkim and Kyongnosla Alpine Sanctuary of east Sikkim. Both areas are situated in Kanchenjunga landscape apart from 200 km distance. They share significant amount of floristic elements but also differ in some due to different microclimatic conditions, varied topography and nature of habitat degradation. In Dzongri Goecha La, a total of 254 plant species belonging to 151 genera and 47 families was recorded while Kyongnosla Alpine Sanctuary was represented by 269 species belonging to 138 genera and 51 families. Recent studies are indicating that the biodiversity of these two landscapes has been increasingly threatened due to various anthropogenic activities, unsustainable practices, waste generation, habitat degradation and climate change. Hence an integrated scientific approach is the need of the hour to understand the complexity of diversity of these two fragile Himalayan landscapes, development of protocol for assessment of threatened species, prioritization of areas for conservation of RET species. Keeping view this, the study was conceived and executed for the documentation of the biodiversity of these area and asses the threat of selected species. The data on species richness, composition and number of individuals, height and DBH were collected. Community structure in terms of species richness, diversity (Shannon and Simpson), abundance, composition and association of species in each landscape elements. An inclusive threat assessment was undertaken according to "IUCN criteria B" for twelve selected species belonging to ten genera and eight families. Out of twelve studied species, ten species were categorized as 'Endangered', and rest of the species categorized as 'Vulnerable' at regional level. The area of occupancy and extent of occurrence of each of the species were calculated based on geo-coordinate data and projected in GeoCAT for rapid geospatial analysis of each of the species.

Abstract 4

Plant Diversity of Dzongri-Gocha La Region in Sikkim Himalaya

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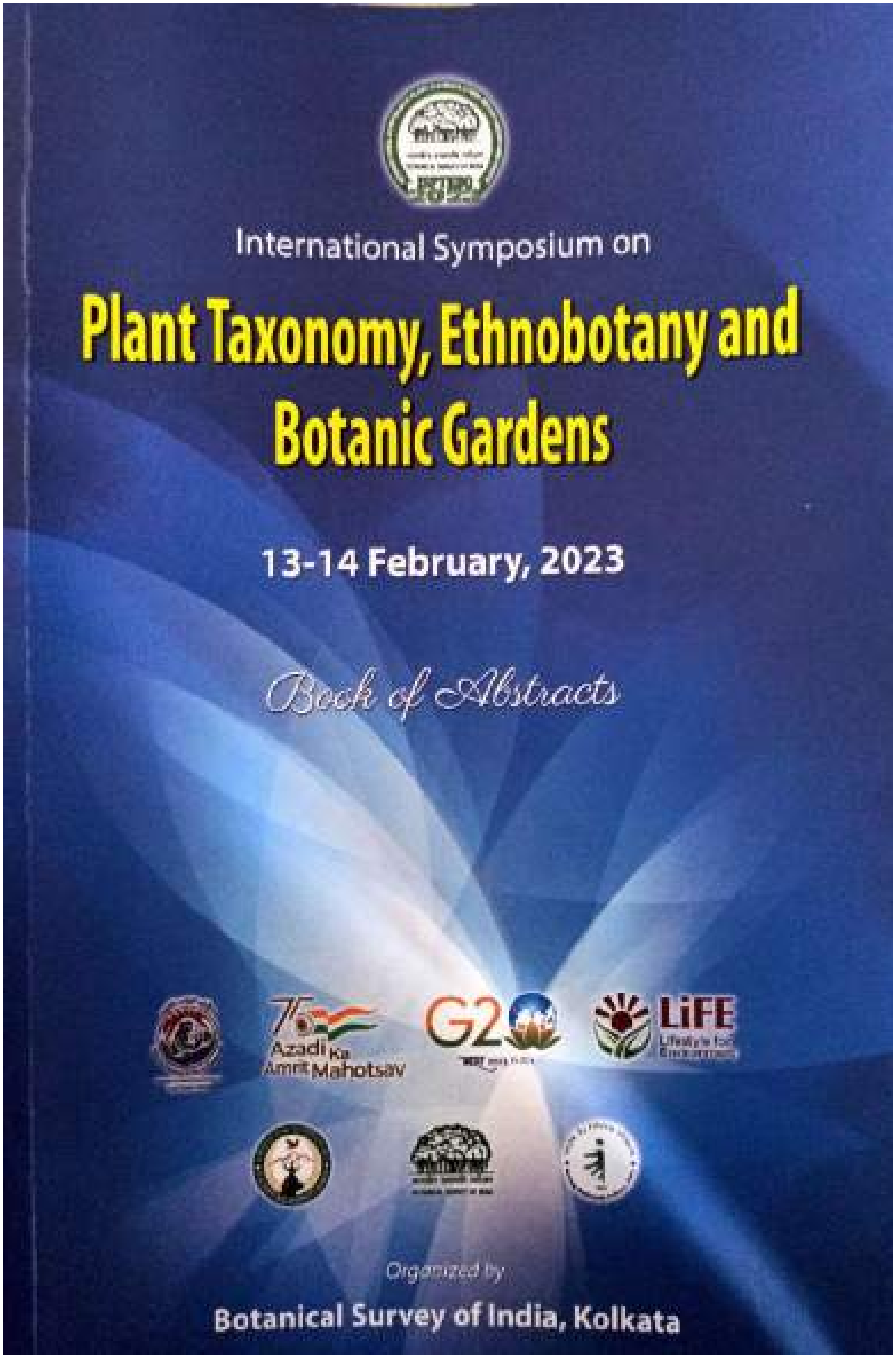
Dzongri-Gocha La region in the west district of Sikkim encompasses an are of 90 sq. km located between 3000 to 5000 m. The region is one of the uniq alpine ecosystems of Sikkim Himalaya bestowed with rich and diverse flor The area shares boundary with 3 adjacent countries i.e. China, Nepal an Bhutan. Thus, there is a great influence of different floristic elements of thes adjacent countries. This region also a part of Kanchenjunga Biosphere Reserv which is declared as a world heritage site by UNESCO in 2018.

During our study, Biodiversity Assessment through Long-term Monitoring Plots in Indian Himalayan Landscape, we have undertaken three explorator tours and collected 203 plant species belonging to 48 families and 117 gener Analysis of our collection shows that Ericaceae is the most dominated famil followed by Rosaceae, Polygonaceae, Primulaceae, Gentianaceae etc. Th investigation also revealed that these areas share high repository of vario medicinal plants viz., *Bergenia purpurascens* (Hook.f. & Thomson) Eng *Nardostachys jatamansi* (D. Don) DC., *Rheum nobile* Hook.f. & Thomson, *Saussu obvallata* (DC.) Edgew.etc.The study also reports one new distribution record India, one distribution record to Sikkim and 22 new distribution records fo biosphere reserve. However, this region faces heavy anthropogenic pres particularly from tourism, overgrazing and over-exploitation of plant ge resources. Therefore, our assessment on quantitative and qualitative stud this region is very much significant to understand the changing pattern of flora or any altitudinal shift in view of the recent climatic changes


International Symposium on
Plant Taxonomy, Ethnobotany and Botanic Gardens
13-14 February, 2023
Book of Abstracts
Azadi Ka Amrit Mahotsav
G20
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Botanical Survey of India, Kolkata

Abstract 5

CR/O-32

Threatened Plant Conservation in Western Himalaya: An Initiative and Approach

Amber Srivastava*[1], Puneet Kumar[1], Giriraj Singh Panwar[1] and A. A. Mao[2]

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India is one of the 17 mega biodiverse countries of the world and one of the five in Asia harboring c 10.5 percent of the world's total floral diversity. At present,India represents c 49,003 species of plants distributed in its various geographical regions,of which nearly 28% taxa are endemic to the country and confined their distribution in Western Ghats, North-West Himalayas, North-East India, and Andaman & Nicobar Islands. The Indian Western Himalaya (IWH) being one of the three mega-centres of endemism in the country constitutes nearly 297 endemic flowering plant species.

In recent years, habitat loss due to anthropogenic activities and other natural causes has resulted in the immense loss of biodiversity. Many species have become threatened and several are on the verge of extinction. Some of the species were overexploited to meet the commercial demand and uncontrolled collection from wild has resulted in rapid decrease of their population, thus demanding an urgent need of conservation initiatives for their survival in natural habitats.

The present study is carried out for the conservation of such threatened plants of Indian Western Himalayan region and their restoration practices. During the study, the targeted species viz., *Aconitum heterophyllum*Wall. ex Royle, *Gentiana kurroo*Royle, *Jasminum parkeri*Dunn, *Indopiptadeniaoudhensis*(Brandis) Brenan, *Sophora mollis* (Royle) Baker, etc. were relocated in their natural habitats and propagating materials were collected for mass propagationalong with other relevant data required for threat assessment of these species. Further, their specific habitat requirement, growth pattern, regeneration potential andpropagation methods werealso studied to develop a species recovery protocol. Attempts were made for the reintroduction of the propagated saplings in their suitable habitat marked through Ecological Niche Modeling. The local communities which are directly associated with these species were also involved and initiatives were taken to inculcate the feeling of conservation and sustainable use of these natural resources.

Key words: Conservation, endemic, threatened, Western Himalaya.

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Abstract 6

OP-7-07

Phytochemical screening and HPLC/LC-MS analysis of leaf extract of *Illigera grandiflora* (Hernandiaceae), a lesser known medicinal plant from Northeast India

Deepu Vijayan[1], Nripemo Odyuo[1], David L Biate[1], Dilip Kr Roy[1], Ashutosh Pathak[1*], Rahul Das[1] & A.A. Mao[2]
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Northeast India, being a biodiversity hot spot, harbors many plant species of medicinal value which are utilized in traditional system of medicine. Traditional knowledge leads mankind towards the discovery of new compounds and their mode of action as therapeutic agents. *Illigera grandiflora* W.W.Sm. & Jeffrey (Hernandiaceae) tubers and leaves are used traditionally in China to treat dropsy and traumatic injury. In the present study, *I. grandiflora* was evaluated for phytochemical compounds, antioxidant activities and *in silico* pharmacokinetic properties calculated for the identified compounds. Qualitative phytochemical analysis of this plant confirms the presence of various compounds like proteins and amino acids, carbohydrate, tannins, flavonoids and alkaloids. Compounds were identified from the leaf extract using HPLC/LC-MS method *via* Waters UPLC-TQD Mass spectrometer. HPLC/LC-MS analysis of methanolic extract of *I. grandiflora* leaves reveal the presence of thirty-four compounds. This is the first report on the antioxidant properties and phytochemical studies of *I. grandiflora* from India.

