

Graphic Era
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DEHRADUN

Winter Internship Report

(January-February 2025)

By

Students of
Department of Biotechnology
Graphic Era University, Dehradun

at

Anand Van, Jhajra Range
Dehradun Forest Division, Uttarakhand

उत्तराखण्ड
वन विभाग

AMBER FOUNDATION
जैव विविधता संरक्षण में सुधार एवं पर्यावरण अनुसंधान
AMELIORATION OF BIODIVERSITY AND ENVIRONMENTAL RESEARCH

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1. Introduction

Anand Van, a pioneering urban forest nestled within the Jhajra Range of Dehradun Forest Division, Uttarakhand, stands as a testament to the transformative power of ecological restoration. Spanning 50 hectares, this verdant sanctuary serves as a vital green lung for the region, combating pollution and fostering a deep connection between urban dwellers and the natural world. More than just a collection of trees, Anand Van is a thriving ecosystem, rich in diverse flora and fauna, offering a tranquil escape and a powerful reminder of nature's resilience.

This report details a 30-day summer internship program (January-February 2025) undertaken by ten students from the Department of Biotechnology, Graphic Era University, Dehradun. Under the guidance of Professor V.P. Uniyal and Dr. Manu Pant, Head of the Biotechnology Department, these students embarked on a practical exploration of ecological principles, focusing on two key initiatives: the development of a recycling yard and solitary bee houses. These projects were meticulously designed to align with the United Nations Sustainable Development Goals, demonstrating the potential for hands-on ecological intervention to drive positive environmental change.

(i) A Symphony of Decomposition: The Ecological Recycling Yard

At the heart of a healthy ecosystem lies the intricate process of decomposition. Natural recyclers, including bacteria, protozoa, fungi, and invertebrates, play a crucial role in breaking down organic matter, transforming waste into essential nutrients. Recognizing the often-overlooked value of fallen leaves, the students conceptualized and implemented a specialized leaf litter recycling yard. This initiative aimed to transform a perceived waste product into a valuable resource, simultaneously fostering a thriving community of decomposers.

The recycling yard, constructed using a robust wooden structure, was meticulously designed to optimize conditions for decomposition. The students employed a layered approach, combining leaf litter with grass clippings and small twigs to create a balanced compost mix. This strategy ensured proper aeration, a critical factor in efficient decomposition, while providing a diverse habitat for a range of forest recyclers. Earthworms, beetles, ants, termites, snails, slugs, centipedes, and millipedes, all integral components of the forest's ecological fabric, found refuge and sustenance within the recycling yard. By enhancing the population growth of these vital organisms, the students contributed to the acceleration of nutrient cycling and the maintenance of soil health within Anand Van.

This project transcended the simple act of waste management. It became a powerful demonstration of how seemingly mundane organic materials can be transformed into valuable resources, contributing to a healthier and more sustainable ecosystem. The recycling yard not only reduced the volume of waste generated within the park but also provided a tangible example of nature's inherent recycling capabilities, enriching the soil and supporting biodiversity.

(ii) A Sanctuary for Solitary Pollinators: The Solitary Bee House

Beyond the realm of decomposition, the students recognized the critical role of pollinators in maintaining ecosystem health. Solitary bees, unlike their social counterparts, live independent lives, nesting in individual cavities. These vital pollinators, often more efficient than honeybees for certain plant species, face significant population declines due to habitat loss and pesticide use.

To address this challenge, the students constructed a solitary bee habitat, utilizing locally sourced bamboo canes. The bee house was carefully designed to mimic natural nesting sites, with varying diameters and depths of cavities to cater to the diverse needs of different solitary bee species. By providing these essential nesting sites, the students aimed to boost the local population of these crucial pollinators, enhancing plant reproduction and overall ecosystem health within Anand Van.

The strategic placement of the bee house within the park ensured maximum exposure to sunlight and floral resources, optimizing conditions for solitary bee activity. This project not only contributed to the ecological health of Anand Van but also served as an educational tool for park visitors, raising awareness about the importance of solitary bees and the need for their protection.

(iii) Synergy and Sustainability: Interconnected Ecological Benefits

The ecological recycling yard and the solitary bee habitat, while distinct in their focus, are intrinsically linked, contributing to a range of interconnected ecological benefits within Anand Van. The recycling yard enhances soil health and nutrient cycling, creating a foundation for thriving plant life, while the bee house supports pollinator populations, ensuring the continued reproduction and diversity of plant species. Together, these initiatives promote sustainable waste management, ecological restoration, and overall ecosystem resilience.

The students' work at Anand Van exemplifies the power of practical, hands-on ecological intervention. By integrating biodiversity conservation and urban greening, they have made a significant contribution to the forest's long-term sustainability. Their efforts serve as a testament to the potential for students and researchers to play a vital role in addressing environmental challenges and promoting a more sustainable future. This report will further delve into the methodologies, findings, and conclusions of these projects, highlighting their individual and combined contributions to the ecological vitality of Anand Van.

2. Objectives

(i) Initiation of Positive Impact On Environment and Community

The main objective of the internship at Anand Van, was to make a positive impact on the environment and the community by working on two important projects: creating habitats for solitary bees and setting up a recycling yard. These projects were not just about

building things; they were about learning, sharing, and inspiring others to care for the planet. Through our work, we wanted to show how small actions can make a big difference and how each of us can play a part in protecting nature.

(ii) Creating Habitats for Solitary Bees

One of our projects focused on solitary bees, which are tiny but very important creatures. Unlike honeybees, solitary bees don't live in big groups or make honey, but they are amazing pollinators. This means they help plants grow by carrying pollen from one flower to another. Sadly, many people don't know about them, and their habitats are disappearing. During our internship, we built special homes called "bee hotels" for these bees. These hotels are safe places where solitary bees can lay their eggs and rest. By doing this, we wanted to help these bees survive and also teach others about their importance. We hoped that by learning about solitary bees, people would feel more connected to nature and understand how even the smallest creatures play a big role in keeping our environment healthy.

(iii) Setting Up a Recycling Yard

The second project was about recycling. We created a recycling yard where we collected things like plastic, paper, and metal that people usually throw away. Instead of letting these materials go to waste, we sorted them and found ways to reuse or recycle them. This project taught us how much waste we produce and how much of it can actually be turned into something useful. It was a reminder that we need to be more careful about what we use and throw away. By setting up the recycling yard, we wanted to show the community that recycling is not just good for the environment but also a way to be creative and resourceful. We hoped to encourage people to think twice before throwing things away and to see waste as something that can have a second life.

(iv) Broader Learning and Impact

Both of these projects were about more than just the work we did. They were about learning to care for the planet and understanding how everything in nature is connected. We wanted to inspire others to take small steps, like building a bee hotel or recycling, to make the world a better place. Our internship was a chance to not only help the environment but also to grow as individuals. It taught us teamwork, creativity, and the importance of taking responsibility for our actions. Most of all, it reminded us that even small efforts, when done together, can create a big change. Through our work, we hoped to leave a lasting impact on Anand Van and the people who visit it, showing them that caring for the Earth is something we can all do, one step at a time.

3. Micro-Invertebrates

Micro-Invertebrates are the small and microscopic invertebrates, usually measuring less than 1 millimetre in dimension. They are a heterogeneous group of organisms, including little arthropods (such as water fleas or copepods), rotifers, and other minute invertebrates, existing in aquatic environments. They have got substantial value in the

ecosystems that include important aspects, such as their role in nutrient cycling, serving as food for bigger organisms, and the process of degrading organic matter.

(i) Importance of Micro Invertebrates

Micro-invertebrates have a considerable impact on soil functions important to the restoration process, such as decomposition; yet, soil organisms have received relatively little attention in restoration ecology in terms of their applicability as agents of restoration. Listed are some importance of them:

- **Food Source in Food Chain**:

Micro - invertebrates are also primary food sources for many larger organisms like fishes, amphibians, and of course, birds. The majority of the tiny aquatic organisms, such as copepods, rotifers, and water fleas, play important roles as primary or secondary consumers in food webs for supporting higher trophic levels.

- **Nutrient Cycling:**

They further play a big role in decomposing organic materials and recycling essential nutrients among various ecosystems. micro invertebrates are important detritus, algae, and bacteria consumers which form a significant part of organic materials into plant-usable forms. By feeding on detritus, algae, and bacteria, macroinvertebrates help decompose organic materials and convert them into forms that can be used by plants and other organisms.

- **Indicators of Water Quality:**

Micro invertebrates are very sensitive to water quality change. Their existence, nonexistence, or diversity can be very critical indicators of the health status of the aquatic ecosystem. For instance, some of the most common generalizations say that a certain type of macroinvertebrate indicates clean well-oxygenated water, while poor diversity may mean pollution or low water quality.

- **Soil and Sediment Aeration**:

In the freshwater and marine environments, oxygenated substrates are made by micro invertebrates such as nematodes and some worms, resulting in healthy soil and sediment because they break down organic matter which favours plant growth and increases microbial activity.

- **Pollination and Decomposition:**

Some types of midges and larvae contribute to the process of pollination and decomposition of decayed organic matter, which further helps in the indispensable nutrient cycling in the environment.

In other words, these organisms are members of the foundation of the food web, and they are also those that constitute vital forces in the continuance of health, stability, and resilience of most ecosystems. They have a relatively great deal of importance, from the biodiversity point to that of water quality, and also to that of nutrient cycling.

(ii) Types of Macroinvertebrates

- **Annelids - Earthworms**

Earthworms are found in soil and leaf litter, with different spp. at different soil levels. Earthworms develop within a cocoon in the soil, young emerge looking like smaller adults (sans clitellum), and can live for 4+ years. They influence soil structure by creating channels and mixing organic matter into the soil. Earthworm casts (digested materials) help make minerals and nutrients available to plants. Nearly 1/3 of spp. found in the US are introduced, some have negative ecological impacts (e.g., jumping worms, Amynthas spp.). Can also be used as an indicator for water filtration.

How to find them: Mustard extraction; hand digging and sorting; Berlese funnel.

- **Myriapods - Millipedes**

Millipedes live in moist habitats like under bark, logs, and stones, and in leaf litter and upper soil layers. Some excavate deep tunnels and are found in deep soil layers. Millipedes are long lived (<11 years) and females guard eggs within a nest. They are primary decomposers and scavengers, making significant contributions to the decomposition of plant debris while also facilitating further decomposition by microbes.

How to find them: Pitfall traps; Berlese funnels.

- **Isopods - Sow bugs and Pill bugs**

Isopods are active underneath logs, stones, and bark, leaf litter, and other moist habitats; they are mainly nocturnal in the upper soil layers in warm, dry areas. Adults live 2+ years. All pill bugs and about 25% of spp. of sow bugs in North America are introduced spp. Isopods are decomposers that contribute significantly to nutrient cycling, fragmenting fresh plant debris and further breaking down decomposing plant materials. Isopods are easily recognized; they accumulate heavy metals and so can serve as bio indicators of pollution, and also can serve as indicators of farm practices, due to their sensitivity to pesticides.

How to find them: Pitfall traps; Berlese funnels.

- **Carabids - Ground Beetles**

Ground beetles are found under debris, stones, and logs, in soil cracks and leaf litter, and on the soil surface or vegetation; live <4 years. Most are nocturnal, some spp. is day active. They are Predators as larvae and adults; important in controlling crop pests like slugs, caterpillars, aphids, and more; also contribute to weed control via seed predation. Some also eat detritus and fungi, contributing to decomposition and nutrient cycling.

How to find them: Pitfall traps; Berlese funnels

- **Arachnids - Spiders**

Hunting spiders (wolf, ground, jumping) are found on the soil surface or in leaf litter, web-building spiders (dwarf sheet, sac, funnel weaver) are found within webs spun on/in the ground. 1 generation per year, live 1–3 years. As predators that either hunt or spin webs to capture prey, spiders help regulate arthropod populations. As diggers, they also move and work the soil. Wolf and jumping spiders can contribute to control of crop pests.

How to find them: Pitfall traps; Berlese Funnels

- **Enchytraeids - Potworms**

Pot worms are most common in the leaf litter or upper soil layer; tend to prefer soils with lots of decaying matter. Increase the integration of organic matter and minerals in soil as they feed and may also increase soil porosity. Pot worms are also important decomposers and consumers of plant material, fungi, and bacteria.

How to find them: Run soil core samples through a Biermann funnel

- **Acarids - Mites**

Soil mites are found at the soil surface, within soil layers, and even in deep soil horizons. Mites can live several weeks to <3 years; lifespan varies by spp. Mites are critical in soil food webs as predators and are particularly important in their role as detritivores, breaking down leaf litter into pieces accessible to smaller decomposers. Mites also help disperse bacteria and fungi.

- **Scarabs - Dung Beetles**

Adults live <3 years in grasslands, forests, farmlands, deserts and elsewhere, within or near dung. Some spp. excavates tunnels in which to rear their young below dung piles, others lay their eggs within piles, and a few other spp. will form dung into a ball and roll it away from the main pat before burying it to feed to their young. These beetles transform manure to humus, speeding up the process of returning nutrients to the soil. Their work enhances forage palatability for grazing animals, recycles nitrogen, reduces pest and parasite habitat, and reduces food-borne pathogens on crops. Used to detect effects of land and crop management decisions due to their sensitivity to habitat changes and disturbances.

How to find them: Pitfall traps; traps baited with dung; dig into dung pat.

- **Collembolans - Springtails**

Many spp. lives in soil surface litter and vegetation, decaying logs, and fungi, as well as under bark (Entomobryomorpha & Symphypleona), while others dwell within the soil (Poduromorpha & Neelipleona). Abundant and widespread, occurring in all terrestrial habitats, including Arctic soils, springtails can reproduce rapidly and live several weeks to a year. As decomposers, springtails facilitate nitrogen mineralization and plant growth. Their selective consumption of fungi can also alter fungal communities. Can be used as

indicators of soil disturbance and pollution; High ratios of mites to collembolan often indicate high-quality soils.

How to find them: Pitfall traps; Berlese funnels.

4. Solitary Bees

Out of the 20,000 estimated species of bees, about 90 percent (18,000) are considered Solitary instead of social. Solitary bees are those which are constructed and reared single handedly by a female. Renowned entomologist Charles D. Michener's definition of solitary bees does not apply to the species where some form of behavioural interaction occurs between the mothers and the young after the young have hatched. Some of these species excavate nests in wood cavities, such as the stems of trees and shrubs, the burrows of wood–boring beetles, and artificial cavities like hollow pipes of wind chimes and keyholes in doors most of them do not pose a stinging threat to people.

(i) Importance of Solitary Bees

The contribution of Solitary bees to pollination, plant reproduction, and seed development makes them extremely important. Certain crops and plants are better off with these bees as their pollinators than with honeybees. In order to provision their nests, these bees visit flowers for nectar and pollen. This form of cultivation causes the natural disbursal of pollen leading to seed and fertilization production.

Pollinators that use buzz pollination as a means of pollination are much more proficient at using these bees. Buzz pollination is a type where bees vibrate their bodies to scatter pollen. Such bees serve as a base to a myriad of animals that depend on flora and their seeds, thus maintaining a food chain.

(ii) Types of Solitary Bees in India

- **Mining Bees**

The largest group of solitary bees with at least 25 species of mining bee in the Northeast. They are ground-nesting bees where females burrow into soil to construct their nest burrows and gather pollen on hind legs. These bees may vary from 6mm (referred to as mini-miners) to honeybee-sized females.

- **Leafcutter Bees**

They adopt Aerial-nesting. These bees are generally found nesting in bee hotels and dead wood cavities. The females have large jaws with which they cut off leaf sections as nesting material. In gardens, rose leave is a special favourite of theirs. These females differ from most other bees in the way they take pollen onto specialized hairs on their underside.

- **Carpenter Bees**

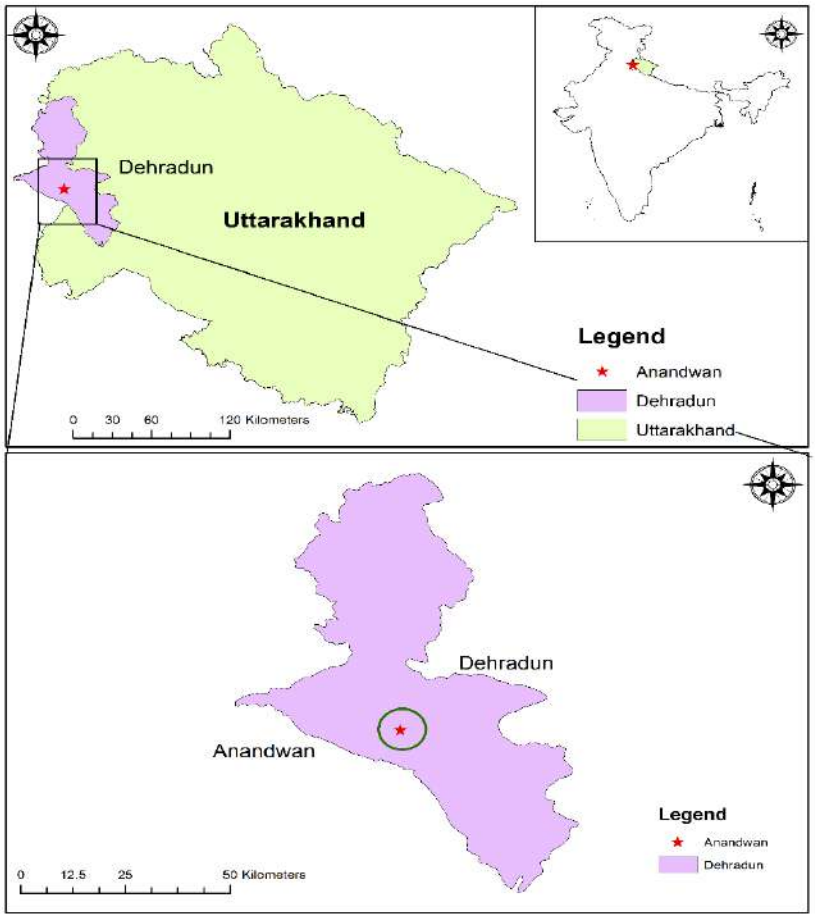
Carpenter bees are a familiar instance of a solitary bee. The blue-black, fuzzy bees you notice on flowers or hear flying around every spring are female carpenter bees. They are more than an inch long and as wide as your thumb. They nest in wood, like dead tree trunks, firewood or weathered wood on buildings. They bore a tunnel some ten inches in length inside the wood.

(iii) Concern About Solitary Bees

Isolated populations of solitary bees are under threat from habitat destruction, pesticide use, and climate change. Conserving their habitats and protecting them is crucial to ensure healthy ecosystems and food security. The females, which are blue-black and fuzzy, nest in wood such as dead tree trunks or weathered wood on buildings, boring tunnels up to ten inches long. These bees play a crucial role in ecosystems as pollinators. However, their populations are threatened by habitat destruction, pesticide use, and climate change. Protecting their habitats is essential for maintaining healthy ecosystems and ensuring food security.

5. Study Area- Anand Van

Anand Van, meaning "Forest of Joy," located in the Jhajra Forest Range near Prem Nagar in the heart of Dehradun. Uttarakhand's first urban forest, developed by the Uttarakhand Forest Department The project was officially opened to the public on October 17, 2020.



It was made to serve a purpose of providing peace and tranquility to the people as well as promote environmental awareness, eco-tourism, and biodiversity conservation. This forest is spread over 50 hectares of land which has been developed to reduce the severe levels of air pollution in the region. Since it's opening in 2020 it has become a known picnic sport for people all over Dehradun, many schools have also planned educational trips in and around the van. Here are some main attractions of the van.

(i) The Kids' Corner

In Anand Van is a vibrant haven of joy. Swings sway gently and slides beckon with thrilling descents. Children of all ages explore with boundless energy, their imaginations ignited by colorful play structures and the sounds of joyful play. It's a place where childhood dreams take flight, children of all ages can explore activities like zipline, cycling, tyre net, tree hut, etc.

(ii) Picnic Spot

Anandi Bugyal in Anand Van is perfect for a picnic. Sunlight filters through the trees, and a Vasudhara waterfall nearby. The ground is covered with soft grass and the air is filled with the sounds of families enjoying their meal. It is a peaceful place to relax and connect with the natural world.

(iii) Adventure Activities

Anand Van is a thrilling playground for adventure seekers. Zip lines soar through the treetops, offering breathtaking experience. Climbing Commando rope walls and tyre walls test strength and agility. It's a place where adrenaline surges and memories are made. Not only this but Anand van also offers knowledge about nature and wildlife by genius and creative depictions like

(iv) Herbal Garden

Herbal gardens also known as Sita Vatika is a living libraries of nature, cultivating a diverse array of aromatic and medicinal plants. These vibrant spaces offer a sensory feast, with fragrant blooms, soothing textures, and the promise of natural remedies.

(v) Butterfly Garden

Butterfly garden also known as Titalee udyaan is vibrant haven designed to attract and nurture these delicate creatures. A profusion of nectar-rich flowers, host plants for caterpillars, and sheltered areas provide the perfect environment for butterflies to thrive, offering a captivating spectacle of color and movement.

(vi) Information Corridor

The Information Corridor in Anand Van provides valuable insights into the diverse wildlife. Informative panels and statues of fascinating creatures that inhabit the wildlife, fosters a deeper appreciation for the wildlife and encourages responsible eco-tourism.

(vii) Astral Garden

Astral garden also known as Nakshtra Vatika**,** is a astro-themed garden, which has a large variety of plants and trees linked to the zodiac signs. the garden has been designed according to the Indian system of astrology.

6. Field Work

(i) Construction and Implementation of a Solitary Bee House Using Bamboo

Objectives:

To design and construct a solitary bee house using bamboo materials to support local solitary bee populations by providing suitable nesting habitats.

Ecological Importance:

Solitary bees are vital pollinators in many ecosystems. Unlike social bees, solitary bees do not live in colonies but nest individually. Providing artificial nesting sites, such as bee houses, can help support their populations, especially in areas where natural habitats are limited.

Materials Used:

Bamboo Sections: Bamboo was selected for its natural hollow structure, which can serve as nesting tunnels for solitary bees.

Wooden Frame: A wooden box was constructed to hold the bamboo sections securely.

Protective Covering: Steel mesh was used to cover the front of the bee house to protect against predators while allowing bees to access the nesting tubes.

Construction Process:

Preparation of Bamboo: Bamboo stalks were cut into sections approximately 15–20 cm in length, ensuring one end was naturally sealed by a node to mimic natural nesting sites.

Assembly of Wooden Frame: A wooden box was constructed with dimensions suitable to hold multiple bamboo sections tightly together.

Arrangement of Bamboo Sections: The bamboo pieces were packed horizontally into the wooden frame, with the open ends facing outward.

Application of Protective Covering: A steel mesh was attached to the front of the wooden box to prevent predators from accessing the nests while allowing bees to enter and exit freely.





Placement and Monitoring

Location: The bee house was installed in a forested area, mounted on a tree trunk at a height of approximately 1.5 meters. It was oriented to face southeast to receive morning sunlight, which helps warm the bees and encourages activity.

Monitoring: Regular observations were conducted to check for signs of occupancy, such as sealed bamboo tubes, which indicate active nesting.

(ii) Construction of A Recycling Yard

Objectives:

Establish a recycling yard using natural materials such as wood and wooden logs.

Collect and compost dry leaves to produce nutrient-rich compost for soil enrichment.

Promote environmental sustainability through effective organic waste management.

Site Selection: The site was chosen based on the following criteria:

- Proximity to areas with abundant dry leaf fall.
- Minimal disturbance to existing flora and fauna.
- Adequate space to accommodate the recycling yard without impacting the natural landscape.





Materials Used:

Locally sourced wooden logs and planks.

Basic tools for cutting and assembling wood.

Protective gear for safety during construction.

Design Specifications:

Dimensions: 8 feet (length) x 5 feet (width) x 2 feet (height), providing a volume of 80 cubic feet.

The structure includes slatted sides to allow adequate airflow, essential for aerobic decomposition.

Construction Process:

Design Planning: Developed a simple design for the yard, ensuring it blends with the natural surroundings. Site clearing: Cleared the selected area of debris while preserving existing vegetation.



Foundation laying: Arranged wooden logs to form the perimeter of the yard, securing them firmly into the ground. Wall Construction: Stacked additional logs to build walls approximately 1-meter-high, leaving an entrance for accessibility. Flooring: Left the natural forest floor intact to facilitate direct contact between composting materials and soil organisms.

Composting Process

Collection of Materials:

Dry leaves from mango, teak, and other local trees. Green plant materials, including weeds and fresh pruning. Fresh cow dung to introduce necessary microorganisms. Soil to provide additional microbial inoculants.

Preparation Steps:

Shred or break down large dry leaves to increase the surface area for microbial action.

