Training Resource Material

Diversity, distribution and ecology of wild bee (Hymenoptera: Apoidea) communities along the elevational gradient in Western Himalaya, Uttarakhand.

Community Outreach Programme

The Rufford Foundation
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HiMalayan Wild bees project

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

About Our Project:

The Himalayan region, a biological hotspot is extremely rich in biodiversity and endemism. However, the biodiversity of this region is facing major threats due to forest fragmentation, overexploitation, and climate change. Wild bees of this region are among the numerous species that are exposed to the challenges posed by these threats. Nevertheless, the diversity and ecology of wild bees in the Himalayan region is not well documented. As the wild bees contribute immensely to the sustainability and regeneration of forests, this study aims to contribute towards the elucidation of ecology and diversity of wild bees in the Himalayan region.

This study is a part of descriptive research on the level of community ecology of plants and bees and will describe the species diversity of flowering plants and bees along with their occupancy in different habitats (macro and micro) at different elevations. Apart from preparing the plant and pollinator's inventory, this study will also depict the interaction of pollination and in and across different habitats and elevations.

The nestedness of a pollinator into another pollinator shall also be analyzed. An interaction is called nested when a specialist pollinator interacts with the subset of plants pollinated by generalists. This analysis of pollination interactions will elucidate the ecological importance of bees and plants for each of them and also in the ecological community. The comparative risk of local extinction of plants and bees can also be described, on the basis of interdependency and abundance in the study site.

The awareness and outreach programs shall also be conducted in the schools, villages, tourist spots around the study site. Awareness programs will explain about the importance of pollination services, bee habitat preferences, a brief life cycle of bees, and methods for the conservation of wild bees.

Chapter 1

Introduction to Pollination

The ultimate goal of every living organism, including plants, is to produce offspring for the next generation. As plants are sedentary and require a medium for sexual reproduction, the concept of pollination becomes vital for them. Pollination is **the transfer of pollen grains from the anther of one flower to the stigma of the same or another flower.** It is the first step in the sexual fertilization of the flowering plants and is fundamental for the survival of the plant diversity in the ecosystem.

The pollination can be broadly categorized into two types:

1.1 Self-Pollination: When the pollen is transferred from the anthers of a flower to the stigma of the same flower, it is called as self- pollination. This form of pollination is common in hermaphrodite or dioecious plants which contain both male and female sexual parts on the same flower.

- These plants depend on **wind or other smaller insects that visit the flower regularly**.
- In self- pollinating flowers, the anthers, and stigma are of similar lengths to facilitate the transfer of pollen.
- Self – pollination can be further divided into two types:

1.2 Cross Pollination: In this type of pollination, the pollen is transferred from the anthers of one flower to the stigma of another flower. In this case, the two flowers are genetically different from each other.

- Cross-pollination is **always dependent on another agent** to cause the transfer of pollen. The agents of pollination include **birds, animals, water, wind, and insects.**
- Based on the agent of pollination, cross-pollination can be of different types:
    - **Hydrophilous Flowers**-These flowers are pollinated by water means. The pollen is adapted to be able to float in water.

- Zoophilous flowers– In this type of pollination, the pollinating agents are animals like human beings, bats, birds etc. The zoophilous flowers have pollen that is designed to stick on to the body of the animal so that they can be easily carried from one flower to another.

- Anemophilous flowers– These flowers are pollinated by the agency of wind. The pollen grains are very light, non-sticky and sometimes winged.

- Entomophilic flowers– These flowers are pollinated by insects. These flowers are often striking to look at with bright petals and are fragrant to attract the insect visitors. Many of the insect-pollinated flowers also secrete nectar which attracts bees, butterflies or other similar insects to the flowers. The pollen grains in these flowers are often spiny or have extensions that help them to stick on to the body of the insects.

- Ornithophilous flowers– These flowers are pollinated by birds. Very few flowers and birds show this form of pollination.

1.3 Advantages of cross-pollination

The cross-pollination benefits the race of the plants by introducing new genes into its lineage. This happens as a result of the fertilization between genetically different gametes. The cross pollination benefits the plant as it improves the resistance of the off springs to environmental changes and disease outbreaks. The seed produced has a good vigor and vitality as any recessive trait gets eliminated by genetic recombination.

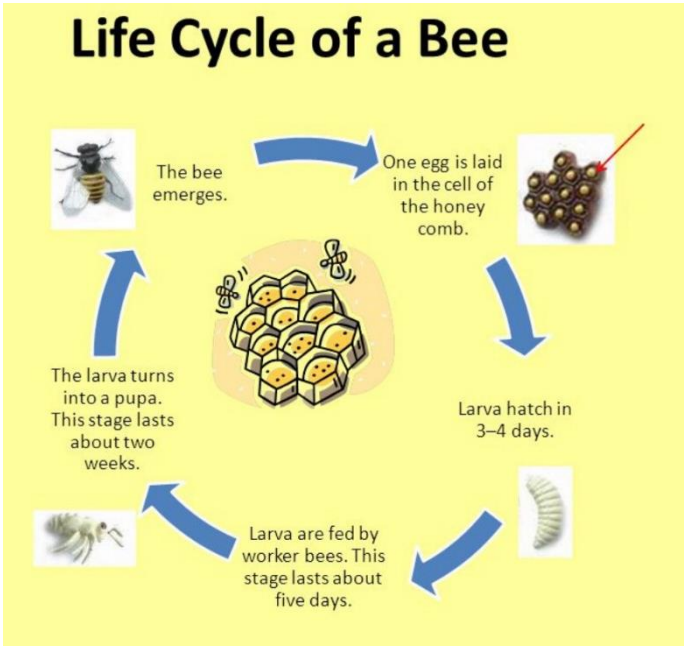
As we have learnt so far that generally pollination requires a pollinator which carries the pollen from flower to another. And in almost 80% of plant diversity this task is done by Bees. The bees and plants share an interspecific relationship which is often termed as 'mutualism'. Mutualism can be defined as, a long-term, close association between two species in which both partners benefit, (denoted by + / +).