OP-7-08

Purification of a glucose-binding seed lectin from *Leucaena leucocephala* and its fluorescence polarization studies

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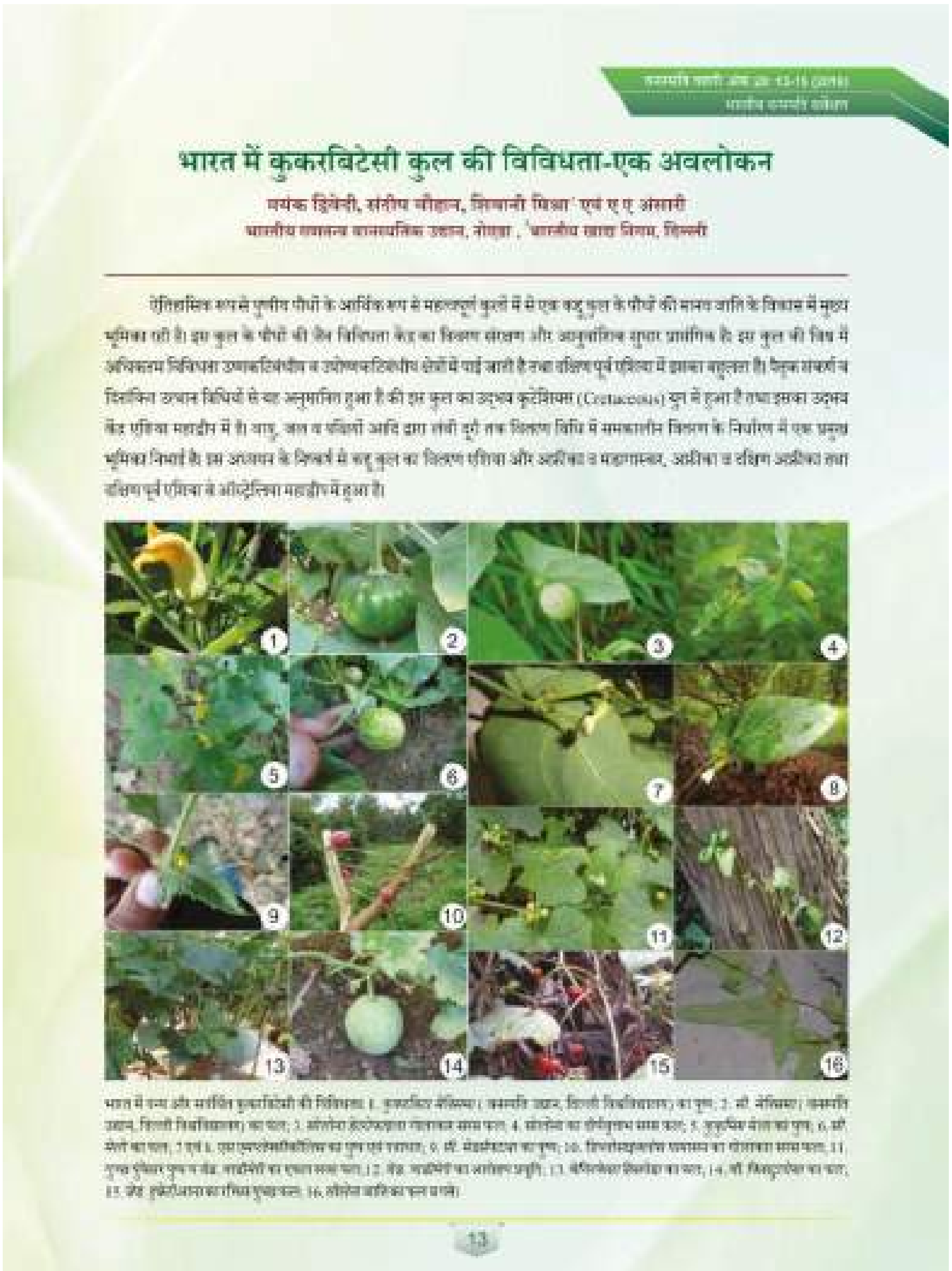
Lectins are a specialized group of proteins with immense biological properties and applications. This particular study describes the purification and characterization of a lectin from the seeds of *Leucaena leucocephala* (Lam.) de Wit, a plant belonging to Fabaceae family utilized

Popular Hindi Articles



भारत में कुकरबिटेसी कुल की विविधता-एक अवलोकन

मयंक द्विवेदी, संदीप चौहान, शिवानी मिश्रा[1] एवं ए.ए. अंसारी

भारतीय वनस्पति सर्वेक्षण वानस्पतिक उद्यान, नोएडा, [1]भारतीय खाद्य निगम, दिल्ली

ऐतिहासिक रूप से पुष्पीय पौधों के आर्थिक रूप से महत्वपूर्ण कुलों में से एक कद्दू कुल के पौधों की मानव जाति के विकास में मुख्य भूमिका रही है। इस कुल के पौधों की जैव विविधता केंद्र का विवरण संरक्षण और आनुवंशिक सुधार प्रासंगिक है। इस कुल की विश्व में अधिकतम विविधता उष्णकटिबंधीय व उपोष्णकटिबंधीय क्षेत्रों में पाई जाती है तथा दक्षिण पूर्व एशिया में इसका बाहुल्य है। पैतृक संबंधों व तिथिकित उत्थान विधियों से यह अनुमानित हुआ है की इस कुल का उद्भव क्रेटेशियस (Cretaceous) युग में हुआ है तथा इसका उद्भव केंद्र एशिया महाद्वीप में है। वायु, जल व पक्षियों आदि द्वारा लंबी दूरी तक वितरण विधि ने समकालीन वितरण के निर्धारण में एक प्रमुख भूमिका निभाई है। इस अध्ययन के निष्कर्ष में कद्दू कुल का वितरण एशिया और अफ्रीका व मेडागास्कर, अमेरिका व दक्षिण अमेरिका तथा दक्षिण पूर्व एशिया से ऑस्ट्रेलिया महाद्वीप में हुआ है।

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वनस्पति वाणी अंक 28: 65-69 (2019)
भारतीय वनस्पति सर्वेक्षण

वानस्पतिक यात्रा

गोचा-ला ट्रेक: सिक्किम, हिमालय की गोद में एक वानस्पतिक स्वर्ग

सुभोजीत लाहिड़ी, सुधांशु शेखर दाश, विपिन कुमार सिन्हा एवं माधव कुमार झा
भारतीय वनस्पति सर्वेक्षण, कोलकाता

जोंगरी-गोचा-ला सिक्किम, हिमालय की गोद में बसा एक रोमांचकारी ट्रेकिंग गलियारों में से एक है, यह कंचनजंगा बायोस्फियर रिजर्व के उच्चतम पारिस्थितिकी तंत्र में से एक है, जो यूनेस्को की विश्व धरोहर स्थल के रूप में भी दर्ज है। यह पर्वतारोहण के लिए बहुत महत्वपूर्ण स्थान माना जाता है और कई देशी-विदेशी पर्वतारोही इस क्षेत्र में पर्वतारोहण करते हैं, इसलिए स्थानीय अर्थव्यवस्था मुख्य रूप से इकोटूरिज्म पर निर्भर करती है, और यह असंगठित क्षेत्र में ट्रैकिंग गाइड, कुली और कई टूर ऑपरेटरों के रूप में लोगों को रोजगार मुहैया करवाता है।

अब तक हमने इस क्षेत्र में हिमालयी अध्ययन परियोजना पर राष्ट्रीय मिशन के तहत भारतीय हिमालयी लैंडस्केप में दीर्घकालिक निगरानी भूखंडों के माध्यम से जैव-विविधता मूल्यांकन के बारे में हमारे अविरत अध्ययन के संबंध में चार ट्रैक पूरे किए हैं। हमने मुख्य रूप से इस क्षेत्र की जैव विविधता की स्पष्ट तस्वीर प्राप्त करने के लिए मानसून काल और मानसून उपरांत काल में वानस्पतिक सर्वेक्षण किया।

हमारा यह पहला ट्रैकिंग अनुभव ही बहुत रोमांचकारी और कठिन था। इस ट्रैकिंग की दुर्गमता के कारण, हमने अपनी यात्रा को कई दिनों में बांटा। यह वानस्पतिक सर्वेक्षण कॉरिडोर पश्चिम जिले में स्थित सिक्किम की पहली राजधानी युकसोम से शुरू किया गया है। जोंगरी-गोचा-ला ट्रैकिंग कॉरिडोर की ऊंचाई लगभग 1780 से 5000 मीटर तक है। जोंगरी को एक तरफ सिंगाली ला रेंज

वनस्पति वाणी अंक 28: 10-12 (2019)
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क्योगनोस्ला अल्पाइन अभयारण्य : एक संक्षिप्त विवरण

सुभोजीत लाहिड़ी, सुधांशु शेखर दाश, बिपिन कुमार सिन्हा एवं माधव कुमार झा
भारतीय वनस्पति सर्वेक्षण, कोलकाता

भारतीय हिमालयी क्षेत्र में अंतरराष्ट्रीय सीमाओं से सटा और भारत की सामरिक दृष्टि के साथ-साथ जैव विविधता की दृष्टि से महत्वपूर्ण सिक्किम, एक छोटा हिमालयी राज्य है। यह राज्य हिमालय के सबसे ऊंचे पर्वत पारिस्थितिक तंत्रों में से एक होने के साथ ही प्राकृतिक और सांस्कृतिक तौर पर भी महत्वपूर्ण है। इस राज्य ने न केवल जैव विविधता पर आधारित अपनी ग्रामीण आजीविका को बनाए रखा है, अपितु पारिस्थितिकीय और अन्य सतत विकास के दृष्टिकोणों के माध्यम से आर्थिक विकास के लिए अपनी जबरदस्त क्षमता को भी प्रदर्शित किया है। इसी राज्य के उच्च हिमालयी क्षेत्र में स्थित है, क्योगनोस्ला अल्पाइन अभयारण्य, जो सिक्किम में जैव विविधता पर कार्य करने वाले प्रकृति विज्ञानियों और पारिस्थितिकीविदों हेतु एक समृद्ध जैव विविधता वाला क्षेत्र है, साहसिक गतिविधियों जैसे पर्वतारोहण, ट्रैकिंग और हाइकिंग के लिये असीम सम्भावनाओं को लिये यह क्षेत्र अपने अति दुर्गम होने के कारण पर्यटकों के बीच इतना प्रसिद्ध नहीं है।

क्योगनोस्ला अल्पाइन अभयारण्य सिक्किम की राजधानी गंगटोक से 31 किमी की दूरी पर 27°22'35" उत्तरी अक्षांश, 88°44'3" पूर्वी अक्षांश के मध्य 31 वर्ग किमी से अधिक क्षेत्र में विस्तृत है। यह सिक्किम के पूर्वी जिले में 3200 मीटर से 4500 मीटर के बीच यह नाथु-ला रोड के साथ त्सोंगो (चंगु) झील के निकट स्थित है। क्योगनोस्ला वन खण्ड के अंतर्गत आने वाला यह क्षेत्र आरक्षित वनों से घिरा हुआ है, जिसमें थोड़ी थोड़ी दूरी पर छोटे-छोटे गांव बसे हुये हैं।

इस क्षेत्र में मुख्य रूप से सामान्य रिजर्व अभिरक्षा वन (जीआरईएफ) में ग्रामीण शामिल हैं। हालांकि अभयारण्य के आसपास के क्षेत्र को जैव विविधता के संरक्षण के उद्देश्य से केंद्र सरकार द्वारा पर्यावरण-संवेदनशील क्षेत्र (इको-सेंसिटिव जोन) के रूप में अधिसूचित किया गया है। इस क्षेत्र की सीमा क्योगनोस्ला अल्पाइन अभयारण्य की सीमा से 25 मीटर से 200 मीटर तक की दूरी पर है। यहां का तापमान सामान्यतः 7