Layering Technique:

Lay a 4-inch layer of dry leaves at the base. Add a 3-inch layer of green plant material on top. Add a thin layer of soil to introduce soil microbes and help in decomposition. Repeat the layering process until the pile reaches the desired height, ensuring each layer is moistened adequately.













7. Conclusion

The internship at Anand Van was a transformative experience for the students at Graphic Era University. It not only allowed them to contribute towards environmental conservation but also helped them to understand the deep interconnection between nature and human activities. Through their two major tasks: Constructing bee house for solitary bees and establishing recycling yard. They aimed for creating a meaningful impact on the environment and encourage the community to embrace sustainable practices.

The Solitary Bee House was an initiative project which play a crucial support for pollinators that help in enhancing biodiversity. Solitary bees, unlike honeybees, they do not live in hives so they require specific nesting sites. By constructing bee hotels using bamboo and wooden frames, Students provided safe and artificial nesting spaces for bees to lay their eggs and rest. By strategically placing the bee houses in advantageous spots, these pollinators would be able to carry on their vital job of pollinating plants which ultimately contributing to healthier ecosystems. In addition to the physical construction, this project helped spread awareness about the importance of solitary bees and their disappearing habitats and how visitors and community members can take small steps in protecting them.

The Recycling Yard Project was also a significant step towards sustainable waste management. By building a composting space made of natural materials, they showed how organic waste is recycled into high nutritional compost. With careful consideration in choosing a site, structural design and the layering of dry leaves, green plant material, cow dung and soil, the composting process facilitated decomposition. It highlighted the significance of responsible waste management and offered a template that could be adopted by others across the globe to reduce environmental degradation. It also underscored the concept of circular sustainability, that waste can become an asset rather than become fodder for landfills.

Working within Anand Van, a well-preserved urban forest in Dehradun, transformed additional meaning to their projects. Anand Van is not just a naturally retreat but the eco-tourism site blends conservation and education. With attractions like the Kids' Corner, Picnic Spots, Adventure Activities and themed gardens, including the Herbal Garden, Butterfly Garden and Astral Garden, it is an ideal place to promote environmental awareness. Their projects aligned with Anand Van's expansive vision of sustainability, while also offering visitors tangible examples of conservation in practice. Apart from getting technical skills like managing waste and building structures, the internship was a lesson in teamwork, problem solving, and responsibility. They discovered that even modest measures, like constructing bee houses or composting organic plant waste can yield large ecological returns. In addition, these projects proved how people can create positive environmental change when focused on a common purpose.

In the end their time in Anand Van solidified the idea that conservation is not the responsibility of a few, but everyone has their collective duty. By spending time in nature, learning, and fulfilling responsibilities, they can all make a contribution to a healthier planet. The experience of this internship brought them the opportunity to leave a real impact as well as the knowledge and inspiration they were carrying forward after this experience with them but it also armed with the encouragement and knowledge to incorporate sustainable practices into our daily lives.

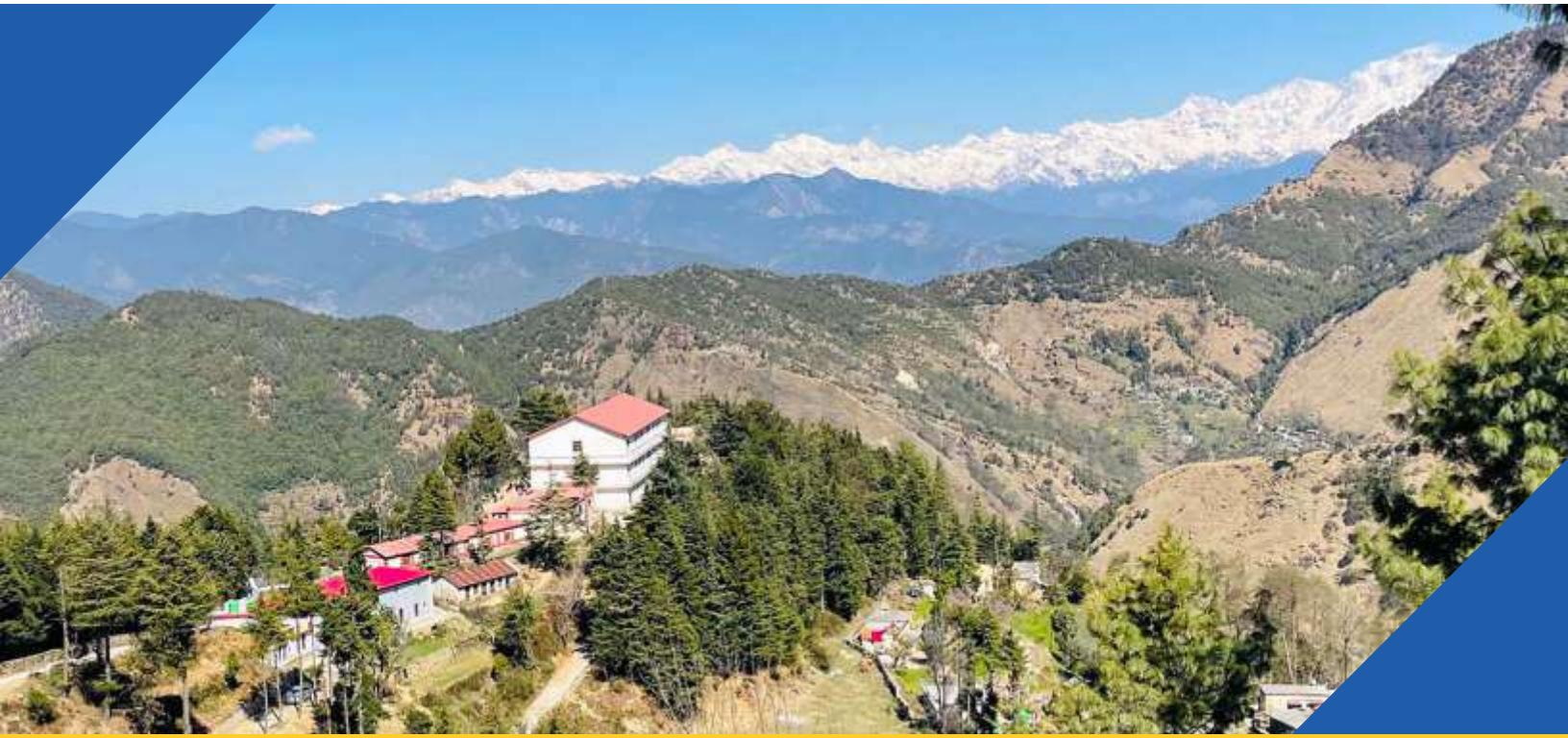
Abstract & Souvenir

Community-Based Field Workshop on-

ORCHID-POLLINATOR CONSERVATION FOR SUSTAINABLE MOUNTAIN DEVELOPMENT IN WESTERN HIMALAYAN REGION



OCTOBER 27-28, 2025



Organized by ——

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AMELIORATION OF BIODIVERSITY AND ENVIRONMENTAL RESEARCH

Preface

The event "*Orchid-Pollinator Conservation for Sustainable Mountain Development in the Western Himalayan Region*" at Ghimtoli, Rudraprayag, Uttarakhand, brings together researchers, conservationists, policymakers, and local communities to deliberate on one of the most crucial aspects of Himalayan biodiversity. The Western Himalaya, known for its exceptional ecological richness, harbors a diverse range of orchid species and their specialized pollinators that play vital roles in maintaining ecosystem health and resilience. However, increasing anthropogenic pressures, habitat fragmentation, and climate change are threatening these intricate relationships, calling for immediate scientific and community-based interventions. This event aims to foster knowledge exchange, showcase recent research, and promote collaborative efforts toward conserving orchids and their pollinators as integral components of mountain sustainability. The abstracts compiled in this book represent the collective insights, innovative approaches, and field-based experiences of participants who share a common vision-preserving the delicate balance between biodiversity and development in fragile mountain landscapes. We hope that the discussions and findings shared through this platform will inspire actionable strategies, strengthen conservation networks, and contribute meaningfully to the sustainable development goals in the Himalayan region.

About the Centre

The Centre of Sustainable Ecology and Biodiversity Research (CSEBR), located at Ghimtoli, Rudraprayag, Uttarakhand, is dedicated to advancing scientific understanding and promoting sustainable management of the unique ecosystems of the Western Himalayan region. Established with a vision to integrate ecological research with community-based conservation, CSEBR serves as a hub for interdisciplinary studies on biodiversity, ecosystem dynamics, and sustainable mountain development. Nestled in the heart of the Himalayas, the Centre provides a natural laboratory for exploring the intricate relationships between flora, fauna, and local livelihoods. Its primary focus areas include orchid and pollinator conservation, climate change adaptation, habitat restoration, and traditional ecological knowledge. Through field research, capacity-building programs, and stakeholder engagement, CSEBR strives to bridge the gap between science and society, ensuring that conservation efforts translate into tangible benefits for mountain communities. The Centre also collaborates with national and international institutions to foster innovative research and policy dialogues on mountain sustainability. By nurturing young researchers and involving local youth in conservation initiatives, CSEBR plays a vital role in shaping a resilient ecological future for the Himalayas. Its commitment to science-based conservation and community empowerment makes it a cornerstone of sustainable development in the region.



Program Schedule

DAY-1

October 27, 2025

10:00 AM	INAUGURAL
10:00 AM -10:30 AM	REGISTRATION
10:30 AM - 10:45 AM	Welcome Dr. V. P. Uniyal, Professor & Director CSEBR, GEU
10:45 AM -10:55 AM	About the Workshop Dr. Manu Pant, Professor & Head, Department of Biosciences, GEU Release of Workshop Souvenir & Research Plan, CSEBR
10:55 AM -11:10AM	Inaugural Address Prof. Narpinder Singh, Vice - Chancellor, Graphic Era (Deemed to be University)
11:10 AM - 11:20 AM	Address by Guest of Honour Dr. I. D. Bhatt, Director G.B. Pant National Institute of Himalayan Environment (GBPNIHE), Almora
11:20 AM - 11:30 AM	Address by Guest of Honour Mr. Rajat, IFS Divisional Forest Officer, Rudraprayag
11:30 AM - 11:45 AM	Key Note Address by Guest of Honour, Dr. R. K. Maikhuri, Professor & Head, Dept. of Environment Science, HNB Central University, Srinagar, Garhwal
11:45 AM -12:10 PM	Address by Chief Guest - Dr. S. P. Subudhi, IFS Chairman, Uttarakhand Biodiversity Board, Govt. of Uttarakhand
12:10 PM	Vote of Thanks & Tea

TECHNICAL SESSION - I

(INVITED SPEAKERS & POSTER PRESENTATION)

THEME: HIMALAYAN BIODIVERSITY, SUSTAINABLE AGRICULTURAL PRACTICES, SOCIO-ECONOMIC BENEFITS

12:15 PM - 12:30 PM	Dr. I. D. Bhatt, Director, G. B. Pant National Institute of Himalayan Environment (GBPNIHE), Almora
12:30 PM - 12:45 PM	Dr. R. S. Negi, Professor & Head Department of Rural Technology, HNB Central University, Srinagar Garhwal
12:45 PM - 1:00 PM	Dr. D. S. Chauhan, Professor & Head, Dept. of Forestry HNB Central University, Srinagar Garhwal
1:00 PM - 1:30 PM	Poster Presentations by Students of Forestry, HNB Central University, Srinagar, Garhwal
1:30 PM - 2:00 PM	Lunch

TECHNICAL SESSION - II

THEME - COMMUNITY PARTICIPATION FOR BIODIVERSITY CONSERVATION

2:15 PM - 2:30 PM	Dr. Vinod K. Bhatt, Director, IRD Foundation, Dehradun
2:30 PM - 2:45 PM	Mr. Hari Raj, Subject Specialist - Soil & Water Conservation
2:45 PM - 3:00 PM	Dr. B. P. Chamola, Associate Professor, Department of Forestry HNB Central University, Srinagar, Garhwal
3:00 PM - 3:15 PM	Dr. I. K. Pandey, Assistant Professor, Govt. P. G. College Karanprayag, Chamoli
3:15 PM - 3:30 PM	Dr. K. P. Chamoli, Asst. Prof., Dept. of Botany, Govt. P. G. College Agastyamuni, Rudraprayag
3:30 PM - 4:00 PM	Discussion, Questionnaire Session, & Feedback

DAY-2

October 28, 2025

SESSION - III - HANDS-ON TRAINING AND FIELD EXERCISE WITH STAKEHOLDERS (COMMUNITY SHGS, FARMERS, STUDENTS, FRONTLINE STAFF OF FOREST DEPARTMENT)

10:00 AM - 10:15 AM	Dr. Manu Pant, Professor and Head, Dept. of Biosciences, Graphic Era Deemed to be University, Dehradun
10:15 AM - 10:30 AM	Dr. Vandana Mehrwar & Dr. V. P. Uniyal, Professor Dept. of Biosciences, Graphic Era Deemed to be University, Dehradun
10:30 AM - 11:30 AM	Hands-On-Training on Orchid Propagation, Substrate-mix Preparation and Pot Preparation by Ms. Ayushi Negi, Project Fellow, and Ms. Aarushi Gautam, Research Fellow Department of Biosciences, Graphic Era (Deemed to be University) Dehradun
11:30 AM - 1:00 PM	FIELD VISIT to nearby villages: Exploration of indigenous Orchids and Pollinators
1:00 PM - 1:30 PM	Distribution of Certificates and Awards
1:30 PM - 1:35 PM	Vote of Thanks
1:35 PM - 2:00 PM	Lunch

Program Committee

Program Coordinator (s)

Dr. V. P. Uniyal
Professor & Director CSEBR

Dr. Manu Pant
Professor & Head, Department of Biosciences, GEU

Programme Team

Ayushi Negi	Junior Project Fellow, IERP Project
Aarushi Gautam	PhD Scholar
Aditi Sharma	PhD Scholar
Eshan Chowdhary	PhD Scholar
Tejaswini Bhatt	PhD Scholar
Pratik Pansare	PhD Scholar
Nitin Vashishth	Lab Staff

Volunteers

Arpit Tyagi	BSc. Biotechnology
Raghav Sharma	BSc. Biotechnology

ABSTRACT

Issues and Challenges for Conservation and Management of Traditional Agro-biodiversity in Indian Central Himalayan Mountain

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Environmental, biological, socio-cultural and economic variations in the central Himalaya (Uttarakhand) have led to the evolution of diverse and unique traditional agroecosystems, crop species, and livestock, which help the traditional mountain farming societies to sustain themselves. During the recent past, as a result of rapid changes in land use caused by socio-cultural and economic changes and various environmental perturbations, the agrobiodiversity of the central Himalayan agroecosystems has changed steadily. Poor scientific understanding of mountain agriculture, policy ignorance, socio-economic and environmental changes seriously impedes the identification of sustainable agricultural development solutions for the Indian central Himalayan mountain. The importance of agro-biodiversity as a key component of natural resource management has been will recognized and holds the key to food security and sustainable agriculture development. But, so far very little emphasis has been given to improve the yield potential of the traditional mountain crops. Despite the fact that Uttarakhand is a predominantly hill region, it has no clear cut hill specific development plan and policies. However, it is not that there have not been initiatives for hill development but largely either it was not implemented properly or overlooked/ignored by the implementers. The lack of understanding and appreciation of the micro-macro linkages in the context of global changes will have a profound impact on the way business of research and development is conducted in central Himalayan conditions (Uttarakhand). Present agricultural policies have largely ignored the vital resource base of traditional crops. And, agricultural research had concentrated only on few major crops such as wheat, rice, maize, sugarcane etc. for increasing their production through external input. Scientific experimental paradigms have often ignored local and indigenous agricultural knowledge and focused on a massive push towards technologies with ever-increasing dependence on external resources. The loss of agrobiodiversity and the changing socio-cultural and economic dimensions and their impacts on the sustainability of Himalayan agroecosystems are emerging as major causes of concern at local/regional/national and global scale. There is a strong need to bring desirable changes in the agricultural policy, research and development, land use and breeding approaches. The present paper describes general characteristics of mountain agriculture, highlight traditional ago-biodiversity and its significance, status, rate and ecological, social and policy impacts and implications on agro-biodiversity loss and strategies for conservation and management of mountain agro-ecosystems which is rich in agro-biodiversity.

Pollinators and Contrivances in Orchidaceae: A Missing Link in Biodiversity Conservation Strategies

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Pollination is a crucial supporting ecosystem service for biodiversity maintenance and resilience by ensuring sexual reproduction and improving genetic diversity. Globally, 87 of the major food crops depend on animal pollination, accounting for nearly 35% of the world's food production volume. Despite this, the role of pollinators in facilitating plant fertilization, particularly in angiosperms, remains largely underappreciated and overlooked, except for a few bee species that pollinate food crops. This oversight is notable when planning and designing biodiversity strategies, especially those focused on wildlife conservation. Among others, Orchidaceae, with all their fantastic flowers, vegetative forms and extraordinary species richness has various contrivances (mechanism of pollination), where besides offering diversity of rewards such as nectar, lipids, floral volatiles, fragrances, trichomes, sleep sites, pollen and resins, the plant employs deceit (food and sexual deception), by exploiting the cognitive and sensory abilities of pollinators via chemical, visual or tactile stimuli, generally in combination. The intricate flowers and visiting pollinators led to the evolution of plant-specific pollinators, displaying an array of multiple pollinators working in tandem and cohesion for sustaining orchids' populations. Most orchids are self-compatible, especially rupicolous and epiphytic species, more so than terrestrial ones. The pollinator guild of orchids is largely represented by bees (hymenoptera), flies (Diptera), butterflies and moths (Lepidoptera), and birds (Aves). Globally, orchids comprise a staggering richness of around 31,000 species, making them one of the largest flowering plant families. In India, the family is represented by 1340 species with the highest concentration in the Himalayas, followed by Peninsular India and the Andaman & Nicobar Islands. Orchid diversity in the Indian Himalayan region is largely influenced by rainfall regime, with the highest diversity recorded in the Eastern Himalayan region (>900 spp.), followed by Western Himalaya (nearly 250 sp.), North West Himalaya (Himanchal-75 spp., Jammu & Kashmir- 60 spp.). High endemism is also recorded in orchids with 115 endemic taxa, of which 20 species are under IUCN'S Critically Endangered (16) and Endangered (04) categories. The pollinator diversity and contrivances in sustaining orchids are poorly understood and underrepresented across the policy-science and practice domains, hence extremely difficult to mainstream and bring into conservation discourses. Bridging this gap is essential for strengthening the biodiversity conservation landscape beyond the existing conventional threats, such as habitat loss, over-exploitation, invasive species, climate change, and pollution.

Keywords: Orchid; Pollination; Ecosystem Services; Biodiversity Conservation; Pollinators; Orchidaceae

Potential of Beekeeping as Symbiotic Conservation Strategy for Biodiversity Conservation and Livelihood Enhancement in the Rudraprayag District of Garhwal Himalayas

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The study explores the potential of community-based beekeeping as a dual-purpose strategy for biodiversity conservation and rural livelihood enhancement in the Uttarakhand, Western Himalayas. The study area represents a global biodiversity hotspot with remarkable orchid diversity, yet face severe conservation challenges due to habitat loss, climate change, and declining pollinator populations. Local communities in these mountain ecosystems possess invaluable traditional knowledge of beekeeping with the native Asian honeybee *Apis cerana,* presents a promising pathway to address both ecological degradation and rural poverty through an integrated community-based approach. It serves as a low-cost, sustainable enterprise that not only empowers local communities economically but also fosters the conservation of native orchid species through enhanced pollination services. Various plant species specially Orchids, being highly dependent on specific pollinators for reproduction, benefit from the presence of managed honey bee colonies that supplement natural pollinator populations. The research integrates ecological and socio-economic assessments to evaluate how apiculture can strengthen the awareness level and mutual relationship between floral diversity and livelihood security. The research utilizes a mixed-methods case study approach, combining qualitative and quantitative techniques to assess the impact of community-based beekeeping on orchid conservation and rural livelihoods in selected Western Himalayan communities. Rudraprayag district hosts 545 beekeepers, as per government records. This study engaged 155 of these households using mixed methods interviews, focus group discussions, participant observation, and structured surveys to document social dynamics, traditional knowledge, and key demographic and socio-economic details. Participants were recruited through snowball and purposive sampling. The results revealed notable knowledge gaps and emphasized the need for integrated strategies to enhance sustainable beekeeping practices. Field observations, floral resource mapping, and community engagement initiatives reveal that sustainable beekeeping practices not only improve household income and nutritional resilience but also contribute to the restoration of orchid habitats and pollination ecology. The findings Suggest for a participatory conservation model such as beekeepers of SHG's and FPO's act as custodians of both biodiversity and cultural heritage, it supports India's National Mission on Beekeeping and Honey (NMBH) by demonstrating beekeeping as a symbiotic conservation strategy linking ecological restoration with community empowerment in the fragile ecosystems of the Western Himalayas.

Keywords: Beekeeping, Conservation, Sustainable, Pollination, Community, Orchid, *Apis cerana*

Empowering Forest Fringe Communities and Local Stakeholders Through Collection/ Harvesting of NTFPs in the Western Himalayas

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Non-timber forest products (NTFPs) play vital role among the rural population and provide a source of income and subsistence living. Fuel-wood, flowers, fruits, nuts, medicinal plants, wild edible vegetables, house building materials etc. are integral part of day-to-day livelihood activities especially for people living in forest finger. In India it plays an important role in the social and traditional life of millions of forest dependent population, particularly the tribal and landless people, women and other rural poor (Stanley et al., 2012; Shackleton and Pandey, 2014; Pandey et al., 2016). Commercial NWFP collection in India, was estimated to generate nearly US$1.6 billion, at the forest gate in 2010 (Kumar et al, 2015; Joshi 2003). Today, it contributes over 75% of total forest export revenue in India. Nearly 400 million people living in and around forests depend on NTFP for sustenance and supplemental income, about 70% of the NWFP collection takes place in the tribal belt. In many rural forest-dependent communities across India (Bhattacharya, 2015), NWFP provide half of the cash income for 30% of rural people (FAO, 2018; Meinhold et al., 2019). More than 80% of forest dwellers depend on NTFPs for basic necessities. The collection of NTFPs comprises the main source of wage labour for 17% of landless labourers, and 39% more are involved in NTFPs collection as subsidiary occupation. According to an estimate the NTFP sector alone is able to create about 10 million workdays annually in the country (Planning Commission, 2011). India has shown remarkable progress during last 15 years for enhancing contribution of forests towards poverty alleviation through empowering people with the ownership of NTFP. Uttarakhand state is a part of Western Himalaya, comprised 938 NTFPs that are used for different purposes, viz. medicinal plants (701), wild edibles (155), oil yielding (32), soap and detergent (22), insecticide/pesticides (15) and fiber (13), etc. (Samant et al. 1998, Maikhuri et al. 1994, 2014, Kala et al. 2005, Negi et al., 2011). An estimated the state having only 1% population involved handlooms, agro based industries, rural artisan, collection of NTFPs (Govt. of UK, 2009). NTFPs did not contribution more than 6% of the total income in village of Chamoli and Rudraprayag districts Nagarwala (2006). Areas above 2000m altitude, or in villages with access to high altitude pastures, a very significant proportion of the population, roughly over 30% households depend on NTFPs gathering for a substantive part of their earnings (Semwal et al. 2007). Jhoola (Lichens), Moss, Tajpata, Resin (Pinus roxburghii), Taxus, Bahera, Harra, Ritha, Kafal, Burans, Ringal, Guchii and MAPs have emerged as the major NTFPs collected and traded in State. NTFPs production during 2014-2015 was 17070.780 quintals which was received Rs. 16, 42, 73550=00 in the state (UFS, 2015). The income generation from important NTFPs available in the Western Himalayas is significant, considering the regional annual per capita income. There is significant option for enhancing the income-generation potential through value addition and empowering forest fringe communities. The present study will explore the possibility of commercialization of some important NTFPs in Western Himalayas for improving the economy of local stakeholders.

Revitalizing Traditional Agroecological Practices in Uttarakhand Himalaya: A Pathway to Sustainable Livelihoods and Food Security

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Uttarakhand Himalaya, with its rich biodiversity and unique cultural heritage, is home to a variety of traditional food crops that have been cultivated for centuries. These nutritionally rich crops, such as millets, pseudocereals, and pulses, are well adapted to the region's fragile mountain ecosystem and offer immense potential for sustainable and climate resilient agroecological farming. Notably, these crops are low in gluten and have a low glycaemic index, making them an excellent choice for people with diabetes. Traditional knowledge systems, passed down through generations of farmers, play a crucial role in the conservation and utilization of these crops. However, the challenging terrain of the Uttarakhand hills, characterized by steep slopes, fragmented landholdings, and erratic weather patterns, limits the effectiveness of conventional agriculture. In this context, traditional agroecological approaches are particularly relevant, as they promote sustainable farming practices that are adapted to the region's unique challenges. Agroecological approaches, combined with community-led seed conservation, participatory breeding, and women-led seed banks, provide a sustainable pathway to strengthen local livelihoods while conserving biodiversity. This paper highlights the importance of traditional food crops and associated traditional knowledge in promoting agroecological farming practices in Uttarakhand Himalaya, enhancing food security, improving livelihoods, and conserving biodiversity in the region, while also providing nutritional benefits and dietary solutions for people with specific dietary needs.