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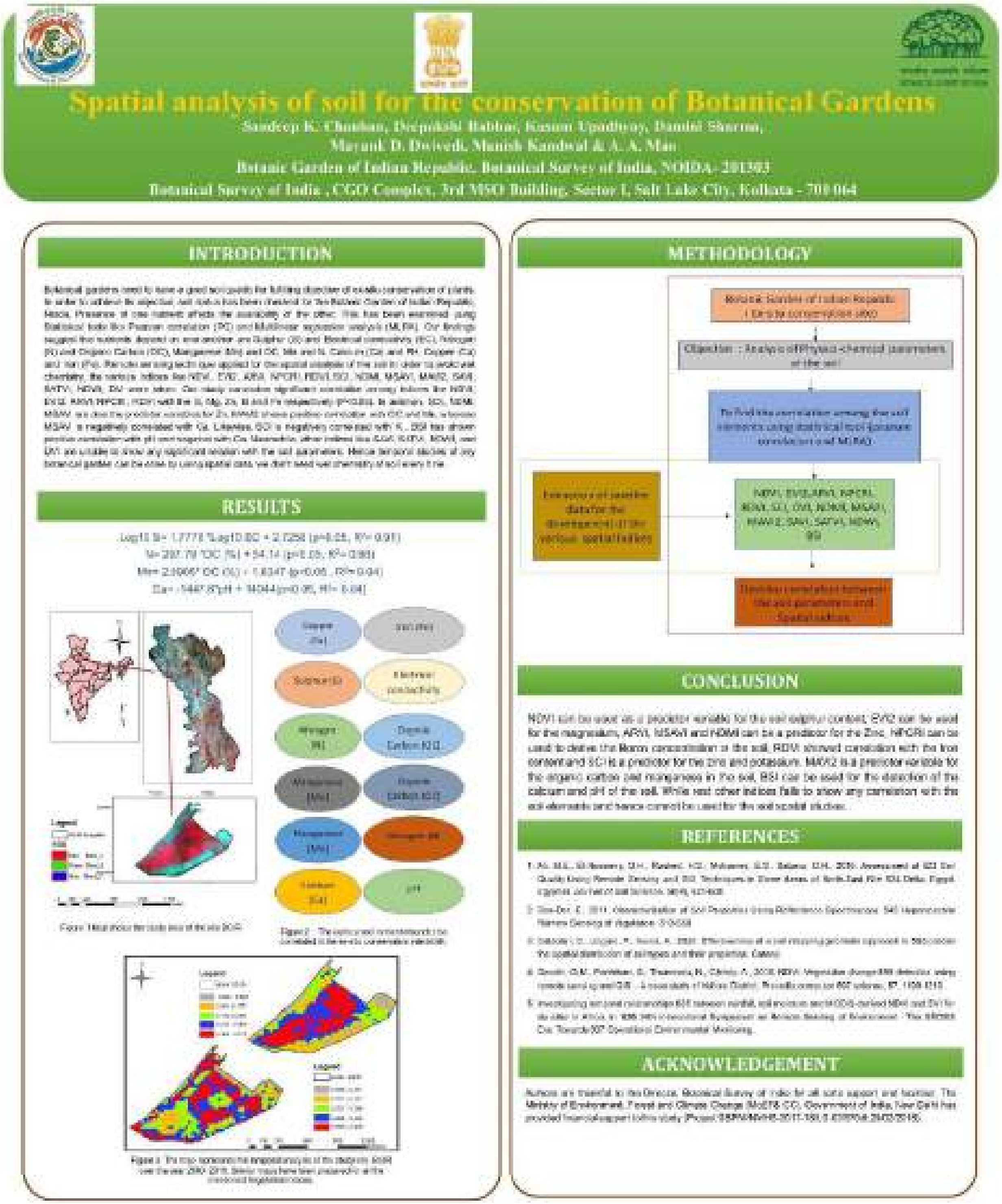
Pamphlets/Posters



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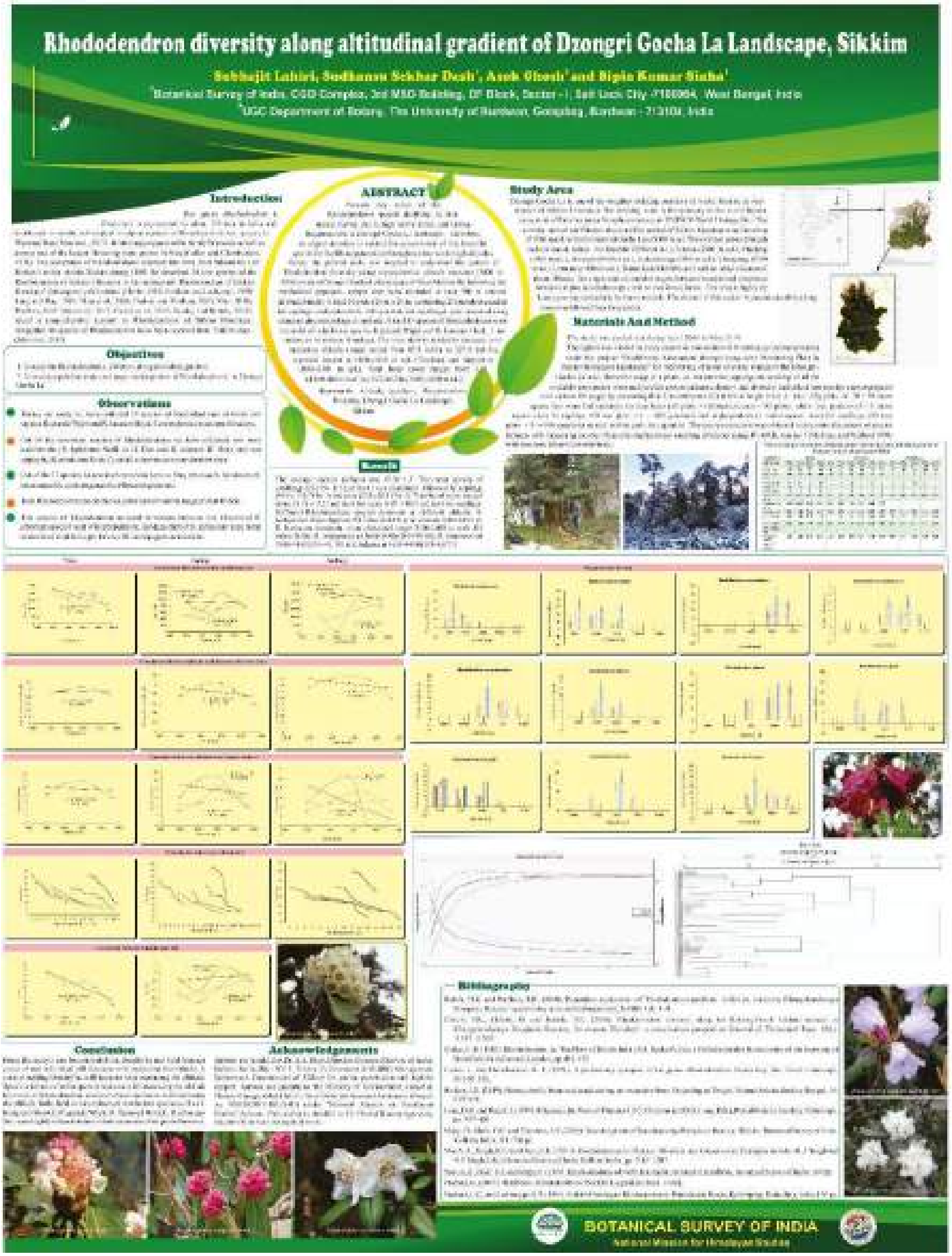

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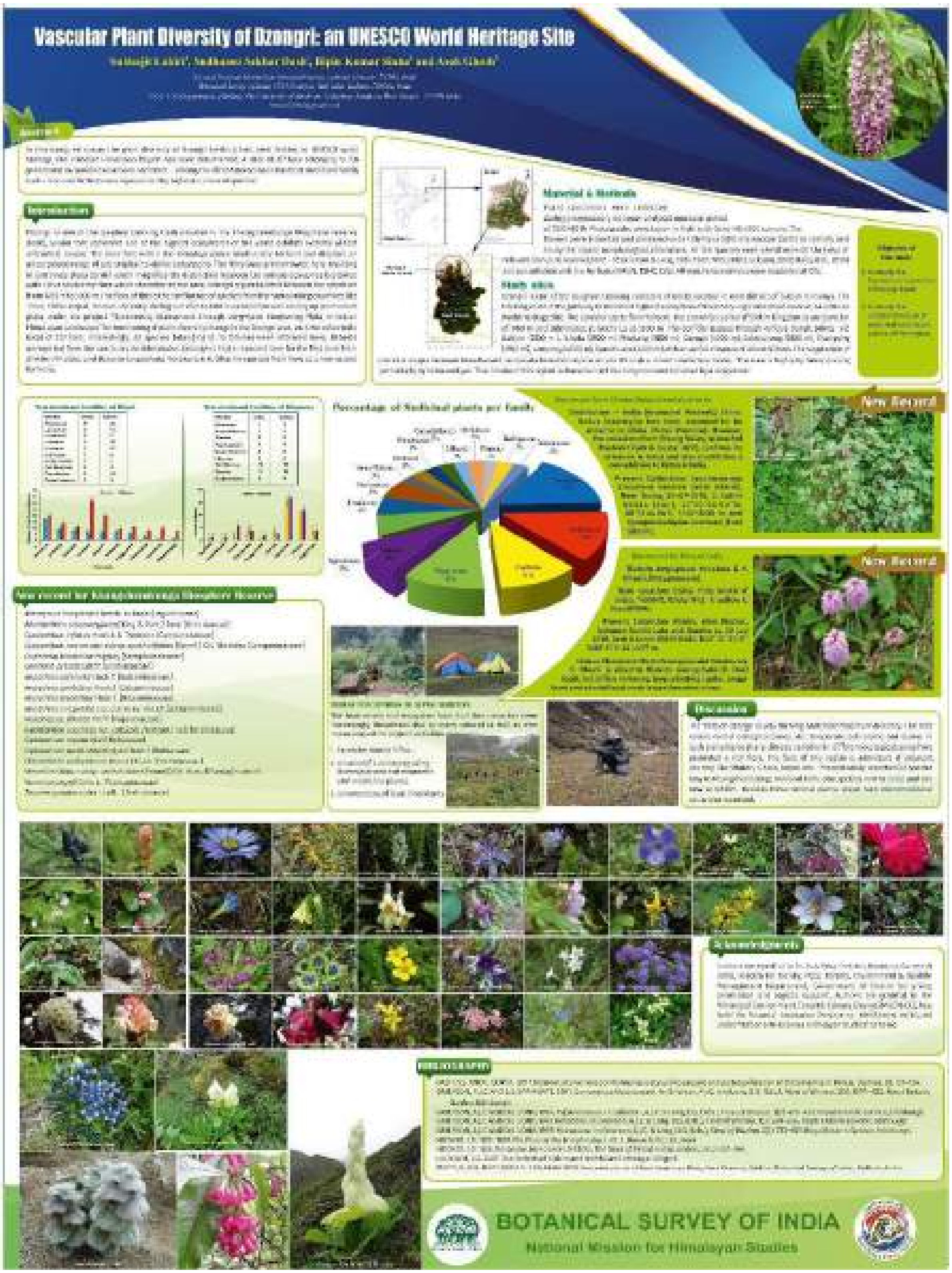

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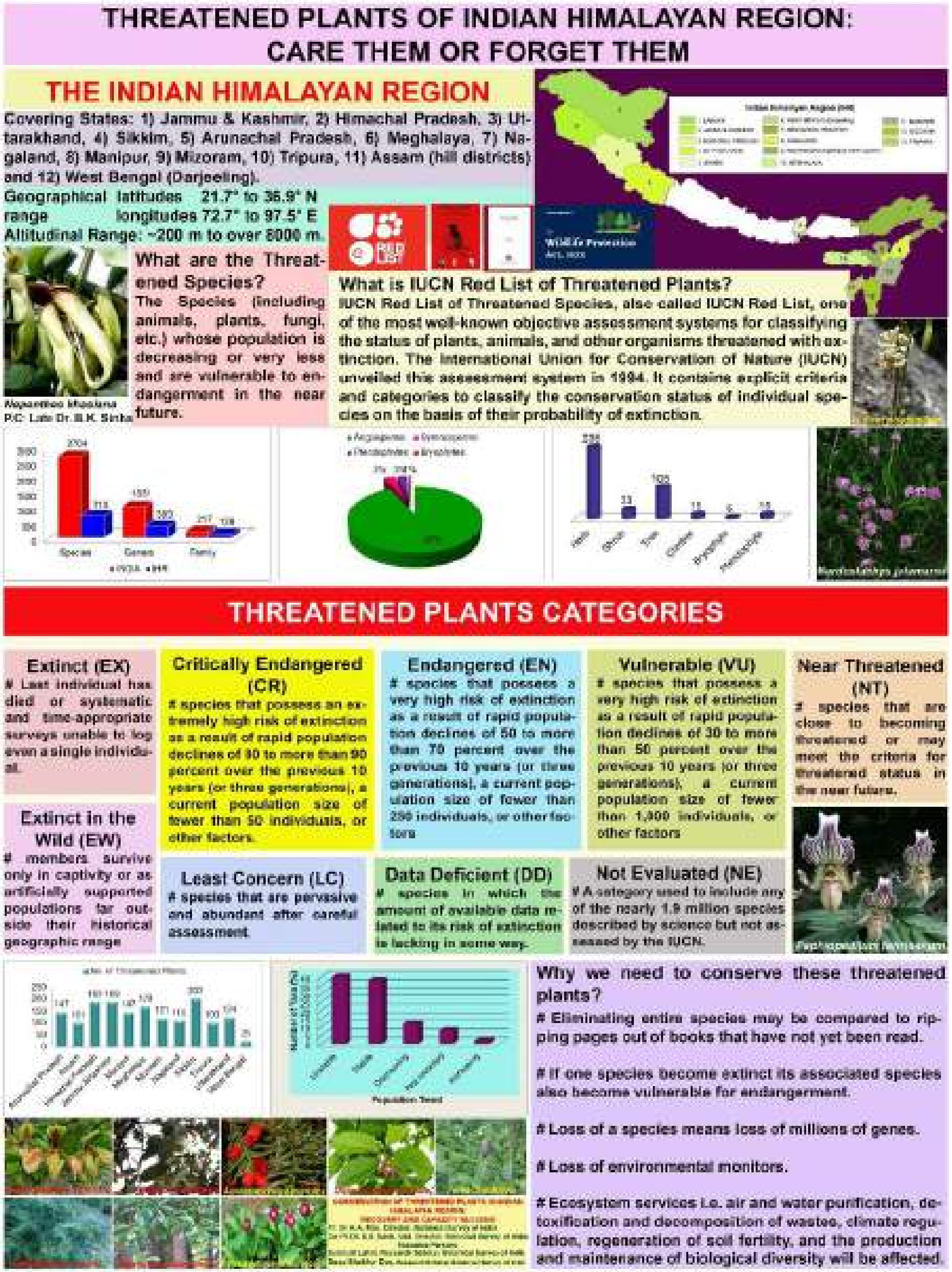
MOLECULAR DATA ANALYSES FOR PLANT TAXONOMY USING **MEGA XI**

MAYANK DHAR DWIVEDI
Research Associate (NMHS)
BGIR, BSI, NOIDA, U.P.

Pamphlets/Posters



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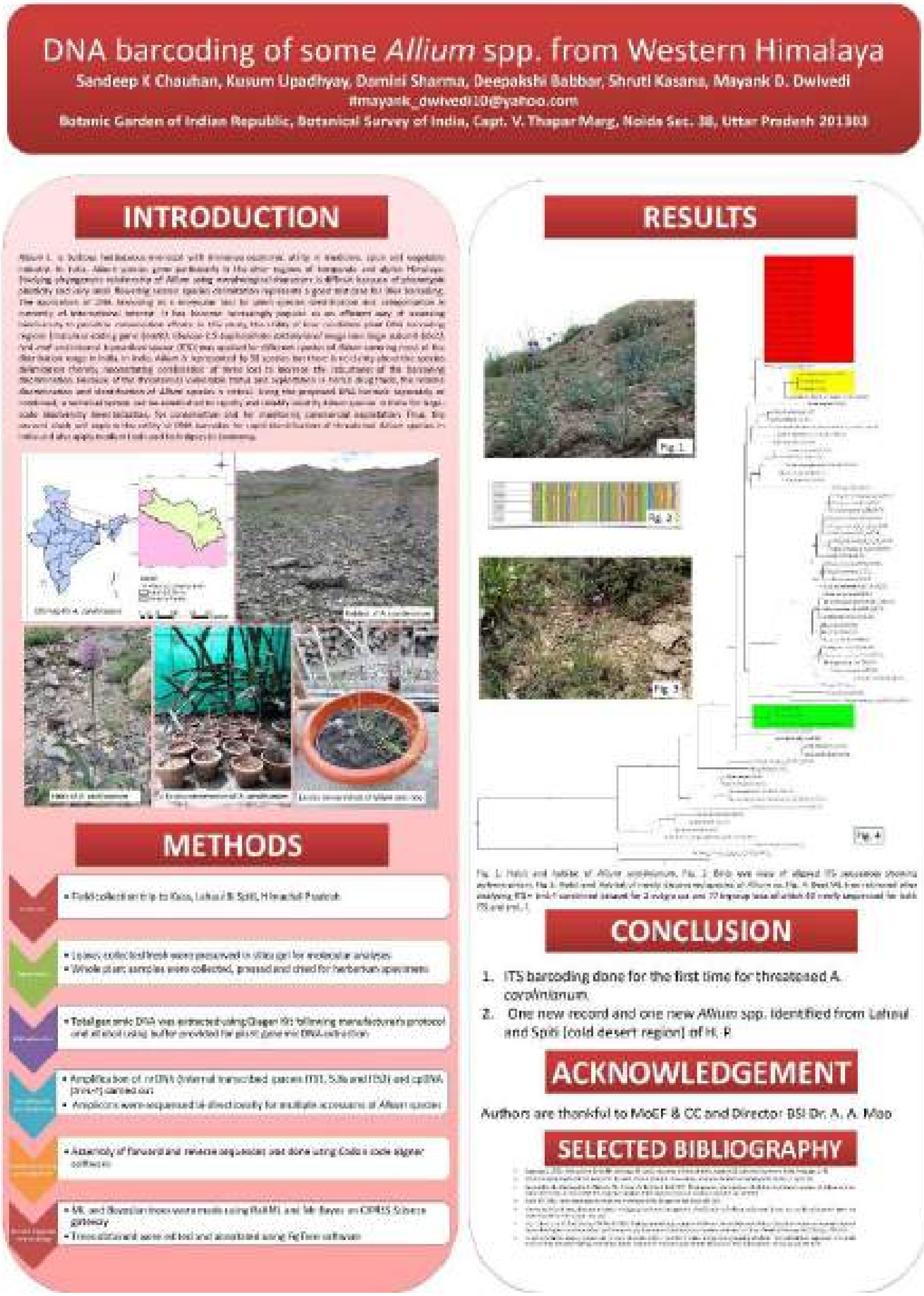

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APPENDIX-3

CAPACITY BUILDING

Awareness and capacity building programmes

9 Environmental Awareness/Capacity Building programmes conducted in 3 different states (Manipur, Nagaland & Meghalaya). A total of 1450 school & college students and farmers/villagers benefited**,** 12 NGOs, 23 local communities/ Village Employment Council and 5 Govt. Organizations benefited.

Sl. no.	Name of the stakeholders in Meghalaya, Nagaland and Manipur	Address
	Awareness programmes	
1.	Various stakeholders during Awareness programme	Laitmawsiang Village, Meghalaya
2.	Martin Luther Christian University for development of Experimental garden	Sohra, Meghalaya
3.	Various stakeholders during World Environment Day celebration	Laitmawsiang, Meghalaya
4.	St. Paul's Sr. Secondary High School during Awareness programme	Nongpoh ,Meghalaya
5.	Various stakeholders during Awareness programme (with Senapati Forest Dept.)	Tadubi, Manipur
6.	Modern College during Awareness programme (with Kohima Forest Dept.)	Kohima, Nagaland
7.	Belfonte Community College during Awareness programme	Nongmensong, Shillong, Meghalaya
8.	Don Bosco School during Awareness programme (with Wokha Forest Dept.)	Wokha Town, Nagaland
9.	Various stakeholders during Awareness programme (with Wokha Forest Dept.)	Pangti village, Nagaland
	NGOs	
10.	Khatarshnong Youth Welfare Organization	Khrang, Meghalaya
11.	Star Cement Ltd.	Lumshnong, Jaintia Hills District, Meghalaya
12.	NGO Mr Tuesday	Shangpung, Jaintia Hills District
13.	Arrupe Charitable Society	Umbir, Meghalaya
14.	East Khasi Hills District Cooperative Milk Union Ltd	Mawiong, Meghalaya
15.	Shillong Bangalee Students Association	Laban, Shillong, Meghalaya
16.	Synjuk Ki Seng Rangbah Katholic Arcchdiocise	Nongthymmai, Meghalaya
17.	Don Bosco Integrated Development society	Nongshilliang, Meghalaya
18.	Ka synjuk ka hima arliang wah	Mawphlang, Meghalaya

	umiam mawphlang	
19.	Iatreilang foundation	Mawphlang, Meghalaya
20.	Forester Eco club	Mawiong Umjapung Meghalaya
21.	Indigenous Agro Tourism Co-operative Society Ltd.	Kongthong, Meghalaya
	Govt. Organization	
22.	BGIR	New Delhi
23.	NEHU, Shillong	Mawlai Mawroh, Meghalaya
24.	CRPF office	Laitumkhrah, Meghalaya
25.	North Eastern Insrtitute of Ayurveda & Homeopathy (NEIAH)	Mawdiangdiang, Meghalaya
26.	Krishi Vigyan Kendra	Upper Shillong, Meghalaya
27.	BSNL	Rynjah, Shillong, Meghalaya
28.	HQ Research development BPO	Shillong, Meghalaya
	Local Communities/ Village Employment Council/ Educational Institutions	
29.	St. George School	Nongmensong, Meghalaya
30.	Thadnongiaw Ri bhoi Seng samla	Thadnongiaw Ri bhoi , Meghalaya
31.	Mr. Mutbhalang wahlang	Siejiong, Meghalaya
32.	Mr. Deisuk Khongngain	Mawprem, Meghalaya
33.	Dorbar Shnong Umphrup	Umphrup, Meghalaya
34.	Mr. Marchester Kharumnuid	Laitkseh, Meghalaya
35.	Dongshyiap VEC	Dongshyiap, Meghalaya
36.	Mr. Phibordro Nongkhlaw	Nongdalum, Meghalaya
37.	Mr Kenes Khonglam	Lumkseh, Meghalaya
38.	Mr. Kobarhun Mynsong	Nonghali, Meghalaya
39.	Mr. Louis Khyriem	Traishnong Mawlynrei, Meghalaya
40.	Mr. Chmen Khonglam	Iewrim Puriang, Meghalaya
41.	Mr. Wanaibok Nongdhar	Nongshiliang, Mawlynrei, Meghalaya
42.	Mr. Riborlang Kharumnuid	Mawmuthoh, Meghalaya
43.	Mr. W Kharbudon	Kynton u Mon, Meghalaya
44.	Mr. Promisestar Nongrum	Mawkathein, Meghalaya
45.	Mr. Nodstar Kharumnuid	Thangshalai, Meghalaya
46.	Mrs. Larihun Kyrsian	Nonglum, Meghalaya
47.	Mr. Cleverington Nongdhar	Mawshbuit, Meghalaya
48.	Mr Farious Mylliempdah	Mawpdang, Meghalaya
49.	Mr Stanley Rymbai	Wapung community, Meghalaya
50.	Mr. Hawni Lapasam	Sakhain, Meghalaya
51.	Mr. Phamborlang Nongrang	Lumphira, Nongmensong, Shillong, Meghalaya
52.	Mr. Janaibha Nongtdu	Dieng shynrum, Meghalaya
	Various local stakeholders Meghalaya, Nagaland and Manipur	
53.	Mr. Openthung	Pangti, Nagaland
54.	Mr. M. Loli Kape	Pangti, Nagaland
55.	Mr. Yamomo	Mao, Manipur
56.	Mr.Anthony B Khongsit	Cantonment Beat House, Shillong, Meghalaya
57.	Mr. James Sylliang	Mawrong, Ri-Bhoi, Meghalaya
58.	Mr.Kami Laloo	Mawngap, Meghalaya
59.	Mr. Vickyson Sten	Lapalang, Meghalaya
60.	Mr. Robert Anthony Dhar	Madanrting, Meghalaya
61.	Mr. Richard Khrawkupar Shullai	Mawlai, Meghalaya