Keywords: Traditional food crops, Traditional knowledge, Agroecological farming, Resilient farming systems, Glycaemic index, Biodiversity conservation, Seed Bank, Food security, Livelihoods, Himalayan region.

Integrated Plant Nutritional and Health Management of Orchids Cultivation in North-West Himalaya

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Integrated plant nutrition and health management practices are the key to achieving the desired plant vigour and targeted economic yields, and the same holds true for the Orchids cultivation in the north-west Himalayan region. Various crop growth limiting factors, like: nutrient and water deficiencies and imbalances, poor seedbed preparations, impeded drainage, competing weeds, pest and disease management and control, improper variety selection can easily be controlled by the farmers through timely interventions. Under protective cultivation conditions, a large number of the environmental factors can easily be controlled to achieve desired crop response and yields, as compared to open field conditions. Considering the high value and sensitivity of the orchid crops it is highly advisable to go for protected cultivation. A 75% shade net helps mimic natural conditions along with maintaining temperature range (18-28°C) and humidity level (70-80%) to achieve healthy and economic yields.

Nutrient management in orchids, typically requires nitrogen, phosphorus, potassium (NPK) fertilizers application as a solution, in the ratio of 1:1:1 every 2 weeks in early growth stage; followed by 3:1:1 ratio in pre-flowering stage and 1:2:2 ratio during flowering stage, respectively. Besides this, organic manures such as: oilseed cakes decoctions, locally available composted mixture, coco peat mixture need to be applied for balanced micro and micro nutrition of the orchid plants. Application of effective microorganisms like: *rhizobium, azospirillum* and *azotobacter* can further enhance nutrient uptake and promote resilient plant growth.

Adequate drainage is the key to the growth of orchids to prevent *root rot*. Various pests, which includes, *slugs* and *snails, mites, caterpillars, aphids* and *sciaridae*, and various diseases need to be timely identified and plant protection measures employed. Reporting of the orchids every 2 to 3 years as they outgrow the containers needs to be done cautiously followed by fortification through nutrients.

With the ever-increasing demand of orchids as a whole plant and as cut flowers, appropriate nutritional as well as pest and disease management practices under a protected cultivation environment, will lead to the desired productivity and a fair marketable quality flower production in the north-west Himalaya.

Keywords: orchid cultivation; integrated plant nutrition management (IPNM); cut flowers; ornamental gardening; protected cultivation; plant protection in orchids (IPM); north-west Himalaya; Himalayan livelihoods

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Native Arbuscular Mycorrhizal Fungi Inoculated Plants for Restoration of Landslide Areas of Garhwal Region

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Landslides pose a significant natural hazard particularly in geologically sensitive regions like the Garhwal Himalaya. This research investigates the pivotal role of Arbuscular Mycorrhizal Fungi (AMF) inoculated plants in the ecological restoration of landslide-affected areas. The study involved the collection, isolation, and identification of indigenous AMF species from various landslide sites, followed by screening for their root colonization capabilities. Key findings indicate that AMF inoculation significantly enhances the growth parameters and survival rates of plant species, specifically *Dendrocalamus strictus* and *Albizia lebbeck,* when transplanted into challenging landslide environments. *Glomus macrocarpum* emerged as a particularly effective AMF species, demonstrating superior growth promotion. The research highlights the potential of AMF as a sustainable and effective biotechnological tool for mitigating landslide impacts and accelerating ecological recovery in degraded mountainous terrains. This approach offers a promising avenue for enhancing soil stability and fostering vegetation establishment in vulnerable ecosystems.

Keywords: Landslide restoration, Arbuscular Mycorrhizal Fungi, Garhwal Himalaya, *Dendrocalamus strictus, Albizia lebbeck,* ecological restoration, *Glomus macrocarpum*.

Impact of Expanding Pine On Pollinator Diversity and Abundance

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This study investigates the impact of expanding *Pinus roxburghii* (Pine) forest on pollinators. The methodology includes field observations and review of published literature. Pine expansion negatively impacts pollinator diversity and abundance by fundamentally altering habitat structure and reducing essential resources. It significantly decreases the richness and abundance of flowers, which are critical food sources for insect pollinators. This reduction in floral diversity is the primary driver of the decline in pollinators, as it limits the availability of nectar and pollen throughout the season. In areas where canopy openness is reduced due to high tree density, understory plant communities and the pollinators that depend on them are significantly suppressed. This habitat homogenization leads to a decrease in overall biodiversity and a shift in pollinator communities towards more disturbance-tolerant species. Pine forest is considered a major cause for forest fire. It also affect pollinators in different ways depending upon the intensity of fire. The long-term effects of pine expansion on pollinator populations highlight the potential conflict between large-scale afforestation for carbon sequestration and biodiversity conservation. Therefore, careful planning and management of forest is crucial to prevent further decline of vital pollinator guilds.

Key words: Pine, Biodiversity, Forest fire, Pollinators

Prominent Ethnobotanical Plants of High-Altitudinal Regions of Rudraprayag District and Their Role in Community Health Management

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The high-altitudinal regions of the Rudraprayag district in the central Himalaya preserve remarkable ethnobotanical traditions that remain vital for community healthcare. Due to limited medical infrastructure and geographic isolation, local inhabitants largely depend on medicinal plants for their primary healthcare needs. The present study documents and evaluates the prominent ethnobotanical species of high-altitude regions (1,600-3,200 m a.s.l.) and their therapeutic significance. The ethnobotanical survey was conducted from October 2023 to March 2025 and included 247 randomly selected informants from different villages. Field surveys and interviews with traditional healers and elderly informants recorded 128 medicinal plant species, comprising 81 herbs, 19 shrubs, 15 trees, and 13 climbers, representing 58 families, with Asteraceae, Lamiaceae, Rosaceae, and Polygonaceae as dominant. Frequently cited species include *Dactylorhiza hatagirea, Aconitum heterophyllum, Valeriana jatamansi, Rheum australe, Berberis asiatica, Picrorhiza kurroa, Bergenia ciliata, Paeonia emodi, Angelica glauca, Saussurea obvallata, Taxus baccata, Betula utilis, Artemisia nilagirica, Nardostachys jatamansi,* and *Swertia chirayita*. These plants are traditionally used to treat gastrointestinal disorders, cancer, diarrhoea, eye diseases, dysentery, jaundice, diabetes, snakebite, tuberculosis, paralysis, rheumatic pain, liver ailments, asthma, cough, skin diseases, toothache, wounds, and cuts, etc. Roots and leaves were the most commonly used plant parts, prepared mainly as decoctions, pastes, and infusions. The findings highlight the significance of these high-altitude ethnobotanical resources for sustainable community health management and emphasize the urgent need for their conservation and scientific validation.

Keywords: Ethnobotany, Medicinal plants, High-altitude Himalaya, Rudraprayag , Community health, Conservation

Creation of Ecofriendly Pollinator Yards in Rudraprayag, Uttarakhand: A Community-Based Approach for Pollinator Habitat Restoration

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Pollinators play a vital role in maintaining ecosystem resilience and agricultural productivity, yet their populations are declining globally due to habitat loss, pesticide use, and climatic stress. The Himalayan region, including Rudraprayag district of Uttarakhand, faces particular vulnerability owing to fragile landscapes and changing land-use patterns. To address these challenges, a proposed initiative titled *Creation of Ecofriendly Pollinator Yards* aims to enhance pollinator habitats through participatory, eco-based interventions. The programme will adopt a hands-on and capacity-building methodology involving local communities, students, and institutions. Site selection will be based on accessibility, sunlight exposure, and existing vegetation. Training modules will cover pollination ecology, native plant selection, organic soil enrichment, and habitat design to ensure year-round floral availability and nesting opportunities. Participants will collaboratively establish pilot pollinator yards using native flowering species and low-input management practices. Periodic monitoring will assess pollinator diversity, plant survival, and community response through field surveys and feedback sessions. Expected outcomes include increased awareness of pollinator importance, strengthened community stewardship, and the development of a replicable model for biodiversity-friendly landscaping in Himalayan ecosystems. The initiative seeks to integrate scientific guidance with traditional ecological knowledge to promote sustainable, community-driven conservation and ecological restoration in mountain environments.

Keywords: Capacity building, Community participation, Ecofriendly landscaping, Himalayan ecosystems, Nature-based solutions, Pollinator conservation

Empowering Farmers Through Hand-On Orchid Cultivation Training for Sustainable Livelihood and Conservation

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The orchid cultivation training program is designed to empower local farmers with sustainable horticultural practices and to promote income generation through high-value floriculture. It will be conducted over a structured series of sessions, the training will introduce participants to the diversity, ecological importance, and market potential of orchids, with emphasis on species adaptable to local climatic conditions. Farmers will be guided in understanding orchid biology, propagation techniques, and appropriate cultivation environments, including shade house construction, controlled humidity, and temperature regulation. Practical demonstrations covering planting media preparation, nutrient management, irrigation systems, and integrated pest and disease management to reduce chemical inputs and protect ecological balance. Special focus will be given to native and commercially viable orchid varieties, ensuring both conservation of indigenous species and economic feasibility. Hands-on modules allowing farmers to practice vegetative propagation methods such as division and backbulb planting. Participants will be provided with guidelines for harvesting and post-harvest handling to maintain quality standards, enabling access to domestic and export markets. Beyond technical aspects, the training will address marketing strategies, cooperative sales models, and linkage with floriculture value chains. Farmers will be encouraged to adopt sustainable practices, integrating orchid cultivation with agroforestry and eco-tourism initiatives to diversify income streams. The program will also stress the role of orchid farming in biodiversity conservation and climate resilience in rural communities. Outcome evaluations indicating significant improvement in farmers' knowledge, skill application, and motivation, along with readiness to implement cultivation models will be made. The training thus, will serve as a catalyst for rural livelihood enhancement and environmental stewardship through sustainable orchid production.

Keywords: Orchid, Propagation, Conservation, Livelihood, Ecotourism


CENTRE FOR
SUSTAINABLE ECOLOGY AND
BIODIVERSITY RESEARCH

Workshop Report

Empowering Communities and Local Stakeholders: The Role of Pollinators in Sustaining Orchids in the Western Himalaya

27th & 28th October, 2025

at

Centre of Sustainable Ecology and Biodiversity Research (CSEBR), Ghimtoli
In Collaboration with Department of Biosciences,
Graphic Era (Deemed to be University), Dehradun



® Centre for Sustainable Ecology and Biodiversity Research (CSEBR)
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Workshop Program Coordinating Team

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Team

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Eshan Chowdhary
Tejaswini Bhatt
Pratik Pansare
Vartika Negi
Pooja Chaudhary
Nitin Vashishth
Arpit Tyagi
Raghav Sharma



Financial Assistance

Indian Council of Social Science Research (ICSSR)
GB Pant National Institute of Himalayan Environment (GBPNIHE)
Uttarakhand Biodiversity Board (UBB)
Graphic Era (Deemed to be University)

PREFACE

The organization of the community-based workshop on *"Empowering Communities and Local Stakeholders in the Role of Pollinators in Sustaining Orchids in the Western Himalayas"* was essential because the fragile Himalayan ecosystems, especially their orchid diversity, are increasingly threatened by climate change, habitat degradation, unsustainable development, and rapid socio-economic transitions that are eroding both ecological processes and traditional conservation knowledge. In the Western Himalayas, orchids are not merely ornamental plants; they are keystone components of forest ecosystems and sensitive bioindicators of ecological change, depending intricately on specific pollinators whose decline directly affects orchid survival. Yet, despite their ecological importance, orchid-pollinator relationships remain poorly understood at the community level, and local people who live closest to these species and interact daily with forest landscapes, are rarely aware of how pollinators influence orchid reproduction, forest health, and long-term biodiversity resilience. Conducting this workshop was therefore vital for bridging scientific knowledge with community-based wisdom, empowering forest-dependent communities, SHGs, farmers, and frontline forest staff with practical understanding of how pollinators sustain orchid diversity and why their protection is fundamental to maintaining the ecological balance of Himalayan landscapes.

Over the years, climate variability, erratic flowering phenology, shifting pollinator ranges, and degradation of microhabitats have disrupted the delicate orchid-pollinator networks in the region; without timely community awareness and training, these disruptions could lead to irreversible losses. The workshop addressed this gap by creating a platform where leading academics, forest officials, biodiversity experts, and local communities could collectively engage in discussions, demonstrations, and field-based learning, emphasising the interdependence of pollinators, orchids, and local livelihoods within mountain socio-ecological systems. Various expert sessions ranging from Himalayan biodiversity and sustainable agriculture to socio-economic linkages, conservation ethics, and ecological restoration helped local participants understand that conserving pollinators is not an isolated scientific exercise, but a community-driven responsibility connected to their food security, water resources, cultural traditions, and environmental stability. This significance was further amplified by hands-on training on orchid propagation techniques, substrate preparation, and pot designing, which equipped participants, especially women from SHGs and youth, with skills that can support livelihood diversification while reducing extraction pressures on wild orchid populations. The field visit to nearby villages, where communities explored native orchid species and observed pollinators in natural settings, allowed participants to see the ecological relationships firsthand-something classroom lectures alone could never achieve. By exposing communities to these real-world observations, the workshop fostered a deeper appreciation for native biodiversity and inspired a sense of stewardship for local forests.

Additionally, involving the Uttarakhand Forest Department, biodiversity board officials, subject experts in botany, zoology, economics, and environmental science ensured that conservation was framed not only as an ecological priority but also as a socio-economic imperative rooted in policy, research, and community livelihoods. Considering the Western Himalayas' vulnerability to forest fires, land-use changes, unregulated tourism, and agricultural expansion, empowering local communities to monitor pollinators, protect orchid habitats, and adopt sustainable practices is indispensable. Local people are the first responders to ecological disturbances, whether noticing a pollinator decline, a new invasive species, or changes in flowering time, and must be equipped with knowledge that enables timely intervention.

The workshop thus served as a long-term investment in community ownership of conservation initiatives, recognising that ecological protection cannot succeed through top-down governance alone but requires active collaboration with local custodians of the landscape. For many participants, the programme was their first exposure to the scientific significance of orchids and the unseen but crucial role pollinators play in sustaining forest ecosystems. By fostering dialogue between scientists and communities, the workshop encouraged inclusive decision-making, strengthened local conservation ethics, and inspired youth engagement in biodiversity monitoring. Furthermore, the event aligned with national priorities such as the National Mission for Himalayan Studies and the Uttarakhand government's emphasis on participatory forest management, biodiversity conservation, and eco-sensitive livelihood enhancement. The exchange of ideas among experts and locals also helped integrate indigenous ecological knowledge-such as traditional plant uses, seasonal indicators, and community-based protection practices-into scientific conservation frameworks, ensuring culturally grounded and locally adaptable conservation strategies. The presence of school students in parallel competitions introduced conservation values early in life, nurturing ecological consciousness among the next generation of mountain stewards. Overall, the workshop was essential not simply as a training event but as a catalyst for long-term collaborative conservation, enabling community members to become informed partners in safeguarding orchid populations and pollinator diversity. In a region where ecological fragility and socio-economic dependence on natural resources intersect, building such community capacities is the most direct and sustainable approach to ensuring that the Western Himalayan ecosystems continue to thrive. By empowering local voices, strengthening scientific-community linkages, and promoting ecological literacy, the workshop laid the foundation for resilient, community-led biodiversity conservation that can withstand the mounting pressures of environmental change.

WORKSHOP PROCEEDINGS

A two-day community participation field based national seminar on Empowering Communities and Local Stakeholders: The Role of Pollinators in Sustaining Orchids in the Western Himalayas was held on October 27-28, 2025, at the Centre of Sustainable Ecology and Biodiversity Research (CSEBR) of Graphic Era Deemed to be University, at Ghimtoli, Rudraprayag, Uttarakhand. The seminar aimed to raise awareness on orchids, their pollinators, and the strategies and need for conservation. The deliberations during the event highlighted the role of orchids and orchid pollinators in the mountain ecosystem and. sustainable development. The seminar was attended by over 100 participants, including women farmers, local residents, community representatives from the region, students from Department of Forestry, Hemwati Nandan Bahuguna, Garhwal University (A Central University), Srinagar Garhwal, Graphic Era (Deemed to be University), Dehradun, and Frontline staff of Rudraprayag Forest, Division, Forest Department, Government of Uttarakhand attended the Community based workshop.



CSEBR Station & Workshop Venue



PROGRAM SCHEDULE

Day 1: 27.10.25

9:00 am onwards	Registration (Ms. Tejaswini)
10:00 am	Inaugural (Master of ceremony- Ms. Aarushi Gautam)
10:00-10:15 am	Welcome of dignitaries, guests and participants
10:15-10:30 am	Saraswati Vandana (Ms. Aditi Sharma)
10:30-10:45 am	Welcome Address: Prof. V.P. Uniyal, Dept. of Biosciences, GEU
10:45-11:00 am	Inaugural Address: Prof. Narpinder Singh, Vice Chancellor, GEU (Online address)
11:00-11:15 am	Address by Prof. Manu Pant, Head, Department of Biosciences, GEU
11:15-11:40 am	Key note Address by Guest of Honour, Prof. R. K. Maikhuri, Professor and Head, Department of Environment Science, HNB Garhwal University, Srinagar, Garhwal
11:40-12:10 pm	Address by Guest of Honour, Mr. Rajat Suman, IFS, DFO, Rudraprayag
12:10-12:15 pm	Address by Smt. Kamla Devi, Gram Pradhan, Ghimtoli, Rudraprayag
12:15-12:25 pm	Release of Souvenir and Research Plan of CSEBR
12:25-12:40 pm	Address by Chief Guest, Dr. S. P. Subudhi, IFS, Chairman, Uttarakhand Biodiversity Board, Government of India
12:40- 1:00 pm	Vote of Thanks and Felicitation of the Guests
1:00-1:15 pm	Tea Break
1:15-2:00 pm	Inaugural and Visit to the Orchidarium
2:00-2:30 pm	Lunch

Technical Session – 1 (Presentations)

2:30-2:45 pm	Mr. Navdeep, Research Scholar, HNB Garhwal University, Srinagar, Garhwal
2:45-3:00 pm	Mr. Hari Raj Singh, Subject Specialist- Soil and Water Conservation
3:00-3:10 pm	Discussion, Questionnaire Session and Felicitation of the Speakers
3:10-3:30 pm	Poster Presentation Students of Department of Forestry, HNB Garhwal University

Day 2: 28.10.2025

Technical Session – 2 (Presentations & Hands-on-Training)

11:00-11:30 am	Participant interaction with Mr. Pratik Pansare, Research Scholar, Department of Biotechnology, GEU and Ms. Pooja Choudhary, Research Scholar.
11:30-11:55 am	Prof. D. S. Chauhan, Head, Department of Forestry, HNB Garhwal University, Srinagar, Garhwal
11:55- 12:15 pm	Dr. B. P. Chamola, Associate Professor, Department of Forestry, HNB Garhwal University, Srinagar, Garhwal
12:15-1:00 pm	Hands-on-Training on Orchid Propagation by Prof. Manu Pant, Head, Department of Biosciences, GEU, Ms. Ayushi Negi, Project Fellow, Department of Biosciences, GEU and Ms. Aarushi Gautam, Research Scholar, Department of Biotechnology, GEU
1:00-1:30 pm	Lunch
1:30-2:00 pm	Valedictory and Feedback Session
2:00-2:30 pm	Award Distribution and Group Photograph

DAY – 1 OCTOBER 27, 2025 REGISTRATION

The Centre of Sustainable Ecology and Biodiversity Research (CSEBR) of GEU at Ghimtoli, Rudraprayag, Uttarakhand was the venue of the two days' seminar that had a wide range of participants ranging from students, to farmers, community members, scientists, experts and forest officials.









INAUGURAL

The event was inaugurated by the Chief Guest Dr. S. P. Subudhi, IFS, Chairman, Uttarakhand Biodiversity Board, Government of Uttarakhand and Guest of Honours Prof. Dr. R. K. Maikhuri, Professor and Head, Department of Environment Science, HNB Garhwal University, Srinagar, Garhwal, Mr. Rajat Suman, IFS, Divisional Forest Officer, Rudraprayag, Mr. Devendra Pundir Assistant Conservator of Forests, Dr. Divakar Pant, Assistant Conservator of Forests and Smt. Kavita Devi, Gram Pradhan and Village Representative, Ghimtoli, Rudraprayag.

After a formal welcome of the dignitaries, Dr. V. P. Uniyal, Professor in the Department of Biosciences and coordinator of the Centre for Sustainable Ecology and Biodiversity Research (CSEBR), Graphic Era (Deemed to be University), delivered the opening address and outlined the seminar's goals. In his address, Dr. Uniyal emphasized the importance of society to understand the significance of orchids and their pollinators, while also stressing the need to explore medicinal flora and involve local communities to create livelihood opportunities. He highlighted the increase in forest cover across India and acknowledged the vital role of frontline forest staff in biodiversity conservation. He also encouraged local communities to develop livelihood opportunities, such as doing orchid cultivation, in collaboration with the Uttarakhand Biodiversity Board and the Forest Department. His address was followed by an online speech by Dr. Narpinder Singh, Vice Chancellor of Graphic Era (Deemed to be University), who appreciated the efforts of the organizing team, invited guests, and participants for their involvement in the inaugural seminar cum workshop on Orchid Pollinator Conservation for Sustainable Mountain Development in the Western Himalayan Region at Ghimtoli, Rudraprayag. He recognized the financial support from the Indian Council on Social Science Research (ICSSR) that enabled the smooth execution of the two-day workshop. He highlighted the importance of this workshop for local stakeholders and farmers, providing an opportunity to gain knowledge about local biodiversity. This workshop aims to serve as a capacity-building platform to promote income generation through orchid propagation and product development.















Prof. Manu Pant, Head, Department of Biosciences, GEU in her address, talked about the strategic importance of establishing the research centre at Ghimtoli, Rudraprayag, and the significance of conducting workshops within rural communities to engage local people directly in conservation efforts. Dr. Pant stressed the importance of cultivating orchids in their natural habitats while also advocating that community-based orchid plantations can serve as a sustainable approach to livelihood enhancement and income generation for local communities. Dr. Pant motivated the local community leaders and women farmers to engage in sustainable orchid conservation and propagation, emphasizing the economic importance of orchids in the global and Indian economy.



The Guest of Honour, Prof. Dr. R. K. Maikhuri, Professor and Head, Department of Environment Science, HNB Garhwal University, Srinagar, Garhwal, delivered the keynote address on the vital role of community participation in reducing pressure on forest resources and promoting sustainable development, forest conservation and ecosystem restoration. He discussed the successful agroforestry models, which effectively resolved human-wildlife conflicts while promoting sustainable land use. Dr Maikhuri stressed the need to revive our natural resources for ecological and economic sustainability. He quoted the case study from Niti village (Chamoli District), where local communities cultivate medicinal plants such as Faran (Allium stracheyi) to sustain their livelihoods, and encouraged the growers to work on similar lines for orchid cultivation.

He also shared insights on the carbon sequestration potential of plants, ranging between 3.2 to 3.5 tons per hectare, highlighting the role of forests in climate change mitigation. In his address, Dr. Maikhuri also noted that Northeast India's humid climate supports rich orchid diversity and Uttarakhand similarly possesses extensive orchid and medicinal plant resources. He expressed concern over declining pollinator populations and emphasized the need for increased research. In his concluding remarks, Dr. Maikhuri shared the potential of Ghimtoli village in creating livelihood opportunities through community-based conservation initiatives and the need to promote climate-resilient crops.

Guest of Honour, Mr. Rajat, IFS, Divisional Forest Officer, Rudraprayag, provided valuable insights from a forest management perspective. He emphasized that orchids are among the least-studied flowering plants in the state and in India, as data availability on indigenous orchid species is limited. He cited Dr. V. P. Uniyal's work as an important reference for orchid research in Uttarakhand. He also highlighted the need for focused research on the genus Dendrobium, noting its vast potential to create livelihood opportunities for local communities. He pointed out that both tourists and communities often overlook the importance of microflora, which play vital roles in maintaining ecological balance. Mr. Rajat also stated that Rudraprayag's landscape provides a favorable natural habitat for orchids, making it ideal for in-situ conservation. He also encouraged promoting orchid cultivation in natural environments and replicating successful models on a larger scale to ensure biodiversity conservation and sustainable rural development.