62.	Ms.Lanosha L Nongpiur	Mawlai, Meghalaya
63.	Mr.P.S Lyngdoh	Malki, Meghalaya
64.	Mr. Embhah Ryngnga	Mawlai, Meghalaya
65.	Mr. Rockingham Myrthong	Mawsynram, Meghalaya
66.	Mr. George Kharnaior	Umroi, Nonglum, Meghalaya
67.	Mr. Skhembor Khongjrirem	Wahkhen, Meghalaya
68.	Mr. S.W Nongbri	Mawlai, Meghalaya
69.	Mr. Franky Lamare	Mawiong, Meghalaya
70.	Mr. B.S Lyngdoh	Shyiap Langkyrding, Meghalaya
71.	Mrs. Rikyni Marbaniang	Meghalaya
72.	Mrs. Margreta Suting	Dhankheti, Meghalaya
73.	Ms. Jubanlyne Kharbuki	Mawpat, Meghalaya
74.	Mr. Gareth M Nongkynrih	Risa colony, Meghalaya
75.	Mr. S.P Nongbet	Umtrew, Meghalaya
76.	Mr. Brifate Vanguea	Pynthorumkhrah, Meghalaya
77.	Mr. Lamphrang Nongrum	Laitkor, Meghalaya
78.	Mr. Lam Nongsiej	Riatsamthiah, Meghalaya
79.	Mr. Glorious Dohtdong	Lawmei, Meghalaya
80.	Mr. Phyrnai Tynsong	Wahkhen, Meghalaya
81.	Mrs. Phila Kharsarti	Mawlai, Meghalaya
82.	Mr. David R Ryntathiang	Mawlai, Meghalaya
83.	Mrs. Ibarilin Kharsati	Umtham, Meghalaya
84.	Mrs. Nepaia Papeng	Umshing, Meghalaya
85.	Mr. Charlington Kharumlong	Mawlai, Meghalaya
86.	Mr. E.W Thabah	Sohiong, Meghalaya
87.	Mr. Iashanlang Dunai	Mawroh, Meghalaya
88.	Mrs. P Suting	Nongmensong, Meghalaya
89.	Mrs. Milimon Ryntathiang	3rd Mile, Meghalaya
90.	Mr. Jackson Marbaniang	Mawpat, Meghalaya
91.	Mrs. Durga Chettri	Nongmensomg, Meghalaya
92.	Mrs. Lucy Lumlin Sawian	Laitumkhrah, Meghalaya
93.	Mrs. Sinta Mary Thabah	Shillong, Meghalaya
94.	Mr. S Mawrie	Laitumkhrah, Meghalaya
95.	Mr. A.L Hek	Rynjah, Meghalaya
96.	Mrs. Pakhabakordor Khongsni	Wahkhen, Meghalaya
97.	Mr. Manchestar Kharumnuid	Laitkseh, Meghalaya
98.	Mr. Yoomitre Kharduit	Mawpat, Meghalaya
99.	Mrs. Banrisha Lyngdoh	Happy Valley, Meghalaya
100.	Mr. Freddy Kharduit	Laitumkhrah, Meghalaya
101.	Mrs. Lucy Lumlin Sawian	Laitumkhrah, Meghalaya
102.	Ms. Rose lalfani thianglai	Motinagar, Meghalaya
103.	Mr. Dr A synrem	Khrang, Meghalaya
104.	Mr. E.C Kharwanlang	Laban, Meghalaya
105.	Mr. Overcome shadap	Thangsning, Meghalaya
106.	Mr. K. K Khyriam	Umsning, Meghalaya
107.	Mr. F Ryntathiang	Mawlai, Meghalaya
108.	Mrs. Dr. Suberma Hajong	Umiam, Meghalaya
109.	Mr. Chedrack K Nongbri	Sohryngkham, Meghalaya
110.	Mr. Khlurmangkara Kharmyndai	Laitumkhrah, Meghalaya
111.	Mr. David R Ryntathiang	Mawlai, Meghalaya
112.	Mrs. Elizabeth pohrmen	Wahdienglieng, Meghalaya

113.	Mr. Jesslan Roy	NongseijGreen Hills Mawkyrwat, Meghalaya
114.	Mr. Paul Syiem Clarke	Thistle Lodge, Thangsning, Meghalaya

Fig:206. Laitmawsiang Village Dorbar Secondary School and Ram Krishna Mission Secondary School, Sohra on May 19th 2019. [Attended by 100 students, 200 saplings supplied.]

Fig:207. World Environment Day celebration on June 5^{th} 2019 in collaboration with Martin Luther Christian University and inauguration of Sohra Experimental cum Botanical Garden, Sohra. [Attended by 200 college students, 1200 saplings planted.]

Fig:208. World Environment Day celebration on June 5th 2019 at Laitmawsiang Village Dorbar Secondary School and Ram Krishna Mission Secondary School in collaboration with Khata-rshong Youth Welfare Organization, Sohra. [Attended by students and villagers (150 nos.), 100 saplings distributed.]

Fig:209. Packing of seedlings for transfer to Experimental cum Botanical Garden, Sohra.

Fig:210. Supply of seedings for NGO and plantation (770 nos.)

Fig:211. Awareness programe on July 18th 2019 at St. Paul's Senior Secondary High School, Nongpoh. [Attended by 160 students (150 seedlings distributed).]

Fig:212. Awareness programme at Kohima, Nagaland in collaboration with the Forest Department, Nagaland, on 26th July, 2019. [Attended by 250 school and college students (310 seedlings distributed).]

Fig:213. Awareness programme at Senapati, Manipur in collaboration with the Forest Department, Manipur, on 27th July, 2019. [Attended by 100 local farmers, youth organization leaders, NGO members and village Headman (310 seedlings distributed).]

Fig:214. Distribution of seedlings to NGOs

Fig:215. Awareness programme at Belfonte Community College on 4th October, 2019, Lumshiyap, Shillong. [Attended by 150 students (235 seedlings distributed).]

Fig:216. Awareness programme at Wokha town, Nagaland on 21st November, 2019 in collaboration with Forest Dept. Wokha district Nagaland. [Attended by 160 students (285 seedlings distributed).]

Fig:217. Awareness programme at Pangti village, Nagaland on 22nd November, 2019 in collaboration with Forest Dept. Wokha district Nagaland. [Attended by 120 students (280 seedlings distributed).]

Fig:218. Seedlings supplied to various NGOs in Meghalaya

Fig:219. Seedlings supplied to local stakeholders in Meghalaya

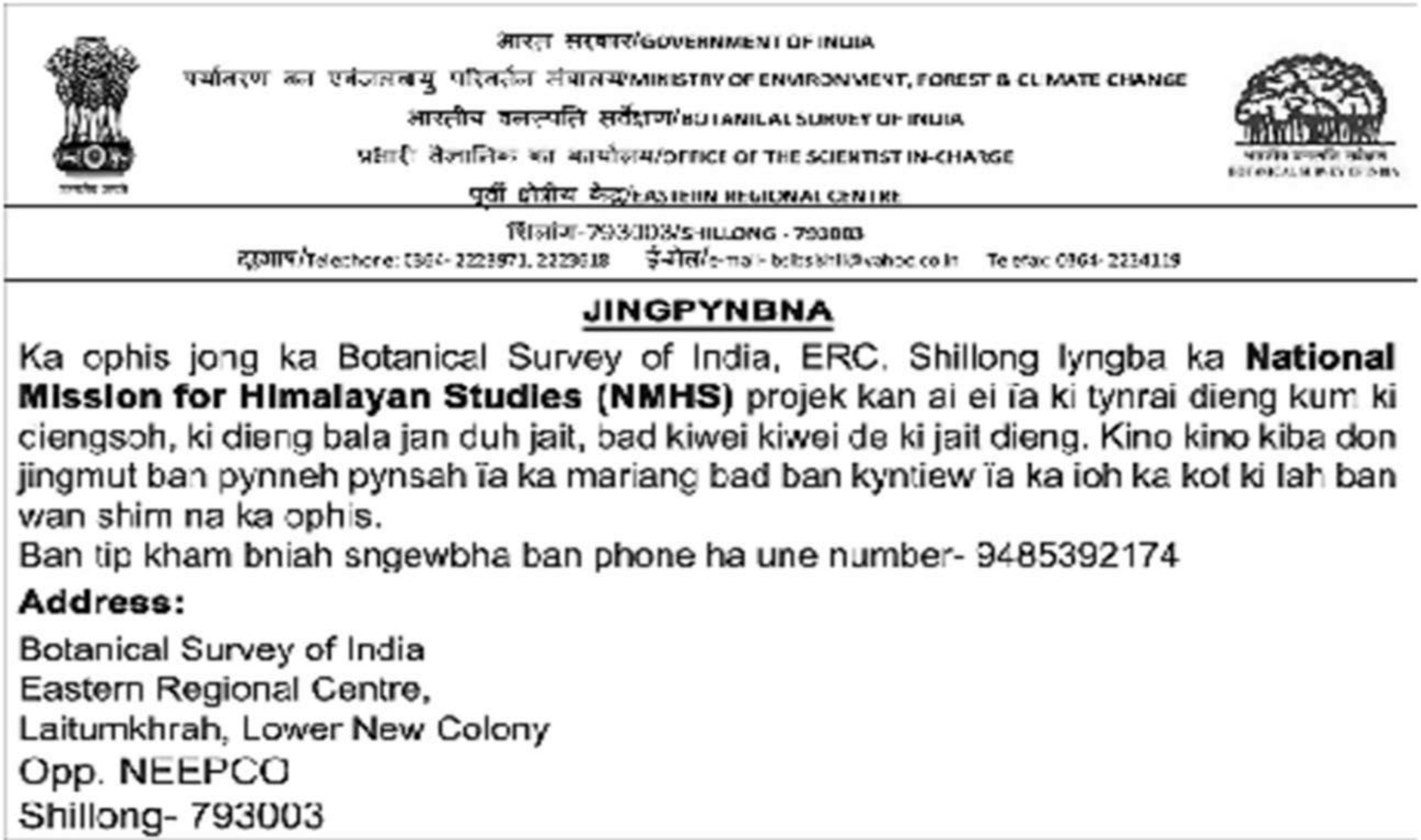
Fig:220. Seedlings supplied to local stakeholders in Meghalaya

Fig:221. Seedlings supplied to various Government organization

Fig:222. Seedlings supplied to various Government organization

Fig:223. Seedling plantation

Fig:224. Community participation in tree plantation and sapling distribution



भारत सरकार/GOVERNMENT OF INDIA
पर्यावरण वन एवं जलवायु परिवर्तन मंत्रालय/MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE
भारतीय वनस्पति सर्वेक्षण/BOTANICAL SURVEY OF INDIA
प्रभारी वैज्ञानिक का कार्यालय/OFFICE OF THE SCIENTIST IN-CHARGE
पूर्वी क्षेत्रीय केंद्र/EASTERN REGIONAL CENTRE
शिलांग-793003/SHILLONG - 793003
दूरभाष/Telephone: 0364-2223971, 2223618 ई-मेल/e-mail: Telefax 0364-2224119

JINGPYNBNA

Ka ophis jong ka Botanical Survey of India, ERC. Shillong lyngba ka **National Mission for Himalayan Studies (NMHS)** projek kan ai ei ïa ki tynrai dieng kum ki ciengsoh, ki dieng bala jan duh jait, bad kiwei kiwei de ki jait dieng. Kino kino kiba don jingmut ban pynneh pynsah ïa ka mariang bad ban kyntiew ïa ka ioh ka kot ki lah ban wan shim na ka ophis.