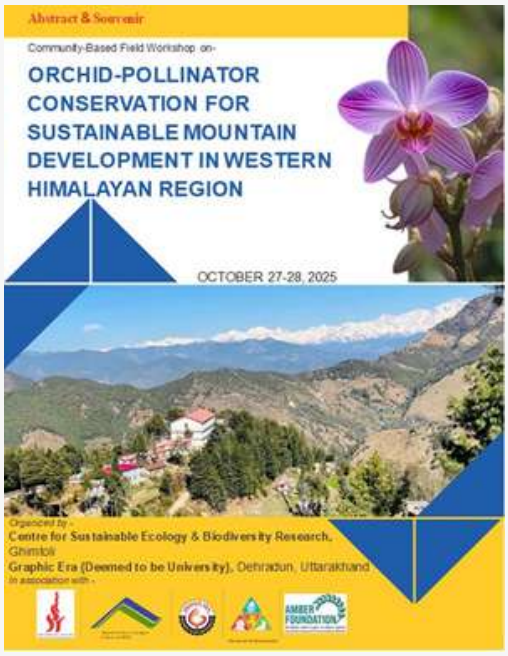




Smt. Kavita Devi, Gram Pradhan and Village representative expressed gratitude on behalf of the local community to all participants and honorable guests for organizing the seminar that directly benefits local people. She also ensured active participation from the local communities and farmers for income generation and sustainable mountain development.

This was followed by official release of seminar souvenir and research plan of the centre by the dignitaries.





The Chief Guest of the event, Dr. S. P. Subudhi, IFS, Chairman, Uttarakhand Biodiversity Board, Government of Uttarakhand, delivered an invigorating talk on biodiversity-based livelihoods. He emphasized the sustainable use of biodiversity for livelihood generation and the role of Biodiversity Management Committees at the Gram Panchayat level in maintaining and managing biodiversity registers. He also pointed out knowledge gaps among communities regarding biodiversity conservation and underlined the importance of raising awareness. Dr. Subudhi also encouraged the initiation of livelihood-based start-ups, including orchid cultivation. He also recommended establishing community-based research and incubation centres in nearby villages throughout the region. In his concluding remarks, Dr Subudhi also encouraged young researchers, students and community leaders to utilise local resources and establish start-ups to generate livelihood and gain benefit from their traditional knowledge.

A major milestone of the workshop was the inauguration of the Orchidarium facility at CSEBR GEU, Ghimtoli, Rudraprayag. The facility was inaugurated by Dr. S. P. Subudhi, Chairman, Uttarakhand Biodiversity Board and was joined by other dignitaries. The Orchidarium facility showcased the Dendrobium and Cymbidium orchid varieties. A brief introduction about orchids, their propagation techniques and potting material was discussed by Dr. Manu Pant and Ms. Ayushi Negi. They emphasized on the commercial importance of orchid species and also highlighted the cost-effective ways to propagate orchids to earn better monetary benefits. The polyhouse will now be available for training of local population in orchid cultivation in Rudraprayag.






TECHNICAL SESSIONS

01 Mr. Navdeep, Department of Development & Technology, HNB Garhwal University, Srinagar, specializing in pollinators, especially bees, delivered an in-depth presentation on the relationship between pollinators and orchids. The correlation between flowers and insects was also explained in depth, with a major focus on Apis bees and their relationship with orchids. He encouraged students and farmers to practice traditional techniques and sustainable practices of beekeeping in conserving pollinator bees, which in turn will also help conserve orchids at the higher altitudes in their natural habitat. He also highlighted major threats to orchid populations, with tourism a major threat to the vulnerable orchid species. He addressed ways to generate economic benefits and enhance livelihoods through pollinator-based initiatives.

02 Mr. Hari Raj Singh, Subject specialist in Soil and Water Conservation, provided essential insights into environmental management. He discussed the impact of weed infestation on different types of biomass, explained the basic concepts of cloudbursts and soil erosion. Mr. Hari Raj also highlighted the importance of forestry in preventing erosion events and its broader scope in environmental management. 32He elaborated on soil properties and components contributing to soil fertility, emphasizing the importance of soil testing and discussed how slope and terrain influence plant growth. He also underlined the need for informed soil and water management practices in sustainable agriculture and forestry.





POSTER PRESENTATIONS

A poster competition was organized for the students on the themes: Forest Fires and their management, Orchid diversity and conservation, Human Wildlife conflict resolution, medicinal plants and their sustainable utilization and biodiversity conservation strategies. Ten teams comprising 2 to 4 students in each team participated and presented their posters. Posters were evaluated by a panel of experts.





DAY 2: OCTOBER 28, 2025

The second day of the workshop commenced with an interaction between Mr. Prateik and Ms. Pooja with the participants, which was followed by an expert talk delivered by Dr. D. S. Chauhan and Dr. B. P. Chamola. Post-lunch, the Valedictory session was organized, where the chief guest, Mr. Puran Singh Negi, and participants shared their feedback about the two-day workshop. This was followed by the award distribution and a group photograph.

Talk by Mr. Pratik Pansare and Ms. Pooja Chaudhary

Mr. Pratik Pansare, Department of Biotechnology, GEU and Ms. Pooja Choudhary presented their research work on the Flora and Fauna of Uttarakhand and shared valuable insights on biodiversity conservation. They also shared recent biotechnological advances being adopted to conserve the biodiversity of Uttarakhand and also promote a sustainable mountain ecosystem.

Expert talk by Prof. Dr. D. S. Chauhan

Prof. Dr. D. S. Chauhan, Professor and Head, Department of Forestry, HNB Garhwal University, Srinagar, presented on empowering local communities and local stakeholders through harvesting of non-timber forest products in the western Himalayas. He also emphasized the collection of commercial NWFP in India which was estimated to generate nearly 1.6 billion USD during 2010. He mentioned the current contribution of total forest export revenue in India to be 75%, out of which Uttarakhand contributes only 1% of the overall commercial NWFP. He highlighted the major NWFPs: Jhoola (lichens), moss, tejpatta, resins, Taxus, kafal, burans, ringal, Guchii and Medicinal and Aromatic Plants (MAPs) collected and traded in the state. He urged local communities to value indigenous knowledge and natural resources for developing eco-friendly products and entrepreneurship opportunities.

Expert talk by Dr. B. P. Chamola

Dr. B. P. Chamola, Associate Professor, Department of Forestry and Natural Resources, HNB Garhwal University, Srinagar, presented on the topic Native arbuscular mycorrhizal fungi (AMF) inoculated plants for restoration of landslide areas of the Garhwal region. He highlighted the role of AMF-inoculated plants in the ecological restoration of landslide-affected areas where the sample was collected from the Mohankhal region of Rudraprayag. The key findings indicated that AMF inoculation significantly enhances the growth parameters and survival rates of plant species, specifically Dendrocalamus strictus and Albizia lebbeck when transplanted into challenging landslide environments. Dr. Chamola also mentioned foreign collaborations for the related work on AMF.

Hands-on-Training Orchid Propagation

Hands-on training on Orchid Propagation was conducted by Dr. Manu Pant, Ms. Ayushi Negi, and Ms. Aarushi Gautam to local farmers and students. Dr. Pant highlighted the economic importance of orchid species like Dendrobium and Cymbidium. Farmers and students visited the Orchidarium facility of the CSEBR, Ghimtoli, Rudraprayag and were given hands-on training to propagate orchid plants. Ideal temperature conditions, morphology and the natural habitat of orchids were discussed with the students and farmers.Further, the requirements for a polyhouse set-up were also described. A cost-effective alternative was also shared with the farmers so that they can reap higher financial benefits from orchid cultivation.





VALEDICTORY SESSION

For the valedictory session, Mr. Puran Singh Negi, Former Principal, Govt. Inter College, and President, Kartkswami Temple Committee, Ghimtoli, Rudraprayag, was the Chief Guest. He appreciated the efforts of the organizing team for taking the initiative in uplifting the local communities through livelihood generation. He was delighted that so many participants from the village and young minds were present to share novel ideas for biodiversity conservation and community outreach. The participants shared their feedback. Students were also asked to share their experience of the workshop; they were delighted to gain more knowledge about orchids and their pollinators. They thanked the organisers for organising the workshop, where novel ideas for research were discussed.









AWARD DISTRIBUTION

Students were awarded for their enthusiastic participation in the poster competition. They were awarded certificates and momento for their efforts by the Chief Guest Mr. Puran Singh Negi, Former Principal, Govt. Inter College.



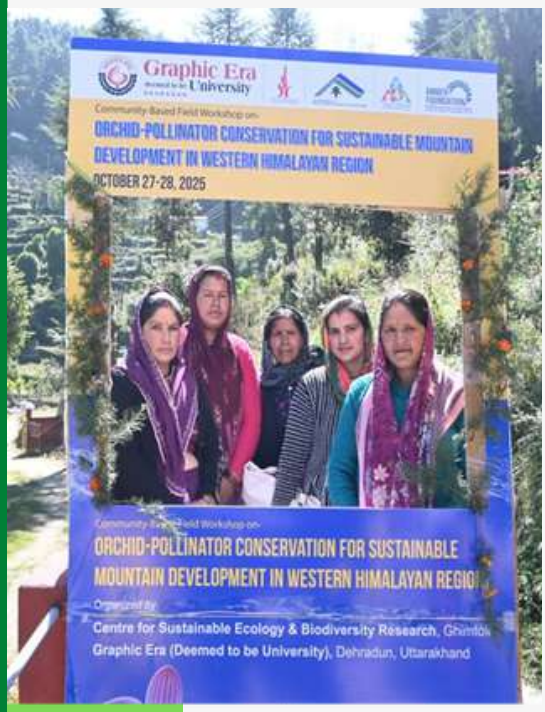


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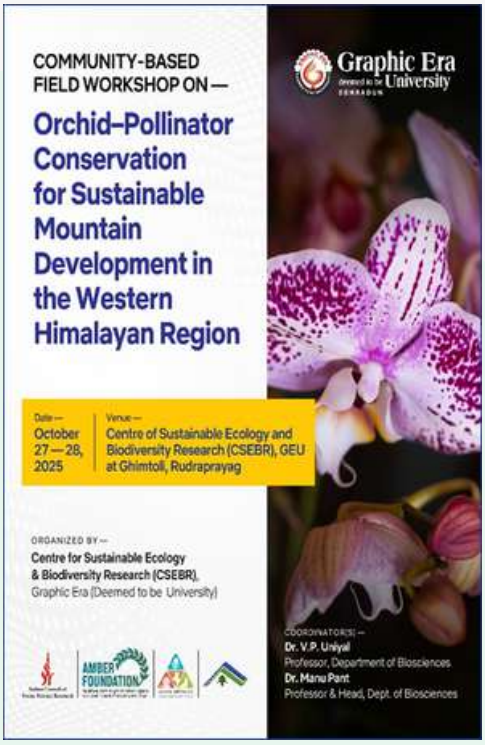
Community-Based Field Workshop on Orchid–Pollinator Conservation

Graphic Era (Deemed to be University), through its Centre for Sustainable Ecology & Biodiversity Research (CSEBR), is organizing a Two-Day Community-Based Field Workshop on "Orchid–Pollinator Conservation for Sustainable Mountain Development in the Western Himalayan Region" on October 27–28, 2025, at Ghimtoli, Rudraprayag.

The workshop is being jointly organized in collaboration with:
– Indian Council of Social Science Research (ICSSR), Govt. of India
– G.B. Pant National Institute of Himalayan Environment and Development
– Uttarakhand Biodiversity Board

Coordinated by Dr. V.P. Uniyal, Professor, Department of Biosciences, and Dr. Manu Pant, Professor & Head, Department of Biosciences, GEU — the event aims to bring together scientists, conservationists, local communities, and policymakers to promote biodiversity conservation and sustainable mountain development.

The initiative focuses on the ecological and cultural significance of orchids and their pollinators in the Indian Himalayan Region (IHR) — a global biodiversity hotspot — while addressing emerging challenges of climate change, habitat degradation, and ecological awareness.



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Graphic Era University organized a two-day Community-Based Field Workshop on Orchid Pollinator Conservation for Sustainable Mountain Development at Ghimtoli, Rudraprayag, on Oct 27–28, 2025.

Held under the joint initiative of the Centre of Sustainable Ecology and Biodiversity Research (CSEBR) and the Department of Biosciences, GEU, the workshop marked the University's first major community engagement program. Sponsored by the ICSSR, GBPNIHE, Almora, and the Uttarakhand Biodiversity Board, the event promoted orchid conservation, sustainable livelihoods, and eco-friendly innovation through expert talks and hands-on training.

Inaugurated by **Dr. S.P. Subuddhi, IFS**, Chairman, Uttarakhand Biodiversity Board, the workshop saw active participation from women farmers, community workers, and students — reflecting Graphic Era's commitment to community-based biodiversity conservation and sustainable mountain development.

The event was convened and coordinated by **Prof. V.P. Uniyal** and **Prof. Manu Pant** (Head, Department of Biosciences, GEU).

#GraphicEraUniversity #CSEBR #OrchidConservation #SustainableDevelopment #Biodiversity #CommunityEngagement #ICSSR #UttarakhandBiodiversityBoard #GEU #WomenEmpowerment #EcoInnovation

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Virendra P Uniyal 9+
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COMMUNITY-BASED FIELD WORKSHOP ON —
Orchid–Pollinator Conservation for Sustainable Mountain Development in the Western Himalayan Region
Date — October 27 — 28, 2025
Venue — Centre of Sustainable Ecology and Biodiversity Research (CSEBR), GEU at Ghimtoli, Rudraprayag
ORGANIZED BY —
Centre for Sustainable Ecology & Biodiversity Research (CSEBR), Graphic Era (Deemed to be University)
Graphic Era deemed to be University DEHRADUN
AMBER FOUNDATION
COORDINATOR(S) —
Dr. V.P. Uniyal
Professor, Dept. of Biosciences
Dr. Manu Pant
Professor & Head, Dept. of Biosciences


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Menu उत्तराखंड समाचार राष्ट्रीय राजनीति मनोरं

रुद्रप्रयाग/श्रीनगर गढ़वाल। पश्चिमी हिमालयी क्षेत्र में जैव विविधता संरक्षण और सतत पर्वतीय विकास को बढ़ावा देने के उद्देश्य से सतत पारिस्थितिकी एवं जैव विविधता अनुसंधान केंद्र (सीएसईबीआर),ग्राफिक एरा विश्वविद्यालय (जीईयू),देहरादून द्वारा जैव विज्ञान विभाग के सहयोग से दो दिवसीय सामुदायिक क्षेत्रीय कार्यशाला का आयोजन 27–28 अक्तूबर 2025 को ग्राम घिमतोली,रुद्रप्रयाग में किया गया। यह कार्यशाला भारतीय सामाजिक विज्ञान अनुसंधान परिषद (आईसीएसएसआर) भारत सरकार तथा गोविंद बल्लभ पंत राष्ट्रीय हिमालयी पर्यावरण एवं सतत विकास संस्थान (जीबीपीएनआईएचई) अल्मोड़ा के संयुक्त तत्वावधान में आयोजित की गई। इसका मुख्य विषय था ऑर्किड परागण संरक्षण-स्थानीय समुदायों के माध्यम से सतत पर्वतीय विकास की दिशा में प्रयास। कार्यक्रम का उद्घाटन सोमवार को मुख्य अतिथि डॉ.एस.पी.सुबुद्धि अध्यक्ष उत्तराखंड जैव विविधता बोर्ड उत्तराखंड सरकार द्वारा किया गया। उनके साथ रजत सुमन प्रभागीय वनाधिकारी रुद्रप्रयाग,डॉ.दिवाकर पंत तथा देवेंद्र सिंह पुंडीर सहायक वन संरक्षक,प्रो.आर.के.मैखुरी विभा[illegible] पर्यावरण विज्ञान हेमवती नंद[illegible] केंद्रीय विश्वविद्यालय श्रीनगर ए[illegible]

ख़बरें फटाफट



उत्तराखंड रुद्रप्रयाग

सतत पर्वतीय विकास के लिए आर्किड परागण संरक्षण पर दो दिवसीय कार्यशाला का आयोजन

By Pardeep Kumar

OCT 28, 2025



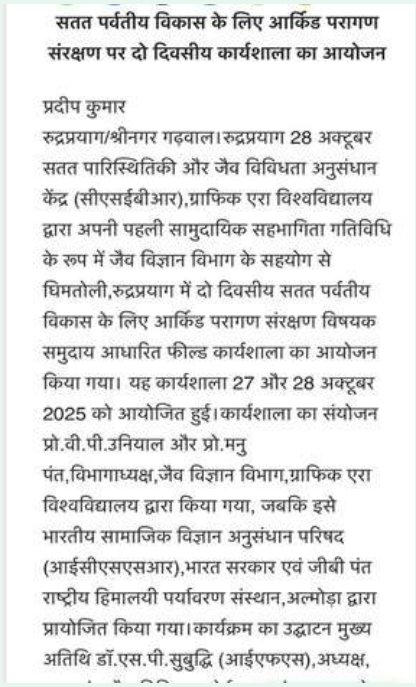
कार्यशाला में स्मारिका का विमोचन करते विशेषज्ञ। [illegible]

कार्यशाला में आर्किड की खेती पर दिया जोर

श्रीनगर। गढ़वाल केंद्रीय विवि के वानिकी एवं प्राकृतिक संसाधन विभाग के छात्र-छात्राओं ने सतत पारिस्थितिकी और जैव विविधता अनुसंधान केंद्र (सीएसईबीआर), जीईयू के जैव विज्ञान की ओर से घिमतोली, रुद्रप्रयाग में आयोजित फील्ड कार्यशाला में प्रतिभाग किया। पश्चिमी हिमालयी क्षेत्र में सतत पर्वतीय विकास के लिए आर्किड परागण संरक्षण पर आयोजित कार्यशाला में विशेषज्ञों ने आर्किड की खेती पर जोर दिया। गढ़वाल विवि के डॉ. वीपी [illegible] ने बताया कि कार्यशाला का शुभारंभ मुख्य अतिथि जैव विविधता बोर्ड के अध्यक्ष डॉ. एसपी सुबुद्धि ने किया। [illegible] संसाधनों के महत्व को समझने के लिए प्रोत्साहित किया। गढ़वाल विवि के पर्यावरण विज्ञान विभाग के अध्यक्ष प्रो. आरके मैखुरी ने कृषि और जैव विविधता के साथ आत्मनिर्भरता की आवश्यकता पर जोर दिया। आईएफएस रजत सुमन ने आर्किड की खेती पर जोर दिया। कहा कि यह ग्रामीण विकास और सतत विकास के लिए अच्छी पहल साबित होगी। मौके पर कार्यशाला स्मारिका का विमोचन भी [illegible] इस मौके पर प्रभागीय वन[illegible] रुद्रप्रयाग डॉ. दिवाकर [illegible] सहायक वन संरक्षक रुद्रप्रयाग [illegible] सिंह पुंडीर, प्रधान कविता देवी [illegible]

Dr. Manu Pant
Professor and Head at Dept of Bioscience...
Of the several significant events that I organise or am a part of, ...more

59 7



सतत पर्वतीय विकास के लिए आर्किड परागण संरक्षण पर दो दिवसीय कार्यशाला का आयोजन

प्रदीप कुमार

रुद्रप्रयाग/श्रीनगर गढ़वाल।रुद्रप्रयाग 28 अक्टूबर सतत पारिस्थितिकी और जैव विविधता अनुसंधान केंद्र (सीएसईबीआर),ग्राफिक एरा विश्वविद्यालय द्वारा अपनी पहली सामुदायिक सहभागिता गतिविधि के रूप में जैव विज्ञान विभाग के सहयोग से घिमतोली,रुद्रप्रयाग में दो दिवसीय सतत पर्वतीय विकास के लिए आर्किड परागण संरक्षण विषयक समुदाय आधारित फील्ड कार्यशाला का आयोजन किया गया। यह कार्यशाला 27 और 28 अक्टूबर 2025 को आयोजित हुई।कार्यशाला का संयोजन प्रो.वी.पी.उनियाल और प्रो.मनु पंत,विभागाध्यक्ष,जैव विज्ञान विभाग,ग्राफिक एरा विश्वविद्यालय द्वारा किया गया, जबकि इसे भारतीय सामाजिक विज्ञान अनुसंधान परिषद (आईसीएसएसआर),भारत सरकार एवं जीबी पंत राष्ट्रीय हिमालयी पर्यावरण संस्थान,अल्मोड़ा द्वारा प्रायोजित किया गया।कार्यक्रम का उद्घाटन मुख्य अतिथि डॉ.एस.पी.सुबुद्धि (आईएफएस),अध्यक्ष,

LIST OF PARTICIPANTS

COMMUNITY-BASED FIELD WORKSHOP ON – **Date: 27-28 Oct, 2025**

Orchid-Pollinator Conservation for Sustainable Mountain Development in the Western Himalayan Region

Organized by: Center for Sustainability Ecology & Biodiversity Research (CSEBR), Graphic Era (Deemed to be University)

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50.	Ruby Devi (Farmer)	Ghimtoli Rudraprayag	9368873918

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57.	Deepa (Farmer)	Ghimtoli, Rudraprayag	—
58.	Archana Jyoti [ANM]	Ghimtoli, Rudraprayag	9837744179.
59.	Mageshi (Farmer)	Ghimoli, Rudraprayag.	—
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64	Chanda Devi (Farmer)	Ghimtoli, Rudraprayag.	7819024090
65	Rahila Devi (Farmer)	Ghimtoli Rudraprayag.	7983015524
66	Kamla Devi (Farmer)	Ghimtoli Rudraprayag.	9410581907.
67	Geeta Devi (Farmer)	Ghimtoli Rudraprayag.	9548406783
68	Asha Devi (Farmer)	Ghimtoli Rudraprayag	9528972293
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70.	Atul Nautiyal (Ardhali (Constable)	UKF.	7351944108

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74.	Prabha (Forester)	UKF	8218416989
75.	Kamal Singh (Driver)	UKF	9412941085
76	Rohit Kumar (Driver, DFO)	UKF	7017755774
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80.	Vinod Singh (Ardhali)	UKF	7060207554

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84.	Upendra Barthwal (Technician)	UPCL	9411180720
85.	Rajeshwari Devi (farmer)	Ghimtoli, Dehradun.	7668229325
86.	Vijaya Devi (Farmer)	Ghimtoli, Dehradun	952 888 4873
87	Vijaya Devi (Farmer)	Ghimtoli, Dehradun	9411598563
88	Babita Devi (Farmer)	Ghimtoli, Dehradun	7453966319
89.	Pushpa (Farmer)	Ghimtoli, Dehradun	9410952671
90.	Deepa Devi (Farmer	Ghimtoli, Dehradun	9548448500

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COMMUNITY-BASED FIELD WORKSHOP ON – **Date: 27-28 Oct, 2025**

Orchid-Pollinator Conservation for Sustainable Mountain Development in the Western Himalayan Region

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Evaluation Sheet for Poster Presentation:

S.No.	Participants	Topic
1.	Priya, Aarti, Deepak, Sahil	Medicinal Plants Found in Uttarakhand
2.	Shivam, Mukul, Ajay, Dinesh	Forest fire Management
3.	Aman Kumar, Vishal, Tillu	The role of Forest in climate change
4.	Parthana, Suchita Anubhav	Agroforestry and sustainable land use
5.	Aisa, Khushi	Save environment
6.	Rajat, Atul, Amit Anurag, Ganga	Human and Wildlife conflict
7.	Anushka Singh, Anushka, Ankur	Afforestation and deforestation
8.	Jyoti, Ashee, Saatvik	Gymnosperm of Uttarakhand
9.	Simran Arya	Orchid Pollination
10.	Ashee Gogoi, Jyoti, Saatvik	Types of Forest & vegetation in Garhwal Himalayas, UK

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Graphic Era
CENTRE FOR
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PROJECT REPORT

Documentation of Orchids & Associated Pollinators of Dalma Wildlife Sanctuary, Jharkhand

APRIL, 2026

GRAPHIC ERA DEEMED TO BE UNIVERSITY

DALMA WILDLIFE SANCTUARY
DALMA, JHARKHAND

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CENTRE FOR SUSTAINABLE ECOLOGY AND BIODIVERSITY RESEARCH (CSEBR)
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UNIYAL, V. P., PANT, M., AND MEHRWAR, V. 2026. DOCUMENTATION OF ORCHIDS & ASSOCIATED POLLINATORS OF DALMA WILDLIFE SANCTUARY, JHARKHAND. PROJECT REPORT.