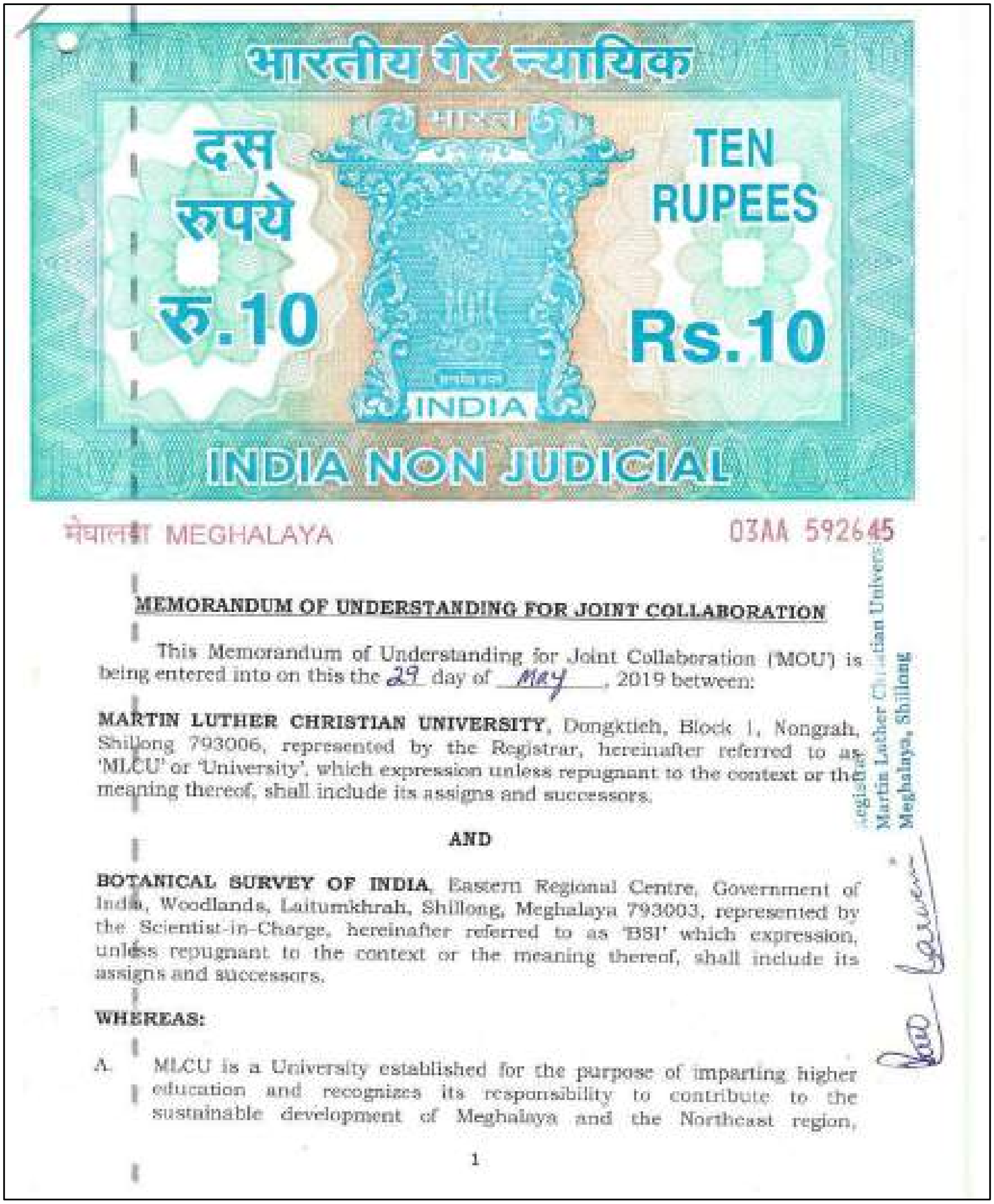
Ban tip kham bniah sngewbha ban phone ha une number- 9485392174

Address:

Botanical Survey of India
Eastern Regional Centre,
Laitumkhrah, Lower New Colony
Opp. NEEPCO
Shillong- 793003

An advertisement was put out in the local newspaper of Meghalaya inviting interested parties to collect seedlings of various plants including wild edible fruits, RET species free of cost

Few selected copies of MoU signed by BSI, ERC on behalf of NMHS Project with various stakeholders



भारतीय गैर न्यायिक

दस रुपये रु.10

TEN RUPEES Rs.10

INDIA

INDIA NON JUDICIAL

मेघालय MEGHALAYA

03AA 592645

MEMORANDUM OF UNDERSTANDING FOR JOINT COLLABORATION

This Memorandum of Understanding for Joint Collaboration ('MOU') is being entered into on this the 29 day of May, 2019 between:

MARTIN LUTHER CHRISTIAN UNIVERSITY, Dongktieh, Block 1, Nongrah, Shillong 793006, represented by the Registrar, hereinafter referred to as 'MLCU' or 'University', which expression unless repugnant to the context or the meaning thereof, shall include its assigns and successors.

AND

BOTANICAL SURVEY OF INDIA, Eastern Regional Centre, Government of India, Woodlands, Laitumkhrah, Shillong, Meghalaya 793003, represented by the Scientist-in-Charge, hereinafter referred to as 'BSI' which expression, unless repugnant to the context or the meaning thereof, shall include its assigns and successors.

WHEREAS:

A. MLCU is a University established for the purpose of imparting higher education and recognizes its responsibility to contribute to the sustainable development of Meghalaya and the Northeast region,

Registrar, Martin Luther Christian University, Meghalaya, Shillong

1

भारतीय गैर न्यायिक

दस रुपये रु.10

TEN RUPEES Rs.10

INDIA NON JUDICIAL

मेघालय MEGHALAYA 03AA 592647

IN WITNESS WHEREOF, the parties hereto have caused this MOU to be made in English and executed by their respective duly authorized representatives on the day and the year first above written.

27/5/2019

SIGNED
For and on behalf of BSI

BSI

वैज्ञानिक ग एवं कार्यालय अध्यक्ष
Scientist D&H.O.O.
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
पू. क्षे. के. / Eastern Regional Centre
शिलांग / Shillong - 793003

In the presence of:

Witness (Name) DEEPU VIJAYAN

Signature

वैज्ञानिक-सी / Scientist-C
भारतीय वनस्पति सर्वेक्षण
Botanical Survey of India
पू.क्षे.के. / Eastern Regional Centre
शिलांग / Shillong-793003

SIGNED
For and on behalf of MLCU

Registrar
Martin Luther Christian University
Meghalaya, Shillong

MLCU

In the presence of:

Witness (Name) Sakyati Khayumi

Signature
Deputy Registrar
Martin Luther Christian University
Shillong, Meghalaya

10

Memorandum of Understanding (MoU)
between
Botanical Survey of India, Eastern Regional Centre, Shillong, Meghalaya
and
Bellefonte Community College

This memorandum of understanding (MoU) is made on this 4th day of October at Shillong, Meghalaya between Botanical Survey of India, Eastern Regional Centre, Shillong, Meghalaya, hereafter referred as 'First Party'.

AND

Bellefonte Community College, hereafter referred as 'Second Party'.

WHEREAS the first party is Government department under Ministry of Environment, Forest & Climate Change.

WHEREAS the second party is a scientific institution/local stakeholders/school/college/non-governmental organization/ others (please specify) .... responsible for plantation and care of seedlings.

Both the parties are interested in promoting plantation and conservation of plants and landscaping of barren lands/colonies/other premises.

Therefore, both the parties agreed here under as follows:

1. First party will provide support in terms of logistics, indigenous trees/plants saplings, raising of seeds, transportation and labour charges incurred for planting seedlings.

2. Second party will take care of all the arrangements for the plantation and taking care of planted seedlings in future.

3. On the submission/publication of report by the party to any agency/agencies, the contribution of each party will be duly acknowledged.

Witness 1. Name Dr. Khumukcham Sanjeta Devi **2. Name** Wildaris Marwein

Address BSI, ERC Shillong **Address** Bellefonte Community College

Party First

Signature 4/10/2019

Address Scientist 'D' and HoO
Botanical Survey of India,
Eastern Regional Centre, Shillong
Meghalaya- 793003

Party Second

Signature

Address Bellefonte Community College
PB No 10 Lumshyiap
Shillong Meghalaya

Principal
Bellefonte Community College
Lumshyiap, ...
Shillong- 793...

Memorandum of Understanding (MoU)

between

Botanical Survey of India, Eastern Regional Centre, Shillong, Meghalaya

and

Department of Environment Forest and Climate change
Wokha Division, Government of Nagaland

This memorandum of understanding (MoU) is made on this 22nd day of November, 2019 at Shillong, Meghalaya between Botanical Survey of India, Eastern Regional Centre, Shillong, Meghalaya, hereafter referred as 'First Party'.

AND

Department of Environment Forest and Climate Change Wokha Division, Govt. of Nagaland, hereafter referred as 'Second Party'.

WHEREAS the first party is Government department under Ministry of Environment, Forest & Climate Change.

WHEREAS the second party is a scientific institution/local stakeholders/school/college/non-governmental organization/ others (please specify) Govt. Organization responsible for plantation and care of seedlings.

Both the parties are interested in promoting plantation and conservation of plants and landscaping of barren lands/colonies/other premises to increase the green cover of the country.

Therefore, both the parties agreed here under as follows:

1. First party will provide support in terms of logistics, indigenous trees/plants saplings, raising of seeds, transportation and labour charges incurred for planting seedlings.

2. Second party will take care of all the arrangements for the plantation and taking care of planted seedlings in future.

3. On the submission/publication of report by the party to any agency/agencies, the contribution of each party will be duly acknowledged.

Witness 1. Name Dr. Khumukcham Sangeeta Devi **2. Name** Zuthunglo Patton

Address BSI, ERC, Shillong **Address** DFO, Wokha, Nagaland

Number of seedlings supplied 485

Party First

Signature 22/11/2019

Address Scientist 'D' and HoO
Botanical Survey of India,
Eastern Regional Centre, Shillong
Meghalaya- 793003

Party Second

Signature

Address DFO Wokha
Nagaland.

Memorandum of Understanding (MoU)

Between

Botanical Survey of India, Eastern Regional Centre, Shillong, Meghalaya

And

East Khasi Hills District Co-operative Milk Union Ltd.

This memorandum of understanding (MoU) is made on this ......04th...................... day of June 2020..... at Shillong, Meghalaya between Botanical Survey of India, Eastern Regional Centre, Shillong, Meghalaya, hereafter referred as 'First Party'.

AND

East Khasi Hills District Co-operative Milk Union Ltd.
.... hereafter referred as 'Second Party'.

WHEREAS the first party is Government department under Ministry of Environment, Forest and Climate Change.

WHEREAS the second party is a Scientific Institution/ Local stakeholders/ School/ College/ Non-governmental organization/ others (please specify) ...Non-governmental Organization... responsible for plantation and care of seedlings.

Both the parties are interested in promoting plantation and conservation of plants and landscaping of barren land/ colonies/ other premises to increase the green cover of the country.

Therefore, both the parties agreed here under as follows:

1. First party will provide support in terms of logistics, indigenous trees/ plants saplings, raising of seeds, transportation and labour charges incurred for planning seedlings.

2. Second party will take care of all the arrangements for the plantation and taking care of planted seedlings in future.

3. On the submission/ publication of report by the party to any agency/ agencies, the contribution of each party will be duly acknowledged.

Witness 1. Name________________ **2. Name**________________

Address________________ **Address**________________

Number of seedlings supplied..........145..........

Party First	**Party Second**
Signature__________	**Signature** [signature]
Address NMHS Project Fellow Botanical Survey of India Eastern Regional Centre, Shillong Meghalaya – 793003	**Address** Central Bojh campus Mawiong – 793016
	Mob. 8257805248

'IATREILANG FOUNDATION'

(For Sustainable Development & Preservation of Environment and Culture)

Nongrum Mawphlang, East Khasi Hills District, Meghalaya -793121

ESTD: 2019

NO.IF/BSI/TFT/2020-2021/2

Dated Mawphlang, the 2nd June, 2020

To

The Director,
Botanical Survey of India,
Laitumkhrah Lower New Colony
Shillong

Approved
NMHS project staff ...
4/6/2020

Subject:- Requisition for 500 temperate fruit trees for people of Mawphlang-

Respected Sir,

With reference to the subject mentioned above, on behalf of **'IATREILANG FOUNDATION'** the Not for Profit Organization thriving for better livelihoods and preservation of environment and culture through collective involvement of young leaders as well as the community, we would like to humbly request your good office to give us 500 saplings of fruit trees so that we can distribute to our progressive farmer in Mawphlang area.

That sir, your institution is known to be one on the best to assist and help cater the needs of the people of different community, greed and religion. Therefore Sir, please kindly consider the case, as we are very much needed to help guide people for alternative livelihood approach through orchard and proper utility of their backyard garden.

Your kind consideration in this regards is highly solicited.

Thanking you.

Yours faithfully,

K. Lyngdoh

(Mr. Khrawborlang Lyngdoh)
Secretary
Iatreilang Foundation

Secretary
Iatreilang Foundation

IATREILANG FOUNDATION
ESTD : 2019

Ka Synjuk Ki Hima Arliang Wah Umiam-Mawphlang Welfare Society

Established : 2011

PAN AANAK 7756

Ref.No./KSKHAWUMWS/TFT/2020-2021/2

Dated Mawphlang, the 4th June, 2020

To
The Director,
Botanical Survey of India,
Laitumkhrah Lower New Colony
Shillong

Subject:- Requisition for 500 temperate fruit trees for people of Mawphlang-

Respected Sir,

With reference to the subject mentioned above, on behalf of **'KSKHAWUMWS'** the Not for Profit Organization thriving for better livelihoods and preservation of environment and culture through collective involvement of young leaders as well as the community, we would like to humbly request your good office to give us 500 sapings of fruit trees so that we can distribute to our progressive farmer in Mawphlang area.

That sir, your institution is known to be one on the best to assist and help cater the needs of the people of different community, greed and religion. Therefore Sir, please kindly consider the case, as we are very much needed to help guide people for alternative livelihood approach through orchard and proper utility of their backyard garden.

Your kind consideration in this regards is highly solicited.

Thanking you.

Yours faithfully,

(Mr. Tambor Lyngdoh) 9865082456
Secretary
KSKHAWUMWS

Already issued
200 seedlings
on 4/6/2020
8/6/2020

पूर्वोत्तर आयुर्वेद एवं होम्योपैथी संस्थान

NORTH EASTERN INSTITUTE OF AYURVEDA & HOMOEOPATHY (NEIAH)

Mawdiangdiang, Shillong, Meghalaya -793018

No.3-30/2013/NEIAH/HERB/ 151

Dated: 2../06/2020

To,

The Head
Botanical Survey of India,
Regional Office, Shillong.

Sub: Providing Sampklings of Medicinal Plants.

Dear Sir,

Warm Greetings!

North Eastern Institute of Ayurveda and Homoeopathy (NEIAH) is a newly established autonomous Institute under Ministry of AYUSH, Govt. of India at Mawdiangdiang, Shillong, and Meghalaya. The Institute is developing an Herbal Garden around the campus premises for the teaching and traning purpose to the students.

Therefore, I request you to kindly provide samplings of available medicinal plants from your Institute. The Institute shall pay for the same as desired producing the original bills.

Thanking you.

Dr. Sanjula ... N.

3/6/2020

Yours faithfully

2/6/2020

Prof. (Dr.) P. K. Goswami
Director, NEIAH.

Seedlings ~~...~~ distributed - ~~...~~ 75

Meghalaya Integrated Mountain Development Initiative (MIMDI)
Martin Luther Christian University
Nongrah, Dongktieh, Block-I, Shillong-793006, Meghalaya
Contact Number: +91-94367-04513
Email:mimdishillong@gmail.com

Executive Committee

President
Mr. TTC Marak
+91-94361-04513

Vice-President
Mr. M. Dollo
+91-87874-78328

Secretary
Dr. S. Das Gupta
+91-85868-86942

Joint Secretary
Ms. GardiniaNongbri
+91-73085-37997

Treasurer
Mr. Eric Kevin Dkhar
+91-96157-40387

Advisory Board
Dr. VT Darlong
VC, MLCU
Dr. S. Chaudhari
MD, NERCORMP
Dr. S. Kakoty
IIM, Shillong

SMDS-VIII
rganising Committee
2019

Sri. TTC Marak – Convener
Prof. B.K Tiwari – Co-convener

File no: I/MIMDI/SMDS-VIII/Invitation/2019-15 Date: 17th October,2019

To,
Dr. N.Odyuo,
Scientist-in-charge,
Botanical Survey of India,
Eastern Regional Circle, Shilling-793003

Sub: Request for permission to procure plant saplings –reg

Dear Dr.Odyuo,

I have the honour to inform you that the Meghalaya Integrated Mountain Development Initiative(MIMDI), Shillong in collaboration with Integrated Mountain Initiative(IMI), New Delhi and North-Eastern Region Community Resource Management Programme (NERCORMP), NEC, Shillong will be hosting the 3-day **Sustainable Mountain Development Summit- VIII** at the North-Eastern Council Auditorium at Nongrim Hills, Shillong from the 4th-6th November,2019 to deliberate on the theme" **Sustainable Mountain Initiative for Livelihood and Entrepreneurship for Youth (SMILEY).** Besides the inaugural function, there will be four technical sessions to deliberate on (1) e-agriculture with water security and climate change, (2) food processing and agri-business, (3) renewable energy and energy efficiency and (4) sustainable tourism spread As the 3-day summit will be attended by a host of delegates from the twelve mountain states situated on the Indian Himalayan Region besides the policy planners, scientists, researchers, entrepreneurs, NGOs and representatives of the industry, I would like to request you to kindly provide us with hundred (100) plant species of *Taxus baccata* to be given to the dignitaries at the inaugural function of the above summit (SMDS-VIII) on the 4th November,2019 and oblige. I would very much appreciate, if you could provide the above saplings with the name tag. This kind gesture of yours would go a long way in enabling us to organize the said event in a befitting way.

Thanking you in anticipation,
Yours Sincerely,

(Dr. S.DasGupta)
Secretary, MIMDI & Organizing Secretary, SMDS-VIII, 2019

Provide 100 seedlings of Taxus baccata.
Dr. Deepu. N
30/10/2019

OFFICE OF THE OFFICER COMMANDING B/1 SIGNAL BN. CRPF, SHILLONG
NO. M.V-1/2020-Q-B/1 Signal Dated the 26 May-2020

To,

The Botanical Officer
Botanical Survey Of India
Eastern Regional Centre,
Shillong (Meghalaya)

Subject : **REGARDING PROVIDING OF PLANTS.**

It is submitted that as per instructions/guidelines issued by Directorate General CRPF New Delhi vide letter No. M.V-1/2020-Adm-II dated 08/05/2020 has directed to this sub unit to plant the trees on Govt. Land of residential and office of CRPF locations. This sub unit proposed to plant 20 Numbers of medicinal/useful plants in the residential campus of this coy at Ravi Lodge, lower new colony, Shillong to make the campus/environment green.

2. In view of above, it is requested that, kindly arrange to provide at least 20 numbers different types of plants to this sub unit to plant in the residential campus as mentioned above please.

3. In this regard, an early action is highly appreciable.

Thanks,

Permitted

25/5/2020

OFFICER COMMANDING

27/5/2020

Request of seedlings by CRPF, Shillong

AWARENESS PROGRAMMES AND OUTREACH ACTIVITIES

Sapling Distribution Programmes at BSI, APRC, Itanagar

More than 5000 saplings were developed in the garden of Botanical Survey of India (BSI), Arunachal Pradesh Regional Centre (APRC), Itanagar. This includes Approximately 500 saplings of two canes species *viz. Calamus flagellum* and *C. tenuis*, recovered from various locations in Papum Pare district. Medicinal plants *viz. Bischofia javanica, Castanopsis indica, Cinnamomum bejolghota, Clerodendrum colebrookeanum, Curcuma caesia, Oroxylum indicum, Saraca asoca, Terminalia arjuna, Wrightia coccinea* were propagated in the garden. Mostly the plants were propagated by seed germination, stem cuttings and/or rhizome cuttings. Ethnobotanically important to the different tribes of Arunachal Pradesh, a threatened plant species *Livistona jenkinsiana* was also propagated in BSI, APRC through seed germination.During the foundation day celebration of BSI, APRC, Itanagar, on 8th August 2019, about 400 saplings of different plant species propagated in BSI, APRC were planted and distributed on various locations of Itanagar.

World Ozone Day on 16th September, 2020 was celebrated at BSI, APRC and and a sapling distribution drive was conducted. Nearly 1000 seedlings and saplings of plant species developed in the office garden, were distributed among ITBP and CRPF, Itanagar. More than 2000 saplings of were distributed among local people of Itanagar celebrating the importance of plantation to cure ozone layer.

About 700 saplings were distributed among locals celebrating the Earth Day, 22nd April 2021 at BSI, APRC Campus, Itanagar.

Celebration of International Day for Biological Diversity, 22nd May 2022 was concluded with distribution of nearly 500 saplings of various plants developed in the garden of BSI, APRC and some were planted on office premise.