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DALMA WILDLIFE SANCTUARY
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Executive Summary

The report Documentation of Orchids & Associated Pollinators of Dalma Wildlife Sanctuary, Jharkhand presents the results of a six-month field study (October 2025–March 2026) undertaken by the Centre for Sustainable Ecology and Biodiversity Research, Graphic Era (Deemed to be University), Dehradun, in collaboration with the Jharkhand Forest Department. Dalma Wildlife Sanctuary, covering 193 km² on the Chhotanagpur plateau, is a vital dry deciduous protected area and a key Asian elephant corridor. Despite its recognized ecological importance, detailed information on its orchid diversity and plant–pollinator interactions had remained limited. Orchids, owing to their specialized reproductive biology, obligate mycorrhizal associations, and sensitivity to microclimatic conditions, function as effective bioindicators of forest health in seasonally dry ecosystems. This study was designed to address this knowledge gap by providing a comprehensive, geo-referenced baseline inventory of wild orchid species and characterising their associated pollinator guilds.

The investigation pursued two primary, interlinked objectives. First, it aimed to document the diversity, distribution, growth forms (epiphytic and terrestrial), microhabitat preferences, phenological patterns, and local abundance of orchid species across different ranges, beats, and habitat types within the sanctuary. Second, it sought to identify major pollinator taxa through direct field observations where feasible and through established pollination-syndrome analysis supported by peer-reviewed literature and expert consultation from the Botanical Survey of India.

A stratified random sampling design was employed across dry sal forests, mixed deciduous slopes, riparian patches, and forest-grassland ecotones. Identification followed dichotomous keys from Misra (2014), with geo-referenced coordinates recorded using handheld GPS units. Given the project duration, direct pollinator observations were constrained; pollinator guilds were therefore inferred from floral traits (colour, morphology, scent, nectar reward, and spur characteristics) and cross-validated with regional references.

The study recorded 20 wild orchid species belonging to 12 genera, comprising 12 epiphytic and 8 terrestrial taxa. Epiphytic species were predominantly associated with mature host trees such as *Shorea robusta*, *Terminalia tomentosa*, and *Diospyros melanoxylon* in closed-canopy mixed deciduous forests at 400–750 m elevation. Terrestrial species occupied shaded forest-floor and rocky substrates in riparian and ecotone habitats. Flowering peaked during the pre-monsoon to monsoon period, with melittophily (bee pollination) predominant among most species and sphingophily (hawk-moth pollination) noted in *Habenaria* taxa. Abundance was highest for *Vanda tessellata*, *Vanda testacea*, and *Aerides multiflora*, while several rarer taxa underscore conservation priorities.

The findings confirm Dalma's role as a significant orchid refuge within the Chhotanagpur plateau and an ecological stepping stone between major Indian biodiversity hotspots. Key challenges include habitat fragmentation, grazing, fire regimes, and anthropogenic pressures. The report provides targeted conservation recommendations, including the designation of "Orchid Conservation Zones," protection of key phorophytes, retention of leaf-litter layers, and integration of orchid monitoring into the sanctuary's management plans. Extension of the study for a full annual cycle is strongly advised to verify syndromes through direct observations and assess reproductive success.

This report delivers a scientifically robust baseline that links orchid diversity to pollinator networks and habitat associations. It elevates the conservation profile of Dalma Wildlife Sanctuary beyond its charismatic megafauna and offers an evidence-based framework for orchid-inclusive protected-area management across the region. Adoption of the recommended measures will strengthen ecosystem resilience and support long-term biodiversity stewardship in one of eastern India's ecologically significant landscapes.

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This report is a reflection of the collective dedication, kindness, and shared passion of everyone who stood by us. It is our humble contribution towards conserving the rich orchid and pollinator heritage of Dalma Wildlife Sanctuary, a place that has left a lasting imprint on our hearts.

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1.Introduction

Dalma Wildlife Sanctuary stands as one of the most ecologically and culturally significant protected areas in eastern India. Nestled on the Chhotanagpur plateau of Jharkhand, it spans approximately 193 km² across East Singhbhum and Saraikela-Kharsawan districts. The sanctuary encompasses the Dalma hill range, with elevations rising to about 915 m above sea level. Its forests, classified predominantly as “Dry Peninsular Sal” and “Northern Dry Mixed Deciduous Forest”, exhibit striking seasonal rhythms. During the intense summer months, most trees shed their leaves under scorching heat often exceeding 42-46 °C, creating an open canopy that allows intense sunlight to reach the forest floor. With the arrival of the southwest monsoon, which delivers 1200–1400 mm of annual rainfall, the landscape transforms dramatically as the canopy becomes lush and green once again. These pronounced seasonal shifts in light, moisture, and habitat structure generate unique ecological windows that support a remarkable diversity of flora and fauna, including highly specialized plant–pollinator interactions.

Geologically, Dalma occupies an ancient landscape where major shear zones separate Precambrian provinces more than a billion years apart in origin. This complex geological history has shaped a mosaic of habitats ranging from dry deciduous slopes and rugged hilltops to riparian patches and forest-grassland ecotones. The sanctuary drains into the Subarnarekha River and Dimna Lake, playing a vital role in the region’s hydrological system. Administratively, it is managed through two main ranges: Dalma Wildlife East and Dalma Wildlife West, each further divided into beats and sub-beats such as Bhadudih, Nutandih, Patamda, Mango, Chakulia, and Dalma.

This hierarchical structure facilitates effective protection, habitat management, and biodiversity monitoring across the varied terrain.

Culturally, Dalma is deeply interwoven with local traditions. The sanctuary derives its name from “Dalma Mai”, a revered local goddess whose hilltop temple and cave continue to attract large gatherings of devotees during annual rituals in the month of Asarh. This intimate link between sacred geography and forested hills has helped foster strong community connections to the landscape and has indirectly contributed to the long-term conservation of its natural resources.

Ecologically, Dalma is best known as a natural stronghold for the Asian elephant. Herds move across its streams, seasonal waterholes, and forested slopes, particularly visible around dwindling water sources during the peak of summer. The same mosaic of habitats also supports an impressive assemblage of wildlife, including pangolin, sloth bear, Indian grey wolf, wild dog, giant red squirrel, and diverse reptiles such as the Indian rock python and bamboo pit viper. A rich avian community featuring the crested serpent eagle, plum-headed parakeet, and paradise flycatcher further enhances its biodiversity value.

Despite its recognized importance for charismatic megafauna, the sanctuary’s orchid diversity and associated pollinator networks remain poorly documented. Orchids, with their exceptional sensitivity to microclimatic changes, dependence on specific pollinators, and obligate mycorrhizal associations, serve as excellent bioindicators of forest health in dry deciduous ecosystems.

In such seasonally dry landscapes, epiphytic orchids like *Vanda tessellata, Vanda testacea, Acampe praemorsa, Aerides multiflora, and Rhynchostylis retusa* are closely tied to particular canopy assemblages and moisture regimes, while terrestrial genera such as *Eulophia, Habenaria, Nervilia,* and *Zeuxine* exploit narrow seasonal windows on the forest floor. However, most regional and state-level orchid accounts, including those for Jharkhand, provide very limited information on pollination biology, phenology, or ecological interactions. Pollinators are rarely identified beyond broad guilds, and quantitative data on visitation rates or fruit-set are almost entirely lacking. This represents a critical knowledge gap, especially in the context of ongoing pressures from habitat fragmentation, fire regimes, grazing, extraction, and climate variability.





The present study, titled “Documentation of Orchids and Associated Pollinators of Dalma Wildlife Sanctuary”, was conceived to address this gap. By generating a comprehensive, geo-referenced inventory of wild orchid species across different ranges, beats, and habitat types, and by characterising their associated pollinator guilds, the project provides essential baseline data for evidence-based conservation planning. It highlights orchids not merely as botanical curiosities but as keystone components of Dalma’s living heritage linking geological history, sacred traditions, seasonal ecology, and contemporary biodiversity stewardship in a single, coherent landscape narrative. In doing so, the study contributes to both regional orchid research and practical management strategies for this important protected area.

2.Objectives of the Study

The present study, titled Documentation of Orchids and Associated Pollinators of Dalma Wildlife Sanctuary, was undertaken to generate a scientific baseline on orchid diversity and plant–pollinator interactions within this ecologically significant dry deciduous landscape.

Situated on the Chhotanagpur plateau, the sanctuary comprises a mosaic of habitats including sal-dominated forests, mixed deciduous slopes, riparian patches, and forest–grassland ecotones. Orchids, owing to their sensitivity to microclimatic variations, dependence on specific pollinators, and obligate mycorrhizal associations, serve as effective indicators of forest ecosystem health. Despite the ecological importance of the sanctuary, systematic information on orchid diversity and associated pollinator guilds remains limited, thereby constraining informed conservation planning and habitat management.

This study was designed to address these knowledge gaps by integrating floristic documentation with ecological observations. Emphasis was placed on recording orchid species across different habitat types and understanding their ecological relationships with pollinators. Direct observations were undertaken for species flowering during the study period, while pollination syndromes were inferred for others based on floral traits and existing literature, acknowledging the limitations of such inference.

The main objectives of the study are:

- To document the diversity, distribution, and habitat associations of orchid species in the sanctuary.
- To identify key pollinator taxa associated with these orchids through direct observation (where feasible) and pollination syndrome analysis.
- To assess ecological interactions and dependencies between orchids and their pollinators.
- To generate baseline data to support long-term conservation planning, habitat management, and monitoring of orchid–pollinator systems.





3.Review of Literature

Orchids (family Orchidaceae) represent one of the largest and most diverse angiosperm families, with an estimated 25,000-28,000 species distributed across nearly every terrestrial habitat on Earth, except Antarctica (Chase et al., 2015). Their extraordinary diversity in floral morphology, life-history strategies, and ecological interactions has made them a focal group in plant evolutionary biology. Orchids are particularly notable for their highly specialized reproductive biology, including intricate floral structures, precise pollinator interactions, and obligate associations with mycorrhizal fungi during germination and early growth stages. These characteristics render them highly sensitive to environmental disturbances, thereby making them reliable bioindicators of ecosystem health, especially in forested landscapes.

The study of orchid pollination biology has historically played a central role in advancing evolutionary theory, beginning with the pioneering work of Charles Darwin, who demonstrated the remarkable adaptations of orchids to specific pollinators. Modern ecological and evolutionary research has further refined this understanding through the concept of pollination syndromes sets of convergent floral traits such as colour, morphology, scent, nectar production, and flowering time that are associated with particular groups of pollinators (Faegri & van der Pijl, 1979; Fenster et al., 2004). In orchids, these syndromes range from melittophily (bee pollination) and psychophily (butterfly pollination) to sphingophily (hawk-moth pollination), as well as highly specialized and often deceptive systems that mimic food sources, mates, or oviposition sites without providing actual rewards.

Such deceptive strategies, although evolutionarily advantageous in reducing energetic costs, make orchids particularly dependent on the presence and behaviour of specific pollinators, thereby increasing their vulnerability to environmental changes.

In India, orchids constitute a significant component of the country's floristic diversity, with approximately 1,300-1,400 species distributed across about 186 genera (Misra, 2014; Singh et al., 2020). The foundational taxonomic framework for Indian orchids was established during the colonial period by eminent botanists such as John Lindley, Joseph Dalton Hooker, and George King along with Robert Pantling. Among these, Hooker's Flora of British India (1888–1890) and A Century of Indian Orchids (1895) remain landmark contributions that described numerous species and established taxonomic concepts that continue to inform modern classifications. Subsequent regional floras, revisions, and monographs have significantly expanded knowledge of orchid diversity and distribution, particularly in biodiversity-rich regions such as the Eastern Himalaya, Northeast India, and the Western Ghats.

Despite this progress, ecological and functional studies, especially those focusing on pollination biology, phenology, and plant–pollinator interactions, remain comparatively underdeveloped in India. This gap is particularly evident in the dry deciduous and plateau ecosystems of central and eastern India, where orchid diversity has historically been underestimated. The Chhotanagpur plateau, encompassing much of Jharkhand, represents one such underexplored region.

Early botanical explorations by Prain, Duthie, and Haines documented scattered orchid occurrences, but comprehensive and systematic accounts were largely absent.

A significant advancement in understanding the orchid diversity of this region came with the work of Kumar et al. (2005), who compiled the first dedicated checklist of orchids for Jharkhand. This study documented 63 species, comprising 33 terrestrial, 29 epiphytic, and one lithophytic species, and included 26 species recorded for the first time from the state. A subsequent study by Kumar et al. (2007) further consolidated these findings for the broader Chhotanagpur region, emphasizing the dominance of terrestrial orchids in the dry deciduous forest ecosystem. These studies also highlighted the increasing threats to orchid diversity, including habitat degradation, deforestation, anthropogenic disturbances, and climate variability.

Comparative insights from adjacent regions, particularly Odisha, have further enriched our understanding of orchid distribution patterns in eastern India. The comprehensive work by Misra (2014) documented over 170 orchid species in Odisha, revealing a higher diversity compared to Jharkhand and underscoring the ecological heterogeneity of the Eastern Ghats region. Notably, epiphytic orchids such as Vanda tessellata, Vanda testacea, Acampe praemorsa, Aerides multiflora, and Rhynchostylis retusa are characteristic of Sal (Shorea robusta)-dominated forests and contribute significantly to canopy-level biodiversity.

Recent ecological research has increasingly emphasized the role of orchids as indicators of forest health and environmental stability.

In dry deciduous and plateau ecosystems, epiphytic orchids are closely associated with specific host tree species, bark characteristics, and microclimatic conditions, particularly moisture availability. In contrast, terrestrial orchids belonging to genera such as Eulophia, Habenaria, Nervilia, and Zeuxine are adapted to seasonal niches, often emerging and flowering within a narrow temporal window during or immediately after the monsoon. These adaptations allow them to exploit transient favourable conditions on the forest floor, but also make them highly susceptible to changes in rainfall patterns, soil disturbance, and grazing pressure (Kumar & Pandey, 2011).

Importantly, plateau regions such as the Chhotanagpur landscape may function as ecological “stepping stones,” facilitating species dispersal and genetic exchange between major biodiversity hotspots, including the Eastern Ghats, Western Ghats, and the Himalayan region. This biogeographical significance adds further conservation value to the orchid flora of Jharkhand, despite its comparatively lower species richness.

Nevertheless, substantial knowledge gaps persist. Most available studies, including those from Jharkhand, remain largely descriptive, focusing on taxonomy and species distribution, with limited integration of ecological or functional data. Detailed studies on pollination biology, reproductive ecology, phenological patterns, and mycorrhizal associations are scarce. In particular, pollinators are seldom identified beyond broad functional groups, and quantitative data on visitation rates, pollination efficiency, and fruit set are largely lacking.

This is of concern because orchids often rely on highly specialized pollination systems, which can be easily disrupted by habitat fragmentation, altered fire regimes, overgrazing, and climate-induced shifts in pollinator populations.

Global syntheses have highlighted that specialized and deceptive pollination systems, which are common in Orchidaceae, are particularly vulnerable to environmental change (Schiestl & Schlüter, 2009; Phillips et al., 2020). The breakdown of these finely tuned plant–pollinator interactions can lead to reduced reproductive success and, ultimately, population decline.

In this context, the present study conducted in Dalma Wildlife Sanctuary assumes significant importance. Situated within the Chhotanagpur plateau, Dalma represents a typical dry deciduous forest ecosystem where both epiphytic and terrestrial orchids coexist across multiple microhabitats. By integrating geo-referenced floristic surveys with pollination syndrome analysis and preliminary field observations of pollinator activity, this study moves beyond traditional taxonomic inventories to incorporate functional ecological perspectives.
Building upon earlier regional works (Kumar et al., 2005, 2007; Misra, 2014), the study provides site-specific and seasonally resolved data on orchid diversity, phenology, and ecological interactions. It offers insights into flowering patterns, habitat preferences, and potential pollinator assemblages, thereby contributing to a more comprehensive understanding of orchid ecology in dry deciduous landscapes. Furthermore, the findings generate a scientifically robust baseline that can inform conservation planning, habitat management, and biodiversity monitoring in Dalma Wildlife Sanctuary.

Given the sanctuary's role as an important elephant corridor and its exposure to anthropogenic pressures, integrating orchid conservation into broader landscape management strategies is both timely and necessary. The study thus not only fills a critical knowledge gap but also supports evidence-based conservation interventions, including community engagement, habitat restoration, and long-term ecological monitoring in one of Jharkhand's ecologically significant protected areas.



4.Methodology

4.1. Study design and protocols followed

The study was designed to document wild orchids and their associated pollinators across key habitat types of Dalma Wildlife Sanctuary using a stratified sampling framework. The sanctuary was first stratified by range and beat, altitude, and dominant vegetation (dry Sal forest, mixed deciduous slopes, riparian patches, forest-grassland ecotones), and within each stratum plots and transects were selected using stratified random sampling to ensure representative spatial coverage. Seasonal surveys were conducted across pre-monsoon, monsoon and post-monsoon/winter periods so that orchid emergence, flowering, fruiting and pollinator activity could be captured through a full annual cycle. Within each plot or transect, all orchids encountered were recorded, and their growth form, micro-habitat, phenological stage and local abundance were noted using a standardised field datasheet (Annexure 1).

Orchid documentation combined classical taxonomic approaches with visual records suitable for training and outreach. Identification was based primarily on floral and vegetative morphology using regional floras, taxonomic monographs and dichotomous keys, cross-checked where necessary with herbarium images and expert opinions. For each species, photographs were taken of the whole plant, inflorescences, individual flowers (when sighted). For focal species, repeated visits were made across the flowering season to refine phenological information and assess fruit-set.

All geo-referenced coordinates were collected with handheld GPS units (accuracy ±5 m) and verified against official sanctuary boundary maps prior to entry into a QGIS database. Orchid abundance was recorded using a standardised semi-quantitative scale (rare, occasional, frequent, abundant) with no additional parametric statistical treatment applied, consistent with the baseline inventory objectives of the study.

4.2. Keys used to identify the major species of Orchids

The dichotomous keys used for the identification of major orchid species were referenced from Sarat Misra's, Orchids of Odisha: A Handbook (2014). These keys comprise sequentially numbered couplets with contrasting morphological characters related to vegetative and floral features such as stem habit, leaf architecture, inflorescence structure, flower size, colour, lip morphology, and spur characteristics. Each couplet leads to the next relevant pair until the specimen is identified to species level. The keys were directly consulted and followed as presented in the book for accurate and systematic identification.



17b. Plants with modified underground stem
18b. Base of stem erect, with a cluster of roots
28b. Lobules obliquely narrow obovate, apices irregularly dentate.....***Zeuxine longilabris***
34a. Leaf radical; inflorescence 1–2 flowered
35a. Scape 1-flowered; lip distinctly 3-lobed
36a. Leaf-blade glabrous on both surfaces with dark purple bands along the veins when young; flower horizontal; mid-lobe of lip entire
34b. Leaf-blade held up by long petioles, apex acuminate; inflorescence many-flowered
38a. Leaf-blade strongly plicate; sepals about 21 mm long..... ***Nervilia aragoana***
38b. Leaf-blade less plicate; sepals about 13 mm long
40b. Inflorescence erect
44b. Pseudobulb underground, ovoid or subglobose; leaves broad, plicate; inflorescence on a separate lateral shoot from base of pseudobulb, simple
45b. Plants 30–40 cm high; flowers yellow, smaller; column foot not forked .....***Eulophia ochreata***
46b. Raceme lax-flowered, flowers 20–25 mm across; sepals and petals reflexed, light yellow with maroon stripes, margins sparingly denticulate .....***Eulophia explanata***
65b. Leaves 1–2, subopposite when two, adpressed to ground, broadly ovate to suborbicular
69b. Flowers many; lip three-partite to the base, segments linear-filiform .....***Habenaria commelinifolia***
63b. Flowers green or yellow
70a. Flowers green; spur linear, curved at apex; leaves clustered about middle of the stem, not margined .....***Habenaria furcifera***
1b. Plants epiphytic or lithophytic
71a. Leafy erect shoots of limited growth, connected to a creeping and rooting base; new shoots arising from base every year (therefore plants tufted); inflorescence from axil of a leaf or on a separate leafless shoot from base of the leafy shoot
90b. Stem pseudobulbous, 35–65 mm long, compressed; leaves pure green; bracts close-fitted
89b. Flowers glabrous, large or small, white or brightly coloured, often showy
92a. Stem branching profusely; flowers very small, white.....***Dendrobium herbaceum***
92b. Stem not branching; flowers medium-sized or large, coloured or white
93a. Leaves persistent (at least for two seasons); flowering in leafy condition
100b. Stem drooping; flowers and lip various
101a. Flowers glossy white, sometimes with a purplish hue; lip with a large orbicular yellow blotch, edge entire .....***Dendrobium crepidatum***
101b. Flowers coloured; lip panduriform; edge fimbriate
102a. Flowers 20-25 mm across, greenish yellow; mid-lobe of lip abruptly narrowed to a mucronately emarginate tip.....***Dendrobium macrostachyum***
105b. Pseudobulb one-two-leaved; leaves persistent or deciduous; lateral sepals free
124b. Plants large and robust; leaves longer, not turning reddish; lip saccate or shortly spurred

125a. Plants to 40 cm high, inflorescence corymbose, to 6 cm long; lip saccate at base; plants inhabiting open forests .....***Acampe praemorsa***

120b. Inflorescence simple

130a. Stem erect; flowering axis straight; flowers variously coloured

131a. Leaves arched, more than 10 cm long, not constricted before apices

132a. Inflorescence racemose, elongate

133a. Lip with a forwardly pointing spur; column foot distinct

134a. Leaves deeply channelled, turning reddish in exposed condition; inflorescence abruptly pendent; flowers violet.....***Aerides multiflora***

134b. Leaves flat, not turning reddish when exposed; inflorescence deflexed; flowers waxy-white speckled with rose.....***Aerides odorata***

133b. Lip with a downwardly pointing spur; column foot indistinct or lacking

135a. Leaves pure green; inflorescence erect, laxly few flowered; flowers yellow

136a. Plants to 20 cm high; inflorescence 10-15 cm long; flowers 12-15 mm across, margins not undulated; pale yellow on both surfaces.....***Vanda testacea***

136b. Plants to 90 cm high; inflorescence 30-35 cm long; flowers 50-60 mm across, margins undulated; variable greenish yellow, brown-tessellated within; white without .....***Vanda tessellata***

135b. Leaves deep green; inflorescence pendent; densely many flowered; flowers white with pink markings; rarely pure white; lip with a compressed spur .....***Rhynchostylis retusa***

(Identification Key - Source: Sarat Misra. Orchids of Odisha: A Handbook, 2014).



4.3. Methodological Approach to Pollinator Observations and Taxa Inference Using Pollination Syndromes

Owing to the limited six-month duration of the project (October 2025-March 2026), direct pollinator observations could be conducted only for those few orchid species whose peak flowering periods overlapped with the survey window. For the majority of the 20 recorded species, flowering occurred either before the surveys began or after they concluded, rendering comprehensive in-situ documentation of pollinator interactions extremely challenging.

To address this constraint, pollinator taxa were broadly identified on the basis of each species' established pollination syndrome, a well-recognized concept in floral biology that refers to the suite of convergent floral traits (such as colour, shape, size, scent, nectar reward, and timing of anthesis) that have evolved to attract specific groups of pollinators (Faegri & van der Pijl, 1979; Fenster et al., 2004). For instance, melittophily (bee pollination) is typically indicated by bright colours, UV-reflective nectar guides, and diurnal anthesis, whereas sphingophily (hawk-moth pollination) is characterised by white or pale flowers, strong nocturnal fragrance, and long nectar spurs. These syndromes were determined through extensive consultation of peer-reviewed scientific literature, standard reference books on orchid pollination biology, and expert advice from Dr. Jeevan Singh Jalal, Scientist 'E', Botanical Survey of India, Kolkata and Shri Prabhat Kumar, orchid specialist from Ranchi, Jharkhand.

Where flowering individuals were encountered during the study period, observations were systematically carried out at regular intervals (early morning, mid-day, late afternoon, and, where relevant, dusk).

Supplementary sampling using hand nets and low-impact coloured pan traps (placed near but not directly beneath target plants) was undertaken to collect representative insect specimens, which were later identified using standard entomological keys and, when necessary, with the assistance of specialist taxonomists.

Direct pollinator observations were not recorded for any of the 20 orchid species during the survey window (October 2025-March 2026), despite repeated diurnal and nocturnal monitoring across all sampled plots and transects. For all 20 recorded species, pollinator taxa were therefore inferred exclusively through established pollination-syndrome analysis, integrating floral morphology, colour, scent, nectar reward, and spur characteristics with peer-reviewed literature and consultation from Dr. Jeevan Singh Jalal. Supplementary hand-netting and low-impact coloured pan traps were deployed but yielded no insect specimens. This approach provided a scientifically reliable baseline characterisation of pollinator guilds while fully acknowledging the temporal constraints of the six-month field programme.

It is important to note that a thorough understanding of pollinator specificity for all 20 species would require at least one full year of rigorous, season-long fieldwork and data collection. The present study therefore supplies a scientifically robust baseline derived from established pollination syndromes, supported by comprehensive literature review and expert consultation. All syndrome inferences were cross-validated against regional orchid pollinator references to ensure reliability.