Fig:225. Seedling plantation and distribution in Arunachal Pradesh

Fig:226. Plantation and Capacity building programme organized at different areas of Itanagar, Arunachal Pradesh.

Fig:227. Plantation and Capacity building programme organized at different areas of Itanagar, Arunachal Pradesh.

Biodiversity Conservation Awareness Programme at Hilley, West Sikkim

Hilley, a beautiful, small village in the lap of east Himalaya, is situated at West Sikkim at an altitude of 2600 m asl. The people residing at Hilley are farmers and deeply depend on forest resources to meet their daily need. Most of the villagers are very less educated. Thus, they are very much unacquainted with the term biodiversity and unaware about the adverse effect of biodiversity loss. Keeping eye on this, Hilley village had been selected to develop awareness about the biodiversity and its value in our daily life.

The awareness programme was arranged on 7th December, 2020 at Mushroom Hut, Hilley. A total of 57 Villagers of Hilley were gathered at Mushroom Hut. Among them, 19 were adult men, 16 were adult women and 22 were boy students. Programme started at 11 am through the introduction of the resource persons and the villagers. The inaugural session started with the plantation of seedlings/saplings along the village roadsides. The seedlings/saplings distributed to the villagers for plantation are developed in the net house of Sikkim Himalayan Regional Centre (BHSC), Botanical Survey of India, Gangtok. A total of 50 seedlings/saplings were distributed to the villagers. They were very keenly accepted those and promised to keep them alive and healthy. After that plantation programme, all the participants were invited to the programme room. Mr. Subhajit Lahiri, Project Fellow, NMHS project elaborate the role of Botanical Survey of India towards conserving biodiversity. Mr. Deep Shekhar Das, Project Fellow, NMHS project brief the aim of National Mission of Himalayan Study (NMHS) towards the conservation of Himalayan biodiversity. The inaugural sessions declared ended after both the speeches and then all the participants were heading for the lunch.

After the lunch break the second/final session started. Mr. Deep Shekhar Das started the session by briefly describing the IUCN categories of threatened plants. Mr. Subhajit Lahiri continued the topic and described why they are needed to be protected. Mr. Deep Shekhar Das spoke about the beautiful landscape and ambient serenity of this area and suggested them to protect those from the anthropogenic activities. Mr. Subhajit Lahiri aware them about the adverse effect of plastics to the environment and suggested them not to litter plastics here and there. He also suggested that the villagers should not allow the tourists to litter the plastics also.

After a long 2-hour session, a short tea break was taken. Then, a short discussion session had been carried out. Participants of different age groups actively took part in the discussion. Mr. Bandhu Sherpa, a field guide, willing to protect plastic pollution suggested that the state government should take initiative to ban plastics in this area. Mr. Prem Dorjee, a ten-standard student, very eagerly discussed about the biodiversity and the processes for its conservation. Mrs. Nim Riki Sherpa, a housewife, told us they are now using LPG for cooking instead of fuelwood. Therefore, the programme was a success. People of Hilley village are now very much eager to work with us towards conserving biodiversity. They promised to keep the given plants healthy and plant more seedling/saplings. At last, Mr. Subhajit Lahiri took the responsibility of giving vote of thanks and declared the programme end.

Biodiversity Conservation Awareness Programme at Chatakpur, Darjeeling, West Bengal

Chatakpur, an eco-development village, situated at Darjeeling district of West Bengal. It falls under Senchal Wild Life Sanctuary area. The village is a hill station and remain full of tourists throughout the year except June to September when the sanctuary remains close. A total of 36 home stays has been operated in this village. During the visit to this area, we observed traces of tourists visit as packets of foods like chips, biscuits, Cadburys etc are littering here and there even inside the forests. The villagers were mainly farmers. But, due to recent development approach by establishing home stays the young generations are not showing interest in farming. They mainly run home stays for income generation. As many tourists visit in this area, the annual income of the people is excellent. But, they are very much unconscious about the adverse effect of plastics and land degradation occurred through unsustainable tourism and development. That’s why, Chatakpur was selected as second site for raising awareness about the biodiversity and their need for conservation.

The awareness programme was arranged on 12.12.2020 in front of Kulung Home stay, Chatakpur. A total of 31 villagers participates in the programme. Among them 23 are men and 8 women. The inaugural session started with introduction of resource persons with the participants. Mr. Subhajit Lahiri, Project Fellow, NMHS project elaborate the role of Botanical Survey of India towards conserving biodiversity. Mr. Deep Shekhar Das, Project Fellow, NMHS project brief the aim of National Mission of Himalayan Study (NMHS) towards the conservation of Himalayan biodiversity. The inaugural sessions declared ended after both the speeches and then all the participants were heading for the lunch.

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After a long 2-hour session, a short tea break was taken. Then, a short discussion session had been carried out. Participants actively took part in the discussion. Mr. Sabin Rai, a home stay owner, complained about the tourist's behavior and told they are not listening to them and litter plastic waste here and there. Mr. Binod Rai, another home stay owner, told that they managed to develop a youth association which try to clean the plastic litter from the area once in a month. When asking about their opinion on the plantation in this area if seedlings are provided to them, they eagerly told us that they will do the plantation and keep the seedling/saplings healthy. A group of 18-20 young people show much eagerness about the conservation of biodiversity and keeping the area clean.

Biodiversity Conservation Awareness Programme at Kalimpong district, West Bengal

Two awareness programme was arranged in two villages of Kalimpong district of West Bengal. The first awareness programme was arranged on 21th September 2021 at Toryok, and the second programme was arranged on 25thSeptember 2021 at Sebjey.

A total of 90 Villagers (50 from Toryok and 49 from Sebjey) were gathered in this awareness programme. Among them, 48 were adult men, 32 were adult women and 10 were students.

At both villages programme was started at pre scheduled time at 9.30 am with the consent from each of the individuals. Programme was initiated through the introduction of the resource persons and the villagers.

The inaugural session started with the discussion on the role of Botanical Survey of India on conservation of country's threatened plant genetic resource with the help of indigenous people and importance of this conservation in our daily life.

Since these two villages are part of one of the attractive tourism sites and the economy of these area mainly driven by ecotourism, therefore, here we briefly discus the importance of sustainable development of tourism site among the villagers.

After initial discussion villagers express their concern over the sustainable development and much aware about this term however, they do not know how it will be implemented. After identifying their concern, we discuss this topic briefly with villagers with the self-arising following questions.

- How does ecotourism promote sustainable development?
- What is sustainable tourism development?
- How can we make ecotourism sustainable?
- Is ecotourism same as sustainable tourism?

We give the idea of ecotourism in the following manner.

- Have a low impact upon a protected area's natural resources.
- Involve stakeholders (individuals, communities, ecotourists, tour operators and government institutions) in the planning, development, implementation and
- monitoring phases
- Limits visitation to areas, either by limiting group size and/or by the number of groups

- taken to an area in a season
- Supports the work of conservation groups preserving the natural area on which the experience is based.
- Hires local people and buys supplies locally, where possible.
- Recognizes that nature is a central element to the tourist experience.
- Uses guides trained in interpretation of scientific or natural history.
- Ensures that wildlife is not harassed.
- Respects the privacy and culture of local people.

Two awareness programmes were arranged on 29th September 2021 at Buriakhop, and on 2nd October 2021 at Lungchok. Buriakhop and Lungchok, are two beautiful small villages situated in the lap of Eastern Himalaya at West Sikkim at an altitude of 2600 m asl.

The people residing at Buriakhop and Lungchok are farmers and deeply depend on forest resources to meet their daily need. Therefore, they are not very much acquainted with the term biodiversity and unaware about the adverse effect of biodiversity loss.

Keeping eye on this, Buriakhop and Lungchok villages have been selected to develop awareness about the biodiversity among the villagers.

A total of 101 Villagers (42 from Buriakhop and 49 from Lungchok) were gathered in this awareness programme. Among them, 59 were adult men, 22 were adult women and 20 were students.

At both villages programme was started at pre scheduled time at 10.30 am with the consent from each of the individuals. Programme was initiated through the introduction of the resource persons and the villagers.

The inaugural session started with the discussion on the role of Botanical Survey of India on conservation of country’s threatened plant genetic resource with the help of indigenous people and importance of this conservation in our daily life.

During the whole programme tenure our recourse person divide the timeline into several key topic on biodiversity conservation viz.

1. What is the biodiversity and its role in our daily life?
2. How we conserve this biodiversity at local levels?
3. What are the steps taken by Indian government to conserve biodiversity?
4. What are the major challenges of biodiversity in India?
5. What are the challenges for biodiversity conservation?
6. What is the Recovery of Endangered Species?
7. What is India's commitment in Paris Agreement?
8. What are the initiatives taken by India regarding Paris Agreement?

Other awareness programs at different locations of West Himalaya

Programs places: Govt. senior secondary school, Nahan; Tender heart public school, Chail (interactive session was conducted); At the Divisional Forest Office, Kaza; Done among farmers working in agricultural fields and locals of Kaza and Kibber; Muncling School located in Kibber, Lahaul & Spiti; Government boys senior sec. school, Dhalpur, Kullu; Range office, Kullu; Panchayat, Bistori; Banners, Brouchers, refreshment and caps were distributed to all.

Capacity building and outreach activities:

To integrate the conservation practices of threatened plant species of the North-West Himalaya, Memorandum of understanding (MoU) was signed with the Forest Department of Uttarakhand and Non-Government Organization (HUMAN-INDIA) for facilitating the conservation work of threatened species in remote areas and to create the mass awareness among the forest forces and local communities. With the help of NGO local community/peoples were also involved in the collection of seeds & planting materials, nursery development and conservation of endemic threatened species.

A meeting was conducted with the local stakeholders of Mana village regarding cultivation and plantation of selected species in their fields and nearby forest areas. The head of the village agreed to give full support for the plantation work and for the workshop which will be organized in the coming season.

Posters and brochures were prepared on "Threatened Plants of Western Himalaya and Adjacent Shiwaliks" for the distribution among local people and educational institution to create mass awareness regarding the threatened species and their conservation.

Fig:228. Moments of awareness programmes at Hilley, West Sikkim

Fig:229. Moments of awareness programme at Chatakpur, West Bengal

Fig:230. Moments of awareness programmes at Kalimpong

Fig:231. Moments of awareness programmes at Darjeeling & West Sikkim

Fig:232. A-Discussion with range officers and other staff at Divisional forest office, Kaza; B- Awareness among farmers working in fields of Kaza; C&D- Distribution of brouchers and seasonal greetings during awareness; E&F- Sharing useful information with students and people around; G&H- Awareness campaign in Bistori village, Kullu; I- Awareness campaign during trekking in Gogarshill, Kullu; J- Awareness done in Nagar, Kullu; K&L- During and after awareness programme in Government boys school, Kullu; M- Interaction session with ACF, Range officer and forest guards in Range office, Kullu; N- During discussion with villagers in Bistori village; O- Meeting with range officer and ACF, Kullu

A. Awareness campaign organized at Budher village, Chakrata, Dehradun

B. Workshop organized at Moila peak with GSDP students

C. Workshop organized at Jaunsar village

D. Delivered lecture to the forest officials at SFRI, Jammu

E. Senior Scientist of BSI, NRC interacting with students during workshop at Green Lawn Academy

F. Distribution of endemic plant species to students.

G. Distribution of endemic plant species to local villagers near Halduwala village

H. Distribution of propagated saplings to forest department officials.

Fig:233. Workshop and awareness campaign in different areas of Uttarakhand.


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