Plate 1: Research Team during the field work









Plate 2: Research Team during the field work







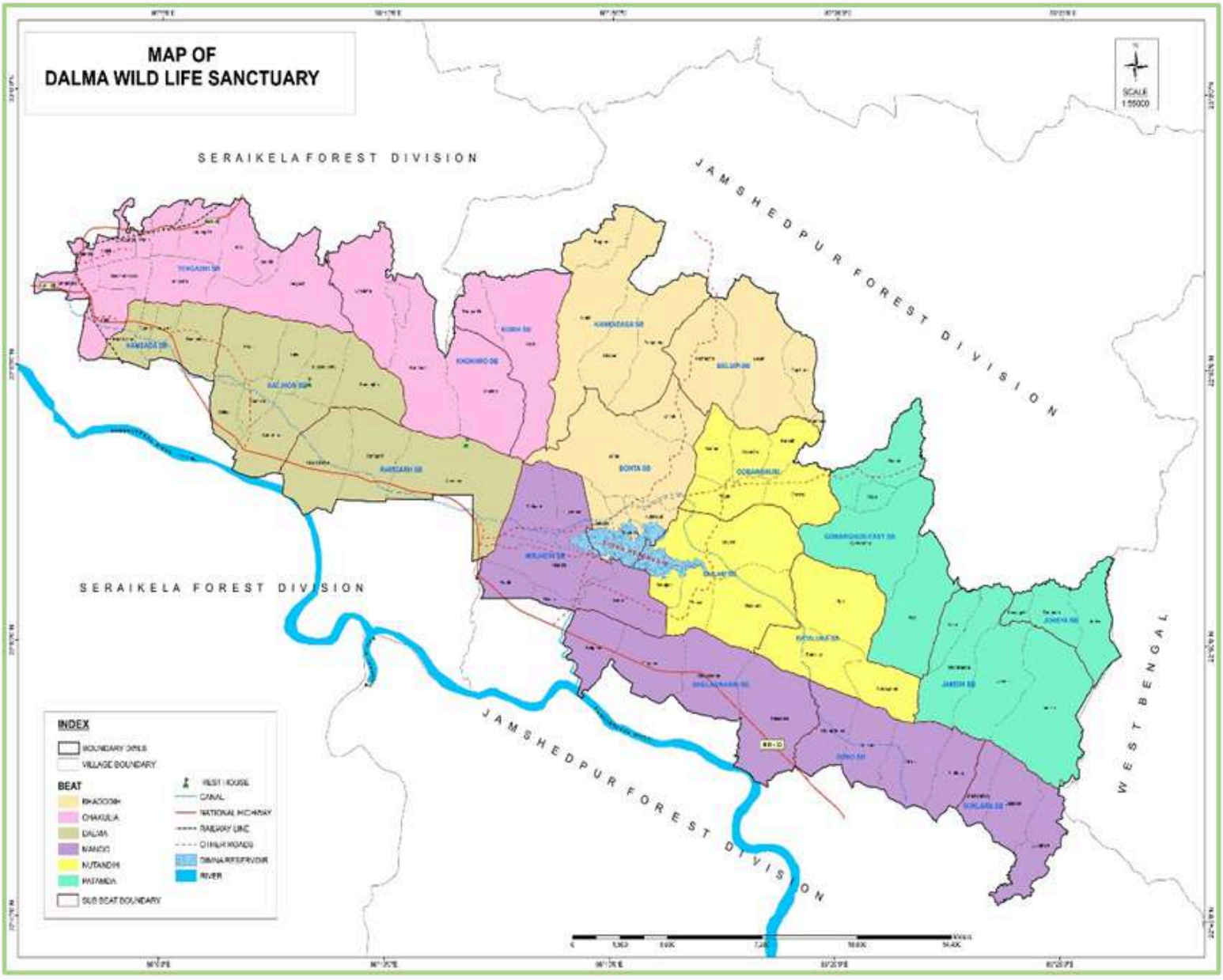






4.4. Study Area

Dalma Wildlife Sanctuary is situated on the Chhotanagpur plateau of Jharkhand, extending over approximately 193 km² across East Singhbhum and Saraikela-Kharsawan districts. The sanctuary follows the Dalma hill range, with elevations rising to about 900–915 m above sea level and the forests draining towards the Subarnarekha River and Dimna Lake. Administratively, the area is divided into Dalma Wildlife East and Dalma Wildlife West Ranges, each with multiple beats and sub-beats (e.g. Bhadudih, Nutandih, Patamda, Mango, Chakulia and Dalma), which provide a practical framework for stratifying sampling and locating permanent monitoring sites. The climate is tropical monsoonal, with a hot, dry summer (often exceeding 42-46 °C in the foothills), a southwest monsoon delivering roughly 1200–1400 mm of annual rainfall, and a cool, often foggy winter with minimum temperatures around 5 °C in sheltered valleys. These strong seasonal and altitudinal gradients in temperature and moisture create distinct windows of growth and reproduction for both plants and insects.



Map 1: Map of Dalma WLS

4.5.Floral-Faunal Diversity

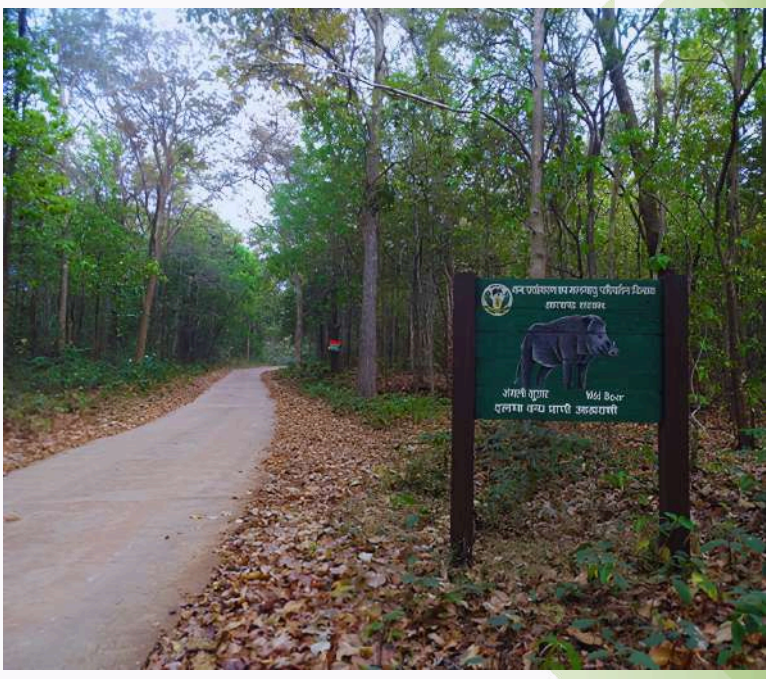
The sanctuary supports a rich assemblage of associated flora and fauna that directly influence orchid distribution and pollination networks. Epiphytic orchids were predominantly recorded on host trees such as *Shorea robusta, Terminalia tomentosa, Adina cordifolia, and Pterocarpus marsupium,* which provide suitable bark texture, canopy cover, and microclimatic moisture regimes. Terrestrial and lithophytic species occurred on forest-floor substrates and rocky outcrops within mixed deciduous and riparian patches. Faunal elements relevant to orchid pollination included a diverse butterfly community *(Plate 3)* and other insect guilds (bees, hawk-moths, and flies) whose activity patterns were documented or inferred. These floral–faunal associations underscore the ecological linkages between orchid species, their phorophytes, and pollinator taxa within the dry deciduous ecosystem of Dalma Wildlife Sanctuary.

The vegetation is dominated by Dry Peninsular Sal and Northern Dry Mixed Deciduous Forest types. *Shorea robusta* forms extensive stands, especially on ridges and upper slopes, while associated mixed forest species include *Aegle marmelos* (Bael), *Albizia procera* (Safed Siris), *Anogeissus latifolia* (Axlewood Tree), *Azadirachta indica* (Neem), *Bombax ceiba* (Semal), *Bauhinia variegata* (Kachnar), *Buchanania lanzan* (Chironji), *Careya arborea* (Kumbhi / Wild Guava), *Carissa carandas* (Karonda), *Clerodendrum infortunatum* (Bhat / Glory Bower), *Colocasia esculenta* (Arbi), *Costus speciosus* (Keokand), *Dillenia indica* (Elephant Apple), *Diospyros melanoxylon* (Tendu), *Drimia indica syn. Urginea indica* (Drimia indica / Wild Onion), *Ficus benghalensis* (Banyan), *Ficus racemosa* (Gular), *Ficus religiosa* (Peepal), *Holoptelea integrifolia syn.* (Indian Elm / Chilbil), *Hyptis suaveolens* (Hyptis / Wild Tulsi), *Lannea grandis* (Jhingan), *Mangifera indica* (Mango), *Murraya paniculata* (Kamini), *Phyllanthus emblica* (Amla), *Psidium guajava* (Guava), *Ricinus communis* (Castor), *Schleichera oleosa* (Kusum), *Selaginella bryopteris* (Sanjeevani), *Shorea robusta* (Sal), *Pterocarpus marsupium* (Bija Sal), *Smilax zeylanica* (Kumarika), *Syzygium cumini* (Jamun), *Tamarindus indica* (Tamarind), *Tectona grandis* (Sagwan), *Terminalia arjuna* (Arjun), *Terminalia bellirica* (Bahera), *Terminalia chebula* (Harar), *Terminalia elliptica* (Asan), and *Ziziphus mauritiana* (Ber) (Kumari *et al., 2017).*

The major faunal groups of the protected area include a diverse assemblage of mammals, birds, reptiles, amphibians, and invertebrates characteristic of dry and moist deciduous forests, sal-dominated landscapes, and plateau ecosystems. Carnivores recorded from the region comprise *Panthera pardus* (Leopard), *Canis lupus pallipes* (Indian Grey Wolf), *Melursus ursinus* (Sloth Bear), *Hyaena hyaena* (Striped Hyena), *Felis chaus* (Jungle Cat), *Viverricula indica* (Small Indian Civet), *Herpestes edwardsii* (Indian Grey Mongoose), and *Canis aureus* (Golden Jackal). Herbivores include *Elephas maximus* (Asian Elephant), *Bos gaurus* (Gaur), *Axis axis* (Spotted Deer/Chital), *Rusa unicolor* (Sambar), and *Muntiacus muntjak* (Barking Deer). Omnivores commonly recorded are *Sus scrofa* (Wild Boar), *Melursus ursinus* (Sloth Bear), *Semnopithecus entellus* (Hanuman Langur), *Macaca mulatta* (Rhesus Macaque), and *Paradoxurus hermaphroditus* (Common Palm Civet).

The avian fauna is rich and includes forest, grassland, and wetland birds such as *Pavo cristatus* (Indian Peafowl), *Gallus gallus* (Red Junglefowl), *Buceros bicornis* and *Ocyceros birostris* (Hornbills), *Psittacula eupatria* (Alexandrine Parakeet), *Alcedo atthis*

(Common Kingfisher), *Dicrurus paradiseus* (Racket-tailed Drongo), *Oriolus oriolus* (Golden Oriole), and several raptors including *Milvus migrans* (Black Kite) and *Spilornis cheela* (Crested Serpent Eagle). Herpetofauna comprises reptiles and amphibians such as *Python molurus* (Indian Rock Python), *Naja naja* (Indian Cobra), *Daboia russelii* (Russell's Viper), *Bungarus caeruleus* (Common Krait), *Varanus bengalensis* (Bengal Monitor), *Calotes versicolor* (Oriental Garden Lizard), *Hoplobatrachus tigerinus* (Indian Bullfrog), and *Duttaphrynus melanostictus* (Common Indian Toad).





Key butterflies commonly observed include *Papilio demoleus* (Lime Butterfly), *Papilio polytes* (Common Mormon), *Danaus chrysippus* (Plain Tiger), *Leptosia nina* (Psyche), *Euploea core* (Common Crow), *Cepora nerissa* (Common Gull), *Junonia almana* (Peacock Pansy), *Junonia lemonias* (Lemon Pansy), *Graphium agamemnon* (Tailed Jay), *Eurema hecabe* (Common Grass Yellow), and *Catopsilia pomona* (Common Emigrant) (Verma, 2009). Important invertebrate guilds include pollinators (honey bees *Apis dorsata, Apis cerana; Xylocopa spp.,* solitary bees; butterflies), decomposers (termites, dung beetles), soil engineers (ants, earthworms), predators (praying mantids, spiders), and detritivores (millipedes, isopods), all of which play critical roles in maintaining ecosystem functioning across Dalma's forested landscapes.

PLATE 3: Diversity of Butterflies in Dalma WLS



Table 1: Diversity of Butterflies in Dalma WLS

S.No.	Common Name	Scientific Name
Family: Hesperiidae (Skippers)		
B1	Common Snow Flat	*Tagiades japetus (Stoll, 1781)*
B2	Indian skipper	*Spialia galba (Fabricius, 1793)*
B3	Bush hopper	*Ampittia dioscorides (Fabricius, 1793)*
B4	Chestnut bob	*Iambrix salsala (Moore, 1865)*
B5	Grass demon	*Udaspes folus (Cramer, 1775)*
B6	Indian palm bob	*Suastus gremius (Fabricius, 1798)*
B7	Common red eye	*Matapa aria (Moore, 1865)*
B8	Continental swift	*Parnara ganga (Evans, 1937)*
B9	Oriental straight swift	*Parnara bada (Moore, 1878)*
B10	Rice swift	*Borbo cinnara (Wallace, 1866)*
B11	Obscure Branded Swift	*Pelopidas agna (Moore, 1866)*
B12	Small branded swift	*Pelopidas mathias (Fabricius, 1798)*
B13	Common dartlet	*Oriens gola gola (Moore, 1877)*
B14	Dark palm dart	*Telicota ancilla bambusae (Moore, 1878)*

S.No.	Common Name	Scientific Name
Family: Lycaenidae (Blues)		
B15	Indian sunbeam	*Curetis thetis (Drury, 1773)*
B16	Apefly	*Spalgis epius (Westwood, 1851)*
B17	Common silverline	*Spindasis vulcanus (Fabricius, 1775)*
B18	Common ciliate blue	*Anthene emolus (Godart, 1824)*
B19	Pointed ciliate blue	*Anthene lycaenina (Felder, 1868)*
B20	Common cerulean	*Jamides celeno (Cramer, 1775)*
B21	Forget-me-not	*Catochrysops strabo (Fabricius, 1793)*
B22	Pea blue	*Lampides boeticus (Linnaeus, 1767)*
B23	Zebra blue	*Leptotes plinius (Fabricius, 1793)*
B24	Common pierrot	*Castalius rosimon (Fabricius, 1775)*
B25	Black-spotted pierrot	*Tarucus balkanicus nigra (Bethune-Baker, 1918)*
B26	Rounded pierrot	*Tarucus nara (Kollar, 1848)*
B27	Dark grass blue	*Zizeeria karsandra (Moore, 1865)*
B28	Pale grass blue	*Pseudozizeeria maha (Kollar, 1844)*
B29	Tiny grass blue	*Zizula hylax (Fabricius, 1775)*
B30	Quaker	*Neopithecops zalmora (Butler, 1870)*
B31	Gram blue	*Euchrysops cnejus (Fabricius, 1798)*
B32	Plains cupid	*Chilades pandava (Horsfield, 1829)*

5. Results

The results of the six-month field surveys (October 2025-March 2026) provide a comprehensive baseline inventory of orchid diversity and associated ecological parameters within Dalma Wildlife Sanctuary. They detail the documented species assemblage, growth forms, habitat preferences, mycorrhizal considerations, phenological patterns, and inferred pollination syndromes, while also presenting quantitative data on species abundance, distribution across habitat types, and key environmental gradients. No direct pollinator observations were recorded despite systematic monitoring, reinforcing the reliance on established pollination-syndrome analysis for guild characterisation. Collectively, these findings fulfil the study's dual objectives by generating geo-referenced floristic and functional data essential for evidence-based conservation planning.

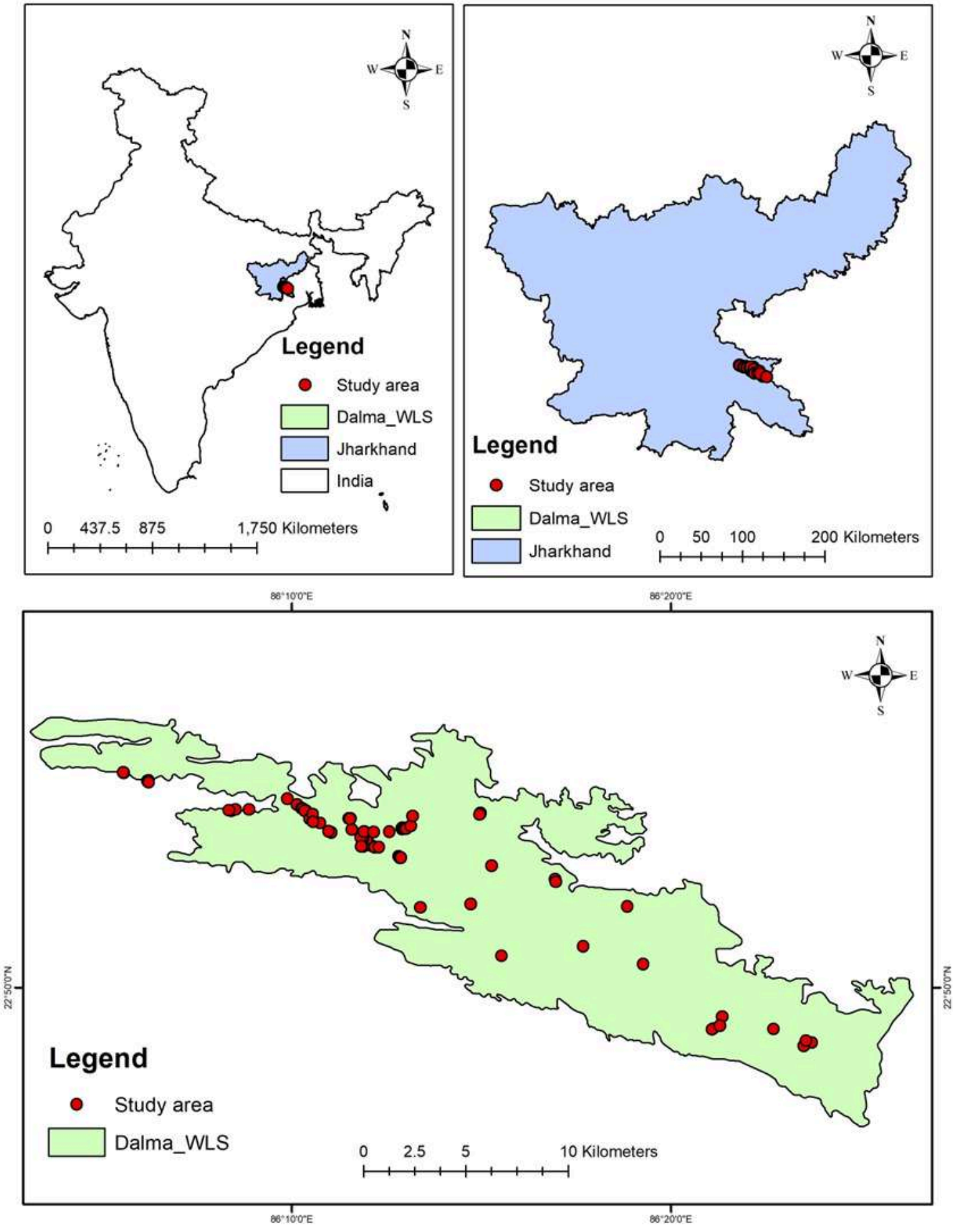
5.1 Orchid Species Inventory

A total of 20 wild orchid species belonging to 12 genera were documented across Dalma Wildlife Sanctuary during the October 2025–March 2026 surveys. The inventory comprised 12 epiphytic and 8 terrestrial species. All identifications were confirmed using the dichotomous keys of Misra (2014) and cross-verified with expert consultation. Representative photographs of each species are presented in Plates 4-17.

5.2 Growth Forms, Habitat Associations, and Mycorrhizal Considerations

Epiphytic species were predominantly associated with mature *Shorea robusta* and *Terminalia tomentosa* trees in closed-canopy dry sal forest and mixed deciduous slopes at 400–750 m elevation. Terrestrial species occurred on shaded forest-floor substrates and rocky outcrops in riparian patches and forest-grassland ecotones. All 20 recorded species form obligate mycorrhizal associations essential for seed germination and early establishment. The consistent occurrence of epiphytes on specific phorophytes and terrestrials on undisturbed substrates indirectly indicates the presence of suitable mycorrhizal fungal partners in these microhabitats.





Map 2 : Distribution Map of Recorded Orchid Species in Dalma WLS

5.3 Fieldwork and habitat diversity ananlysis

Fieldwork was carried out from October 2025 to March 2026 through 25-30 transect-based surveys covering northern and southern stretches of the sanctuary (Map 2). Surveys focused on reconnaissance, vegetation types, host trees for epiphytes, and occurrence of terrestrial orchids along trails, rocky slopes, and shaded patches. Several orchid-bearing trees were geo-tagged for future monitoring. Mixed forest habitats supported the highest orchid diversity (5-7 co-occurring species per locality) at sites such as Manjhla bandh, Bijli ghati, and near Badka bandh. These hotspots featured 50–70 % canopy cover, elevations of 400–600 m, relative humidity of 60–80 %, and gravel-red-black soils. Epiphytes (*Vanda testacea, Acampe praemorsa, Luisia zeylanica*) grew on hosts including *Terminalia bellirica* and *Diospyros melanoxylon,* while terrestrials (*Habenaria furcifera, Nervilia concolor)* occupied organic-rich soils. Roadside forests supported frequent *Vanda tessellata* and *Aerides odorata* on *Madhuca longifolia*, but terrestrial diversity was lower due to disturbance. Open scrub forests and paddy fields showed reduced richness (1-3 species), consistent with lower canopy cover (10–40 %). Dalma's dry deciduous and mixed forests, dominated by *Shorea robusta* and associates, provide ideal phorophytes and litter layers, harbouring two to three times higher diversity than monocultures (Kumar et al., 2005).

5.4 Species and Abundance Patterns

Vanda tessellata, Vanda testacea, and *Aerides multiflora* were classified as "Frequent" (>20 individuals in 60 % of records), indicating resilience in fragmented landscapes.

Rarer species such as *Luisia zeylanica* and *Dendrobium macrostachyum* (classified as "Rare", 1–5 individuals) highlight conservation priorities and often occur on specific hosts (e.g., *Pterocarpus marsupium*) at higher elevations (>500 m). Epiphytes dominate the assemblage (85 % of records), reflecting arboreal niche availability, while terrestrials (15 %) cluster near streams and termite mounds and remain vulnerable to soil disturbance. Abundance was scored using the standardised semi-quantitative scale (rare, occasional, frequent, abundant).

5.5 Associated Flora (Phorophytes) Supporting Epiphytic Orchid Assemblages

Phorophytes are host plants, typically trees or shrubs, that provide structural support to epiphytes (such as mosses, ferns, and orchids) without supplying them with nutrients. Derived from the Greek meaning 'plant bearer,' phorophytes function as physical substrates, enabling epiphytes to access enhanced light and moisture conditions, particularly in the forest ecosystem. The landscape is characterised by native tree species providing critical substrates for epiphytic orchids. Dominant hosts include *Madhuca longifolia* (highest frequency), *Diospyros melanoxylon, Terminalia elliptica,* and *Terminalia bellirica*. Moderately represented species are *Bombax ceiba, Butea monosperma, Ficus benghalensis,* and *Pterocarpus marsupium*. Additional contributors at lower frequencies include *Azadirachta indica, Careya arborea, Mangifera indica, Syzygium cumini,* and *Semecarpus anacardium*. *Ficus* spp. and *Garuga pinnata* enhance moisture retention and faunal interactions. The floristic composition reflects a tropical dry deciduous system where suitable bark texture, canopy spread, and moisture retention sustain rich epiphytic diversity (Fig. 1).

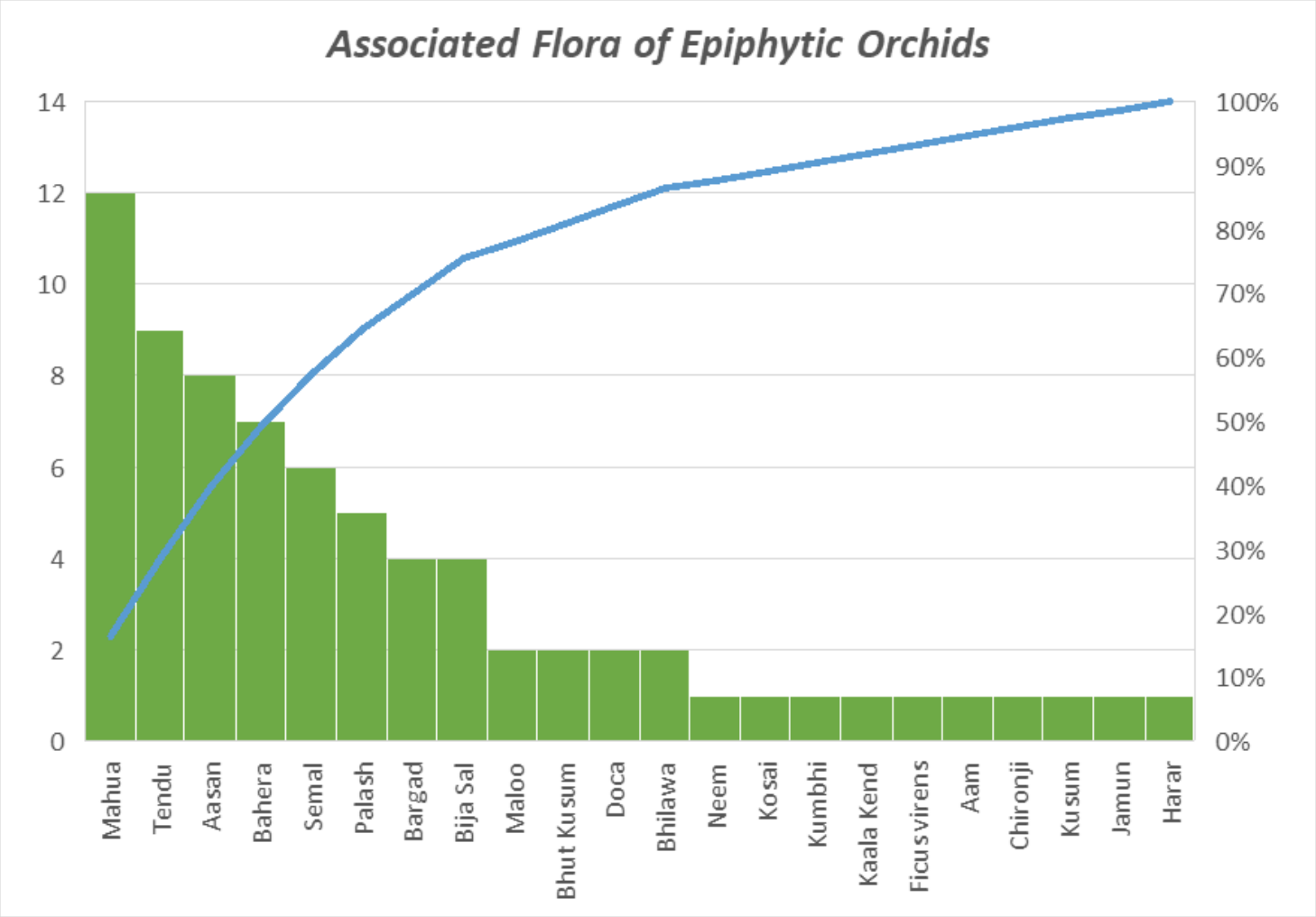


Fig. 1: Associated Flora (Phorophytes) of Epiphytic Orchids in Dalma Wildlife Sanctuary

5.6 Phenological Patterns and Pollination Dynamics

Most species exhibit peak flowering during the pre-monsoon to monsoon period (March-September), with a concentration in April-July *(Aerides multiflora, Vanda tessellata, Acampe praemorsa)*. Fruiting extends into the late monsoon and post-monsoon seasons. A few terrestrials (*Zeuxine strateumatica*) flower in winter to early summer (January-April). Pollination syndromes are dominated by melittophily (bee pollination) in *Aerides, Vanda, Eulophia,* and *Dendrobium*. *Habenaria* species show sphingophily (moth pollination).

Generalist entomophily occurs in *Acampe praemorsa* and *Luisia zeylanica,* while *Nervilia* employs deceptive strategies and *Zeuxine strateumatica* shows partial autogamy. These patterns indicate a functionally resilient orchid community synchronised with seasonal climatic cycles and pollinator availability (Zotz, 2013; Gentry & Dodson, 1987).

Table 2 : Flowering Periods, Pollinators, and Pollination Syndromes of Orchid Species in Dalma Wildlife Sanctuary

S.No.	Species Name	Flowering Period	Pollinators (Taxa)	Pollination Syndrome
1	*Acampe praemorsa*	Mar–Jun	*Apis spp., solitary bees*	Generalist entomophily
2	*Aerides multiflora*	Apr–Jul	*Apis spp., Xylocopa spp.*	Melittophily
3	*Aerides odorata*	Apr–Jun	Bees; butterflies	Melittophily (fragrant)
4	*Dendrobium crepidatum*	Mar–Apr	Solitary bees	Bee pollination
5	*Dendrobium herbaceum*	Jul–Sep	Small bees, flies	Generalist pollination
6	*Dendrobium macrostachyum*	Jun–Sep	*Apis spp., Xylocopa spp.*	Melittophily
7	*Dendrobium primulinum*	Mar-Apr	*Bombus spp., Andrena spp.*	Bee pollination
8	*Eulophia explanata*	May–Jul	*Apis spp., solitary bees*	Melittophily
9	*Eulophia ochreata*	Jun	Ground bees	Bee pollination
10	*Habenaria commelinifolia*	Jul–Sep	Moths (Sphingidae)	Sphingophily
11	*Peristylus constrictus (Lindl.)*	Jul–Sep	Hawk moths (Sphingidae)	Sphingophily
12	*Habenaria furcifera*	Jul–Sep	Hawk moths (Sphingidae)	Sphingophily
13	*Luisia zeylanica*	Mar–Apr	Small bees, flies	Generalist pollination
14	*Nervilia argoana*	Early monsoon	Small bees, flies, fungus gnats (suspected)	Generalist / deceptive
15	*Nervilia concolor*	Early monsoon	Small bees, gnats	Generalist/deceptive
16	*Rhynchostylis retusa*	May–Jul	Bees *(Apis spp., Xylocopa spp.)*, butterflies	Melittophily
17	*Vanda tessellata*	Apr–Jul	*Apis spp., Xylocopa spp.*	Melittophily
18	*Vanda testacea*	Apr–May	Bees, butterflies	Generalist entomophily
19	*Zeuxine longilabris*	Jul–Sep	Small bees, flies	Generalist
20	*Zeuxine strateumatica*	Jan–Apr	Ants, small bees, flies	Autogamy + facultative

5.7 Environmental Gradients and Threats

Peak diversity occurs at 400–800 m under moderate canopy cover, correlating with host-tree girth (>40 ft) and organic soils. Climatic conditions (22–31 °C, 54–89 % humidity) suggest optimal post-monsoon windows. Threats include habitat fragmentation along roadsides, climber competition, and anthropogenic pressures. Compared with the sanctuary's 417 flowering plants, orchids represent a sensitive guild. The survey adds site-specific data to existing floristic inventories and emphasises the need for host-tree protection and microhabitat conservation.



PLATE 4: Orchid Diversity in Dalma WLS (Epyphytic)



Acampe praemorsa



Aerides multiflora



Luisia zeylanica



Dendrobium crepidatum



Dendrobium herbaceum



Dendrobium macrostachyum

PLATE 5: Orchid Diversity in Dalma WLS (Epiphytic)



Aerides odorata



Rhynchostylis retusa



Vanda tessellata



Vanda testacea

PLATE 6: Orchid Diversity in Dalma WLS (Terrestrial)



Eulophia ochreata



Eulophia explanata



Nervilia argoana



Nervilia concolor



Habenaria furcifera



Habenaria furcifera (Seed pods)

PLATE 7: Orchid Diversity in Dalma WLS (Terrestrial)



Habenaria commelinifolia



Peristylus constrictus



Zeuxine longilabris



Zeuxine strateumatica

PLATE 8: *Acampe praemorsa & Aerides multiflora*

Order: Asparagales
Family: Orchidaceae
Subfamily: Epidendroideae

Acampe praemorsa **(Roxb.) Blatt. & McCann.**
Common Name: Brittle Tiger / Clipped Orchid
Tribe: Vandeae
Sub-tribe: Aeridinae

Growth form & habitat
Robust epiphytic orchid forming clumps on tree trunks and larger branches.
Common on deciduous trees in well-lit mid-canopy and forest edges of Dalma WS.

Phenology
Flowering: mainly March-June.
Fruiting: late summer into early post-monsoon.

Diagnostic field traits
Leaves stiff, strap-shaped, overlapping.
Flowers small (1-1.5 cm), creamy-yellow with reddish-brown transverse bands. Lip small, 3-lobed.



Aerides multiflora Roxb.
Common Name: Many-Flowered Fox Brush Orchid
Tribe: Vandeae
Sub-tribe: Aeridinae

Growth form & habitat
Medium-sized epiphyte on trunks and larger branches. Spur prominent.
Occurs in semi-evergreen pockets and moist slopes where humidity remains high.

Phenology
Flowering: April-July.
Fruiting: late monsoon to early winter.

Diagnostic field traits
Upright to slightly arching stems with strap-shaped, leathery leaves.
Long pendent racemes with many waxy white to pale-pink flowers flushed with purple.
Flowers slightly larger than *A. praemorsa,* faint pleasant scent.



PLATE 9: *Aerides odorata & Dendrobium crepidatum*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: EPIDENDROIDEAE

***Aerides odorata* Lour.**
Common Name: Fragrant Foxtail / Foxbrush Orchid
Tribe: Vandeae
Sub-tribe: Aeridinae

Growth form & habitat
Epiphytic orchid with arching stems, open & airy forest canopy.
Often found on exposed branches where it receives filtered sun and good air movement.

Phenology
Flowering: late April to June.
Fruiting: late monsoon.

Diagnostic field traits
Arching stems with strap-like leaves; numerous long, pendent racemes.
Strongly fragrant flowers, white to pale pink with purple tips and a distinct spur.
Attractive fox-brush appearance when in full bloom.



***Dendrobium crepidatum* Lindl. & Paxton**
Common Name: Shoe-lip Dendrobium
Tribe: Malaxideae
Sub-tribe: Dendrobiinae

Growth form & habitat
Epiphytic, often on trunk forks or lower branches. Prefers semi-shaded interior of mixed deciduous forest.

Phenology
Flowering: March-April, usually when canes are leafless or with very few leaves.
Fruiting: late summer

Diagnostic field traits
Pendulous, swollen canes that become leafless in dry season.
Flowers borne singly or in pairs; pale pink to lilac with yellow throat; delicate texture.



PLATE 10: *Dendrobium herbaceum & Dendrobium macrostachyum*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: EPIDENDROIDEAE

Dendrobium herbaceum Lindl.
Common Name: Grassy Dendrobium
Tribe: Dendrobieae
Sub-tribe: Dendrobiinae

Growth form & habitat
Small epiphytic orchid on thin branches and twigs.
Often in semi-open forest edges and secondary growth.

Phenology
Flowering: mainly July-September.
Fruiting: late monsoon to early winter.

Diagnostic field traits
Slender, almost herbaceous stems bearing small leaves along their length.
Tiny pale yellow-green to whitish flowers on short racemes.



***Dendrobium macrostachyum* Lindl.**
Common Name: Long-spike Dendrobium
Tribe: Malaxideae
Sub-tribe: Dendrobiinae

Growth form & habitat
Medium epiphyte occurring on trunks and large branches. Found in moderately moist, partially shaded forest patches.

Phenology
Flowering: June–September.
Fruiting: post-monsoon.

Diagnostic field traits
Upright to arching canes with linear-lanceolate leaves.
Long, many-flowered racemes with pink to purple flowers and a contrasting lip.
Inflorescences conspicuous against green canopy when in mass bloom.



PLATE 11: *Dendrobium primulinum & Eulophia ochreata*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: EPIDENDROIDEAE

***Dendrobium primulinum* Lindl.**
Common Name: Primrose Dendrobium
Tribe: Dendrobieae
Sub-tribe: Dendrobiinae

Growth form & habitat
Thrives in warm areas with high humidity.
Stems are covered in white sheaths and are found in deciduous forests.
Leafless flowering.

Phenology
Flowering: January-April.
Fruiting: May-June.

Diagnostic field traits
Large, pendant epiphyte with long, slender, cane-like stems that are over hanging / drooping.
Highly Fragrant, pale pink to lavender or white flower with a prominent yellow to orange lip and throat.



***Eulophia ochreata* Lindl.**
Common Name: Golden-Yellow Eulophia / Gold Crest
Tribe: Cymbidieae
Sub-tribe: Eulophiinae

Growth form & habitat
Terrestrial orchid emerging from underground pseudobulbs.
Occurs in open forest glades and grassland edges.

Phenology
Flowering: mainly June (early monsoon).
Fruiting: July-August

Diagnostic field traits
Leafless when flowering; erect scape 20–40 cm tall bearing 5-15 golden-yellow flowers.
Later produces 2-5 oblong-lanceolate leaves from pseudobulbs.
Flowers relatively large, showy and easily visible in open habitats.



PLATE 12: *Eulophia explanata & Habenaria commelinifolia*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: ORCHIDOIDEAE

Eulophia explanata **Lindl.**
Common Name: Flattened Eulophia
Tribe: Cymbidieae
Sub-tribe: Eulophiinae

Growth form & habitat
Terrestrial, sympodial, deciduous herb (geophyte) with fleshy, irregularly ovoid, annulated, or flattened underground pseudobulbs.
Forests, open grassy slopes, and shady places with humus-rich, moist soil.

Phenology
Flowering: April-June.
Fruiting: May-July.

Diagnostic field traits
Golden-yellow flowers (3-lobed) on erect scape.
Inflorescence appears from the ground before the leaves.



Habenaria commelinifolia **(Roxb.) Wall. ex Lindl.**
Common Name: Grass-leaved Habenaria
Tribe: Orchideae
Sub-tribe: Orchidinae

Growth form & habitat
Terrestrial with grass-like leaves, erect herb, ellipsoid or cylindrical tubers.
Found in grassy slopes, forest edges, and grasslands, particularly in moist places in humus-rich soil.

Phenology
Flowering: August-October.
Fruiting: September-November.

Diagnostic field traits
Greenish-white flowers with night-blooming tendency.
Prominent, long, curved, and cylindric-clavate spur.



PLATE 13: *Peristylus constrictus & Habenaria furcifera*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: ORCHIDOIDEAE

Peristylus constrictus **(Lindl.) Lindl.**
Common Name: Slender Habenaria
Tribe: Orchideae
Sub-tribe: Orchidinae

Growth form & habitat
Slender terrestrial. Narrow floral morphology adapted for moth pollination.
Cylindrical to oblong, velvet-hairy tuber.
Found in open forests, moist shaded forest floors, dry deciduous Sal forests.

Phenology
Flowering: June-August.
Fruiting: July-October.

Diagnostic field traits
Leaves are arranged in a rosette or whorl displaying prominent, net-like veins.
Very small, pendulous, globose (spherical) spurs.



Habenaria furcifera **Lindl.**
Common Name: Forked Habenaria
Tribe: Orchideae
Sub-tribe: Orchidinae

Growth form & habitat
Terrestrial orchid of moist grassland patches and forest clearings.
Often associated with seasonally wet depressions and gentle slopes.

Phenology
Flowering: July-September (monsoon).
Fruiting: late monsoon to early winter.

Diagnostic field traits
Slender, erect stem with few lanceolate leaves near the base.
Spike of greenish-white flowers with deeply forked lateral lobes on the lip and a long spur.
Flowers open mostly at night and early morning.



PLATE 14: *Luisia zeylanica & Nervilia argoana*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: EPIDENDROIDEAE

***Luisia zeylanica* Lindl.**
Common Name: Cylindrical-leaved Orchid / Ceylon Luisia
Tribe: Vandeae
Sub-tribe: Aeridinae

Growth form & habitat
Small epiphyte tightly attached to trunks of native trees. Prefers moist deciduous forest with moderate shade.

Phenology
Flowering: approximately March-April.
Fruiting: late summer.

Diagnostic field traits
Short stems with closely spaced, terete (cylindrical) leaves 3-5 cm long.
Small greenish flowers with purple-striped ovary; borne on short, few-flowered racemes.



***Nervilia aragoana* Gaudich.**
Common Name: Tall shield Orchid
Tribe: Nervilieae
Sub-tribe: Nerviliinae

Growth form & habitat
Tuberous geophytes having smaller tuber than *N. concolor*.
Grows on the moist, shady forest floor in deep humus or leaf litter.

Phenology
Flowering: May-June.
Fruiting: May-September.

Diagnostic field traits
Grows in colonies, leaf emerges after flowering.
More or less circular/kidney-shaped leaves with prominent radiating veins.
Short-lived greenish-yellow, up to 16 flowers per stem.



PLATE 15: *Nervilia concolor & Rhynchostylis retusa*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: EPIDENDROIDEAE

Nervilia concolor (Blume) **Schltr.**
Common Name: One-leaf Orchid
Tribe: Nervilieae
Sub-tribe: Nerviliinae

Growth form & habitat
Geophytic terrestrial orchid of shaded forest floor.
Grows in leaf litter under deciduous and mixed forest, sometimes near streams.

Phenology
Flowering: April-May.
Fruiting: May-September.

Diagnostic field traits
Also grows in colonies, single cordate (heart-shaped) leaf.
Short-lived flower on a leafless stalk, flower greenish to purplish, 2–6 flowers per plant.



Rhynchostylis retusa **(L.) Blume**
Common Name: Foxtail / Bottlebrush Orchid
Tribe: Vandeae
Sub-tribe: Aeridinae

Growth form & habitat
Stout, monopodial epiphytic herb with thick, woody stems.
Tropical/subtropical forests, prefers hosts with high bark pH and moisture.

Phenology
Flowering: May-August.
Fruiting: July-December

Diagnostic field traits
Long pendent inflorescences (Foxtail-like pendulous raceme).
White to pale pink flowers with purple lip, strong fragrance.
Leaves with 3-toothed apex; unlobed purple lip.



PLATE 16: *Vanda tessellata & Vanda testacea*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: EPIDENDROIDEAE

***Vanda tessellata* (Roxb.) Hook. ex G.Don**
Common Name: Checkered Vanda
Tribe: Vandeae
Sub-tribe: Aeridinae

Growth form & habitat
Found in open canopy positions where it receives good light and air circulation.

Phenology
Flowering: April-July.
Fruiting: late monsoon.

Diagnostic field traits
Large robust epiphyte with long strap-shaped leaves.
Erect or slightly arching racemes with showy, tessellated yellow-brown flowers bearing darker net-like pattern and a blue-purple lip.
Strong fragrance, particularly on warm days.



***Vanda testacea* (Lindl.) Rchb.f.**
Common Name: Yellow Vanda
Tribe: Vandeae
Sub-tribe: Aeridinae

Growth form & habitat
Small to medium epiphyte on trunks and outer branches. Prefers well-lit but not fully exposed canopy in mixed Sal Forest.

Phenology
Flowering: April-May; capsules develop by June.
Fruiting: early monsoon.

Diagnostic field traits
Narrow terete to semi-terete leaves; dense clumps of aerial roots.
Many-flowered racemes of small copper-yellow to orange flowers with striking blue to violet lip.



PLATE 17: *Zeuxine longilabris & Zeuxine strateumatica*

ORDER: ASPARAGALES
FAMILY: ORCHIDACEAE
SUBFAMILY: ORCHIDOIDEAE

***Zeuxine longilabris* (Lindl.) Trimen**
Common Name: Long-Lipped Zeuxine
Tribe: Cranichideae
Sub-tribe: Goodyerinae

Growth form & habitat
Slender, terrestrial perennial herb with a creeping fleshy rhizome at base.
Damp, shady places in evergreen or moist deciduous forests.

Phenology
Flowering: January-May.
Fruiting: January till May.

Diagnostic field traits
Fragrant, greenish/yellowish-white flower.
Terminal, glandular-pubescent (hairy) raceme
Copper-brown or reddish leaves; lip mid-lobe is 2-winged and toothed (serrated).



***Zeuxine strateumatica* (L.) Schltr.**
Common Name: Lawn / Soldier Orchid
Tribe: Cranichideae
Sub-tribe: Goodyerinae

Growth form & habitat
Small, erect terrestrial herb with a decumbent base.
Grasslands, streambanks, and moist wetlands, often a "weed" in lawns.

Phenology
Flowering: December-March.
Fruiting: January-March.

Diagnostic field traits
Grass-like linear leaves, dense spike of white flowers with a prominent yellow lip.



6. Discussion

The results of the present study provide a scientifically robust baseline inventory of orchid diversity and associated ecological parameters in Dalma Wildlife Sanctuary, directly fulfilling the two primary objectives. Twenty wild orchid species (12 epiphytic and 8 terrestrial) were documented across stratified habitats, with detailed information on growth forms, microhabitat preferences, phenology, abundance, and inferred pollinator guilds. No direct insect visits were observed despite systematic monitoring, underscoring the value of pollination-syndrome analysis as a reliable proxy for guild characterization within the constraints of the six-month survey period.

6.1 Orchid Diversity and Habitat Associations

Mixed deciduous forests emerged as the most species-rich habitats, supporting up to five to seven co-occurring orchid taxa per locality in areas such as Manjhla bandh, Bijli ghati, and near Badka bandh. This pattern aligns closely with regional findings from the Chhotanagpur plateau and Odisha, where mixed stands harbour two to three times higher orchid diversity than sal monocultures (Kumar et al., 2005; Misra, 2014). The strong association of epiphytic species with mature phorophytes (e.g., *Madhuca longifolia, Terminalia bellirica, Diospyros melanoxylon*) and terrestrial species with organic-rich soils and riparian patches highlights the critical role of canopy cover (50–70 %) and microclimatic stability in sustaining orchid populations. These observations confirm the sanctuary's dry deciduous and mixed forests as key refugia for orchid diversity within the broader Jharkhand landscape.

6.2 Phenological Patterns and Pollination Syndromes

The documented phenology revealed tight synchrony with the sanctuary's monsoonal climate, with peak flowering concentrated in the pre-monsoon to monsoon window (March-September) for most epiphytes and a narrower post-monsoon peak for terrestrials. This temporal partitioning reduces interspecific competition for pollinators and optimises resource utilisation, consistent with patterns reported in seasonally dry tropical forests (Krömer et al., 2005). Pollination syndromes were dominated by melittophily in *Vanda, Aerides, Eulophia,* and *Dendrobium* species, sphingophily in *Habenaria*, and generalist entomophily or deceptive strategies in several others. The inferred guilds, supported by floral trait analysis and expert consultation, mirror those described in Indian orchid literature (Faegri & van der Pijl, 1979; Fenster et al., 2004) and provide a functional baseline for future quantitative studies.

6.3 Mycorrhizal and Pollinator Dependencies

All 20 species exhibit obligate mycorrhizal associations, a fundamental requirement for germination and establishment in Orchidaceae (Chase et al., 2015). The consistent presence of epiphytes on specific phorophytes and terrestrials on undisturbed substrates indirectly indicates the persistence of suitable fungal partners. The complete absence of direct pollinator observations reinforces the methodological reliance on syndromes and highlights the need for year-round monitoring to fully elucidate plant–pollinator–mycorrhizal networks. Such dependencies position orchids as sensitive bioindicators of forest health in dry deciduous ecosystems.

6.4 Distribution, Abundance, and Environmental Gradients

Highest richness and abundance were recorded at 400–800 m elevation under moderate canopy cover, correlating with host-tree girth and organic soils. Frequent species (*Vanda tessellata, Vanda testacea, Aerides multiflora*) demonstrated resilience in fragmented landscapes, while rarer taxa (*Luisia zeylanica, Dendrobium macrostachyum*) signal conservation priorities. These patterns are consistent with state-level checklists (Kumar et al., 2007) and underscore the sanctuary's role as an ecological stepping stone between major Indian biodiversity hotspots.

6.5 Comparison with Literature and Conservation Implications

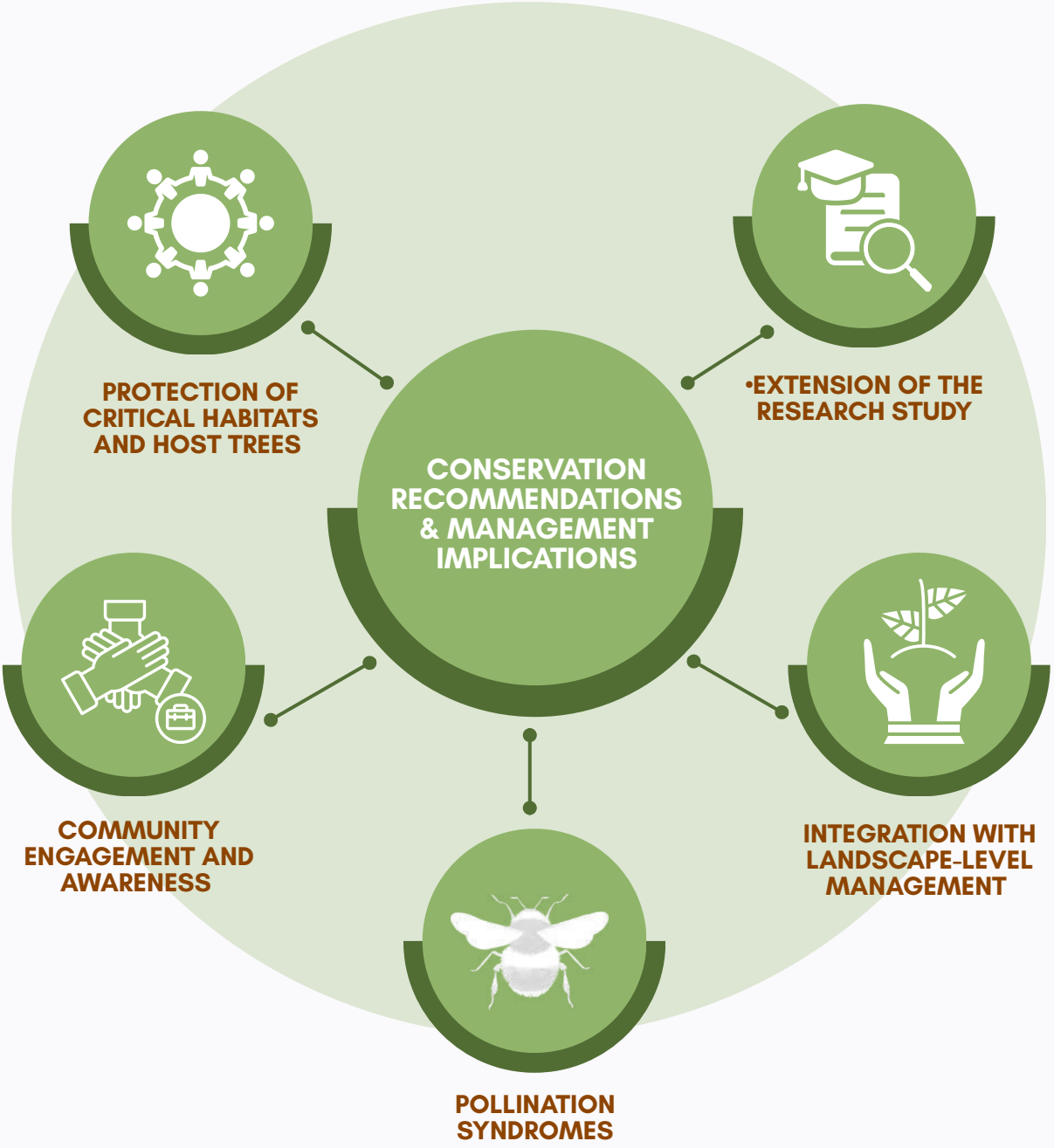
The recorded diversity (20 species) is modest relative to the 63 taxa reported for Jharkhand (Kumar et al., 2005) yet significant for a single protected area. It expands site-specific knowledge beyond earlier descriptive accounts and aligns with Misra (2014) in emphasising the importance of mixed forests and key host trees. The inferred pollination syndromes and mycorrhizal dependencies further reinforce global concerns regarding specialized reproductive systems in Orchidaceae (Phillips et al., 2020; Schiestl & Schlüter, 2009). Threats such as habitat fragmentation, climber competition, and anthropogenic pressures echo those identified in regional studies and necessitate targeted protection of mature phorophytes, soil integrity, and seasonal moisture regimes.

In summary, the findings fulfil the study objectives by delivering a geo-referenced inventory and functional ecological insights that link orchid diversity to pollinator guilds and mycorrhizal networks. They highlight Dalma Wildlife Sanctuary's conservation value beyond its charismatic megafauna and provide an evidence-based foundation for long-term monitoring, habitat management, and community-led conservation in this ecologically significant dry deciduous landscape. Future multi-year studies should prioritise direct pollination observations and mycorrhizal sampling to refine these baseline data.



7. Policy Relevance and Scope of Recommendations

While the present study provides valuable insights into orchid diversity, distribution, and associated ecological patterns within Dalma Wildlife Sanctuary, the findings are based on a relatively short-term survey (six months) and limited ecological observations.
Accordingly, the recommendations derived from this study should be considered as preliminary in nature, intended to inform and support ongoing management planning rather than serve as definitive policy prescriptions. These suggestions provide an initial framework that can be refined and strengthened through long-term monitoring, expanded datasets, and targeted ecological investigations. The recommendations below are explicitly aligned with the sanctuary's existing management framework, the Biological Diversity Act (2002), and the National Wildlife Action Plan, thereby ensuring direct integration into annual working plans and the forthcoming 2027–2032 management plan.



7.1 Protection of Critical Habitats and Host Trees

Mixed deciduous forest patches at elevations of 400–800 m, characterised by 50–70 % canopy cover and organic-rich soils, constitute the primary orchid hotspots. These areas, together with their associated mature phorophytes (*Madhuca longifolia, Terminalia bellirica, Diospyros melanoxylon,* and *Shorea robusta*), warrant immediate designation as "Orchid Conservation Zones." Roadside populations require 50 m buffer strips to mitigate edge effects. Such zoning will be incorporated into the sanctuary's habitat zonation map and enforced through existing patrol protocols.

7.2 Pollination Syndromes – Interpretation and Limitations

Pollination syndromes for the recorded orchid species were inferred based on floral morphology and trait analysis, including flower colour, structure, and presumed attractants. The observed patterns suggest a predominance of melittophily (bee pollination), with possible contributions from sphingophily (moth pollination). However, it is important to note that these interpretations are indicative rather than confirmatory, as no direct observations of pollinator visitation or quantitative data on pollination events were recorded during the study period. Consequently, the assigned pollination syndromes should be treated as hypothesis-driven inferences requiring further validation through targeted field observations, including diurnal and nocturnal monitoring.

7.3 Extension of the Present Study and Justification for a One-Year Research Programme

The survey successfully documented presence, distribution, and inferred pollinator guilds; however, it captured only a partial phenological cycle and yielded no direct insect observations.

A scientifically robust understanding of orchid-pollinator specificity, full seasonal phenology, and reproductive success necessitates at least one complete annual cycle of data collection. Extension of the current project for a further six months (April-September 2026) is therefore recommended. This modest extension will enable:

- documentation of additional orchid taxa potentially present outside the surveyed window,
- verification of inferred syndromes through direct diurnal and nocturnal observations, and
- preliminary mycorrhizal sampling.

Such an extended programme will double the scientific output while requiring minimal additional resources, thereby providing the Jharkhand Forest Department with a comprehensive dataset suitable for evidence-based decision-making and compliance with national biodiversity reporting obligations.

7.4 Community Engagement and Awareness

Targeted training modules for forest guards, eco-tourism guides, and local communities will reduce incidental collection and promote non-destructive documentation. Revenue from regulated ecotourism may be ring-fenced for habitat restoration.

7.5 Integration with Landscape-Level Management

Orchid conservation must be mainstreamed into the Singhbhum elephant corridor plan to avoid inadvertent microhabitat degradation during fire-line creation or water-hole development. Coordination with the Biodiversity Management Committee will embed these recommendations into the sanctuary's official management plan.

Adoption of the foregoing policy-focused recommendations will secure the documented orchid diversity, strengthen ecosystem resilience, and position Dalma Wildlife Sanctuary as a model for orchid-inclusive protected-area management across the Chhotanagpur plateau. The proposed one-year extension represents a high-return investment that directly addresses the temporal constraints acknowledged in this study and will generate the additional data required for informed, long-term conservation planning.



8. Conclusion

In conclusion, the present study has successfully documented a comprehensive baseline inventory of orchid diversity and associated ecological interactions within Dalma Wildlife Sanctuary, thereby addressing the two primary objectives outlined at the outset. Twenty wild orchid species across 12 genera, 12 epiphytic and 8 terrestrial were recorded through systematic stratified surveys conducted. Detailed information on growth forms, microhabitat preferences, phenological patterns, abundance, distribution, and inferred pollination syndromes has been generated, fulfilling the requirement for geo-referenced floristic and functional data essential to evidence-based conservation planning.

The findings affirm the sanctuary's dry deciduous and mixed forests as important refugia for orchid assemblages, with peak diversity observed in mixed deciduous patches supporting mature phorophytes and organic-rich soils at 400-800 m elevation. Phenological synchrony with the monsoonal climate and the predominance of melittophily, supplemented by sphingophily and generalist or deceptive strategies, underscore the functional integration of orchids within the broader pollinator network. The absence of direct pollinator observations during the survey period highlights the methodological value of pollination-syndrome analysis while emphasising the need for extended, year-round monitoring. Collectively, these results expand site-specific knowledge beyond earlier state-level checklists and position Dalma as a significant orchid habitat within the Chhotanagpur plateau.

The survey captured only a partial phenological cycle, precluding comprehensive direct observations of pollinator activity and preliminary mycorrhizal sampling. Abundance estimates relied on semi-quantitative scales rather than exhaustive population censuses, and the study did not encompass potential additional taxa flowering outside the survey window. These constraints suggest productive avenues for future research, including a recommended one-year extension to verify syndromes, assess reproductive success, and elucidate plant–pollinator–mycorrhizal networks more fully.

The practical implications of this work are substantial. Stakeholders, particularly the Jharkhand Forest Department, are encouraged to designate critical orchid hotspots as "Orchid Conservation Zones," protect key host trees, safeguard pollinator guilds and mycorrhizal communities, and integrate these measures into the sanctuary's management plans. Community engagement initiatives will further enhance local stewardship and reduce incidental threats. By mainstreaming orchid conservation into landscape-level strategies, including the Singhbhum elephant corridor plan, the sanctuary can serve as a model for inclusive protected-area management across the region.

Ultimately, this research underscores the importance of evidence-based approaches in conserving specialized floral guilds within seasonally dry ecosystems. As Dalma Wildlife Sanctuary continues to face pressures from habitat fragmentation, climate variability, and anthropogenic activities, the insights derived herein offer a constructive pathway for sustained biodiversity protection. The study does not represent a final statement but rather a foundational step toward informed action, continued scholarly inquiry, and the long-term preservation of the sanctuary's rich orchid and pollinator heritage.

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Annexure 1

Sr. No.	Area/ Locality Name	GPS Coordinates (Latitude)	GPS Coordinates (Longitude)	Elevation (m/ft)	Habitat Type	*Orchid Species Scientific Name*	Type (Epiphytic/ Terrestrial)	Plant Height (m/cms)	*Associated Flora*	Notes / Threats Observed	Abundance Scores (RARE scale: Rare=1–5 plants, Occasional=6–20, Frequent=>20)
PROJECT: Documentation of Orchids, Dalma Wildlife Sanctuary (Field Datasheet), ORDER: Asparagales, FAMILY: Orchidaceae											
1	From Guest house towards Kadamjhor	22.911188	86.139059	150.5	Forest	*Vanda tessellata*	Epiphytic	1.5 m	*Madhuca longifolia (Mahua)*		Frequent
2		22.911609	86.14192	147.6	Open Forest	*Acampe praemorsa*	Epiphytic	1.5 m	*Diospyros melanoxylon (Tendu)*	Every branch had dense orchids	Frequent
3		22.916346	86.164595	278.56	Roadside Forest	*Vanda tessellata*	Epiphytic	1.5-2 m	*Semecarpus anacardium (Bhilawa)*		Occasional
4		22.913666	86.168855	317.8		*Aerides multiflora*	Epiphytic	1.5 m	*Bombax ceiba (Semal)*		Occasional
5		22.912071	86.170925	355.31		*Rhynchostylis retusa*	Epiphytic	1.5-3 m	*Diospyros melanoxylon (Tendu)*	Flooded with orchids	Occasional
6		22.911903	86.17145	358.6		*Vanda testacea*	Epiphytic	1-2 m	*Pterocarpus marsupium (Bija Sal)*	Less climbers	Frequent

7		22.911003	86.172857	356.17		*Vanda testacea*	Epiphytic	1-2 m	*Semecarpus anacardium (Bhilawa)*	Less climbers	Occasional
8		22.911049	86.172329	360		*Luisia zeylanica* Lindl.	Epiphytic	2m	*Diospyros melanoxylon (Tendu)*	Slender & thin leaf	Rare
9		22.906199	86.175893	442.6		*Vanda tessellata*	Epiphytic	~1-2m	*Terminalia elliptica (Aasan)*		Occasional
10	Opp. Jubla Kocha range	22.927695	86.092809	138.77	Paddy field	*Aerides multiflora*	Epiphytic	~1m	*Madhuca longifolia (Mahua)*		Occasional
11		22.924343	86.103775	131.35	Open	*Acampe praemorsa*	Epiphytic	upto 2m	*Madhuca longifolia (Mahua)*		Frequent
12	Hamsa Dah Village (Main Entrance gate towards guest house ~4kms)	22.923908	86.103317	133.05	Open forest, Field with trees of Mahua, Banyan, and Palash	*Aerides multiflora*	Epiphytic	~1-2m	*Madhuca longifolia (Mahua)*		Frequent
13		22.924196	86.103341	130.72		*Vanda testacea*	Epiphytic	~2-3m	*Madhuca longifolia (Mahua) & Ficus benghalensis (Bargad)*		Frequent
14		22.924343	86.103775	131.35		*Aerides odorata*	Epiphytic	2m	*Madhuca longifolia (Mahua) & Ficus benghalensis (Bargad)*		Frequent
15		22.927933	86.092612	134.5		*Vanda testacea*	Epiphytic	~1-2m	*Madhuca longifolia (Mahua)*		Frequent
16	Opp. Jubla Kocha range (watch tower on tree, small water body)	22.923407	86.103801	131.61		*Aerides multiflora*	Epiphytic	~2m	*Azadirachta india (Neem), Madhuca longifolia (Mahua) & Ficus benghalensis (Bargad)*		Frequent

17	Towards Pinderabeda Rest House	22.911141	86.138973	158	Stream Forest	*Vanda testacea*	Epiphytic	~1-1.5m	*Madhuca longifolia (Mahua)*		Frequent
18		22.911503	86.147886	167.4	Open ground, 1 km towards RH	*Vanda testacea*	Epiphytic	Upto 1.5m	*Butea monosperma (Palash)*	Two different species, slender leaf and broader leaf	Frequent
19		22.905608	86.179109	492.4		*Acampe praemorsa*	Epiphytic	~1-2m	*Lannea coromandelica (Indian ash tree, Doca)*		Frequent
20	Towards Penderabeda' RH	22.901424	86.184061	562.6	7kms from Mukulakocha RH	*Eulophia ochreata*	Terrestrial	<15-20 cm	*Herbs, shrubs, grasses*		Occasional
21		22.895494	86.201961	643.61	1km from Pinderabeda RH towards temple	*Vanda testacea*	Epiphytic	~1-2m	*Terminalia bellirica (Bahera)*		Frequent
22		22.898087	86.19962	597.02	Right side of the road, 50m inside	*Aerides odorata*	Epiphytic	1m	*Pterocarpus marsupium (Bija Sal)*		Occasional
23		22.897914	86.199542	590.12	Left side of road	*Luisia zeylanica Lindl.*	Epiphytic	~1m	*Diospyros melanoxylon (Tendu)*		Rare
24		22.898896	86.197771	589.1	Right side of the road, 50m inside	*Acampe praemorsa*	Epiphytic	~1m	*Terminalia chebula (Harar)*		Occasional
25		22.899256	86.196943	565.64	Left side of road	*Eulophia ochreata*	Terrestrial	~1-2m	-		Occasional

26	Manjhla bandh, Southern	22.901915	86.198421	560.83	Mixed forest	*Acampe praemorsa*	Epiphytic	~2-3m	*Terminalia bellirica (Bahera)*		Frequent
27		22.901814	86.198391	552.5		*Vanda tessellata*	Epiphytic	2m	*Lannea coromandelica (Indian ash tree, Doca) (dried)*		Frequent
28	Chota bandh, 100mts	22.901666	86.202551	560.1		*Vanda testacea*	Epiphytic	1-2m	*Terminalia bellirica (Bahera)*		Frequent
29	Aam daarhi naala	22.902718	86.193095	521.7		*Vanda tessellata*	Epiphytic	1-2m	*Terminalia bellirica (Bahera)*		Frequent
30	150mt from old bijli ghaati	22.907614	86.191655	500.5	Mixed forest	*Luisia zeylanica* Lindl.	Epiphytic	1	*Diospyros montana (Kaala Kend)*	Collected fallen orchid for propagation	Rare
31	Near Bijli ghati	22.907599	86.192414	479.25			Epiphytic	1	*Terminalia elliptica (Aasan)*		Rare
32	Bijli ghati right side of road	22.907549	86.192408	486.2		*Dendrobium macrostachyum*	Epiphytic	1-2m	*Bridelia retusa (Kosai)*		Rare
33	Bijli ghati right side of road	22.907471	86.192258	482.81		*Not orchid*	Epiphytic	0.5m	*Kukdi Champa*		
34	Towards Badka bandh road	22.895293	86.197955	608.41		*Rhynchostylis retusa*	Epiphytic	0.5-1m	*Terminalia elliptica (Aasan)*		Occasional
35	Towards Badka bandh road	22.895368	86.197139	599.3		*Not orchid*	Epiphytic	0.5m	*Kukdi Champa*		
36	Rest house premises	22.19629	86.196129	598.8		*Luisia zeylanica*	Epiphytic	1	*Karkat*		Rare

37	Baak Mor, Right side of the road	22.895079	86.203145	690.8	Mixed forest	*Vanda testacea*	Epiphytic	0.5m	*Terminalia bellirica (Bahera)*		Frequent
38	50m from Bahera Bak	22.895087	86.205042	695.29		*Aerides odorata*	Epiphytic	3.5m	*Garuga pinnata (Bhut Kusum)*		Occasional
39	Left side of road, 1km to temple	22.890891	86.213664	812.6		*Dendrobium herbaceum*	Epiphytic	0.5-1m	*Bombax ceiba (Semal)*		Occasional
40	Teesri, 4kms from Pendabeda RH	22.909529	86.175842	373.2		*Aeides multiflora*	Epiphytic	1-2m	*Diospyros melanoxylon (Tendu)*		Occasional
41	Chimti Naka, After bridge left side of road	23.0816667	86.4511111	658	Open, road side	*Aerides multiflora*	Epiphytic	0.5m	*Schleichera oleosa (Kusum)*		Occasional
42	Chimti Naka, Before bridge left side of road	23.0641667	86.4316667	626	Open, road side	*Vanda testaces, Aerides multiflora, Aerides odorata,Rhyncho stylis retusa*	Epiphytic	0.5-1m	*Bombax ceiba (Semal)*		Frequent
43	Forest towards Rest house 4kms, left side of road	23.0641667	86.2558333	1498	Forest climber (Combretum decandrum), Bauhinia roxburghii	*Unidentified*	Terrestrial	~upto 30cm			Rare
44	Bandar Jal, Aam Jharna	22.909525	86.2493	384.3ft	Mixed Semi-deciduous forest - Dense, high OM, prevalence of orchid Species near termite mounds	*Habenaria furcifera*	Terrestrial	Upto 15-45cms with stalk	-	Maoist activity noted, Leaves lie at the ground in 5-6 in number, waxy and shiny, multiple sightings at a distance of 100-200 mts	Occasional
45		22.909931	86.249609	476.4ft		*Habenaria furcifera*	Terrestrial		-		Occasional

46		22.909394	86.249213	451.7ft		*Habenaria furcifera*	Terrestrial		-		Occasional
47	Saal Doha Village	22.9586111	86.4980556	602ft	Rice field, agroforestry, stream flowing	*Vanda tessellata*	Epiphytic	Upto 1m	*Madhuca longifolia*		Frequent
48		22.9594444	86.4955556	598ft		*Vanda tessellata*	Epiphytic	Upto 1m	*Madhuca longifolia*		Frequent
49		22.9572222	86.4944444	614ft		*Acampe praemorsa*	Epiphytic	Upto 1m	*Madhuca longifolia*		Frequent
50		23.0277778	86.4883333	821ft	On hill forest beyond	*Vanda sp.*	Epiphytic	1-3m	*Diospyros melanoxylon (Tendu) & Madhuca longifolia*		Frequent
51		23.0280556	86.4888889	814ft	River stream	*Dendrobium macrostachyum*	Epiphytic	1-3m	*Diospyros melanoxylon (Tendu)*		Rare
52		23.0294444	86.4916667	815ft	600m from river stream	*Habenaria furcifera*	Terrestrial	~50cm	-		Occasional
53		23.0294444	86.4916667	815ft		*Vanda sp.*	Epiphytic	1-2m	*Pterocarpus marsupium*		Frequent
54		23.0333333	86.4927778	830ft		*Vanda sp.*	Epiphytic	1	*Pterocarpus marsupium*		Frequent
55		23.035	86.4938889	846ft		*Dendrobium crepidatum*	Epiphytic	Upto 3m	*Bombax ceiba (Semal)*		Occasional
56		22.875	86.2452778	566ft	Halud Bane, left side of the road	*Vanda tessellata*	Epiphytic	1-2m	*Madhuca longifolia (Mahua)*		Frequent

57		22.890447	86.214217	837	Near Dalma temple	*Dendrobium herbaceum*	Epiphytic	Upto 3m	Garuga pinnata & Bombax ceiba		Occasional
58		22.89047	86.21473	820	Dalma Mandir Gufa	*Dendrobium herbaceum*	Epiphytic	Upto 3m	*Ficus virens*		Occasional
59		22.998611	86.445833	810		*Dendrobium macrostachyum*	Epiphytic	Upto 3m	*Syzigium cumini (Jamun)*		Occasional
60		22.903061	86.216753	473.1	Left side of road	*Dendrobium herbaceum, Dendrobium macrostachyum, Vanda sp.*	Epiphytic	Upto 3m	*Mangifera indica (Aam)*		Occasional
61	Paagda Ground	22.880863	86.28234	138	Scrub Open forest, shrubs bushes,	*Acampe praemorsa*	Epiphytic	~1-2m	*Diospyros melanoxylon (Tendu)*		Frequent
62		22.879719	86.282746	136	Roadside Forest	*Vanda tessellata*	Epiphytic	~1-2m	*Diospyros melanoxylon (Tendu)*		Frequent
63	Pathipani	22.868483	86.223186	115.2	Roadside Forest	*Vanda tessellata*	Epiphytic	~1-2m	*Fibus benghalensis (Banyan)*		Frequent
64	Kadamjhor	22.906029	86.175983	446.2	Mixed forest	*Habenaria furcifera & Vanda tessellata*	Terrestrial & Epiphytic	~1-2m	*Terminalia elliptica (Aasan)*		Frequent
65	Saat Bharia, Teesri	22.902055	86.182779	552	Mixed forest	*Vanda tessellata*	Epiphytic	1	*Dried trunk of Terminalia elliptica (Aasan)*		Occasional
66	Ranga Jal	22.901843	86.209588	561.37	Mixed forest	*Aerides odorata*	Epiphytic	2	*Terminalia elliptica (Aasan)*		Rare
67	Makar Jal	22.902853	86.215223	496.5	Mixed forest	*Aerides odorata*	Epiphytic	Upto 1.5m	*Terminalia bellirica (Bahera)*		Rare

68		22.903208	86.214926	478.9	Dense Mixed forest	*Rhynchostylis retusa*	Epiphytic	Upto 1.5m	Careya arborea & Bauhinia vahlii		Occasional
69					Dense Mixed forest	*Vanda tessellata*	Epiphytic	1m	*Terminalia elliptica (Aasan)*		Occasional
70		22.903488	86.215261	494.3	Dense Mixed forest	*Vanda tessellata*	Epiphytic	Upto 2m	*Terminalia bellirica (Bahera)*		Occasional
71		22.90302	86.216023	496.2	Dense Mixed forest	*Vanda tessellata*	Epiphytic	Upto 1.5-2m	*Terminalia elliptica (Aasan) & Bauhinia vahlii*		Frequent
72		22.903067	86.216792	473.1	Dense Mixed forest	*Luisia zeylanica*	Epiphytic	2m			Rare
73		22.904332	86.218969	493.4	Dense Mixed forest	*Luisia zeylanica*	Epiphytic	2m	*Palash/Buchananania lanzan*		Rare
74		22.90856	86.219701	456.3	Mixed forest	*Nervillea concolor*	Terrestrial	<10cm, 5cm dia	*Shrubs, herbs & grasses*		Rare
75		22.908616	86.21972	467.1	Mixed forest	*Nervillea concolor*	Terrestrial	<10cm, 5cm dia			Rare



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