Chapter 2

Setting the Context: Why Bees matter?

It is no wonder that bees are the most important group of pollinators. Except a few wasp species, the bees deliberately gather pollen and bring back to their nests for the young ones. **They exhibit 'flower constancy', where they repeatedly visit one specific plant species on any given foraging trip.** On a single foraging trip, a female bee may visit hundreds of flowers, transferring pollen throughout her trip. In contrast, butterflies, moths, flies, wasps, and beetles visit flowers to feed on nectar and not to collect pollen. Consequently, they come in contact less frequently with the flower's anthers than bees do.

Bees are immensely diverse insects that form an important group within the Hymenoptera, an insect order that also includes ants, wasps, and sawflies. India is one of the world's most diverse country in terms of diversity of the bee. It has more than 700 bee species, 40 per cent of which are endemic. There are six honeybees, including an exotic species. It can help India's 86 per cent small and marginal farmers, who practice diverse agriculture on their less than two hectare of land size



.2.1 The Bee Lifecycle

Solitary bees usually live for about a year, although humans only see the active adult stage, which lasts about three to six weeks. These insects spend the other months hidden in a nest, growing through the egg, larval, and pupal stages.

Female solitary bees have amazing engineering skills, going to extraordinary lengths to construct a secure nest. About

30 percent of solitary bee species use abandoned beetle burrows or other tunnels in snags (dead or dying standing trees). Alternatively, they may chew out a nest within the soft central pith of stems and twigs. The other roughly 70 percent nest in the ground, digging tunnels in bare or sparsely vegetated, well-drained soil. A few species nest in eclectic places such as empty snail shells and potlike cells that they construct on twigs from pebbles and tree resin.

Each bee nest usually has several separate brood cells in which the female lays her eggs, one egg per cell. The number of cells varies by species. While some nests may have only a single cell, most have five or even many more. Female woodnesting bees make cells in a single line that fills the tunnel. Females of ground-nesting species may dig complex, branching tunnels. To protect the developing bee and its food supply (from drying out, excess moisture, fungi, and disease) the cell may be lined with waxy or cellophane-like glandular secretions, pieces of leaf or petal, mud, or chewed-up wood. 70% of solitary bees are ground nesting, forming burrows in loose soil. The remaining 30% are cavity nesting, forming brood chambers in hollow stems, holes in dead wood, or other materials. The many solitary bee species exhibit a range of nesting behaviors. Some share a nesting site, sometimes in large aggregations or at great densities. For example, in well-established nesting sites of alkali bees (*Nomia melanderi*), 200 or more females may nest in a single square yard of ground, each bee tending a separate burrow. A few "solitary" species are communal in that they share a common entrance tunnel to the nest, but each female creates her own brood cells. More unusual are the large carpenter bees (genus *Xylocopa*): these females live long enough to meet — and share the nest with — their adult offspring.

2.2 Why they matter?

There are a total of 20,507 known species of bees that have been recorded from the World (Ascher and Pickering, 2020). Bees are only associated with apiculture and known for the commercial products like bee honey and bee wax tec. Nonetheless it is interesting to note that approximately 75-80% of crops are pollinated by wild bees and remaining crops are pollinated by honeybees (Allen and Allen, 1990).
The wild bees are often underestimated for their contribution to the pollination due to inadequate data on their nesting behavior, social life and enormous attention on honey bees.

FAO estimates that that global food crops that rely on pollination value between $235 and 577 billion a year. The volume of agricultural production dependent on pollinators has increased by 300 per cent in the last 50 years. Worldwide, a lot of wild bees are known for pollinating about $3/4^{th}$ of our food. These include, leaf cutter bees, carpenter bees, bumble bees, sweat bees and mining bees, etc. Not many species of wild bees have been deployed by humans for pollination activities (Pitts-Singer, 2008).

In a study by Garibaldi *et al.* (2013), 41 crop systems were surveyed worldwide and it was found that the fruit set increased significantly with flower visitation by wild bees in 86% crop systems while it increased in only 14% through flower visitation by honey bees. Visitation by wild bees and

honey bees enhanced fruit set independently in different crop systems, so pollination by managed honey bees added, rather than substituted for, pollination by wild insects.

In past few decades, the transformation of agriculture from holistic to monoculture led to an surge in the use of pesticides. Farmers started growing cash crops, extensively using pesticides, for better income, and these pesticides kill several pollinators, especially bees. It has been observed that loss of bee population resulted in a decrease in crop productivity. Three out of four crops producing fruits or seeds for human use as food depend, at least in part, on the pollinator. Their absence would remove a host of nutritious foods from our diets — including potatoes, onions, strawberries, cauliflower, pepper, coffee, pumpkins, carrots, sunflowers, apples, almonds, tomatoes and cocoa. The pollinator population is declining rapidly due to various threats to the species like forest fire, habitat fragmentation, destruction of natural habitats, climate change apart from indiscriminate use of pesticides (Potts *et al*., 2010).

In this context, the conservation of wild bees is very important to preserve diversified ecosystems.

Chapter 3

Methods Of Conservation of Wild Bees

As discussed in the previous chapters, the pollinator population has been observed to decline. The major factors responsible for this sudden downfall in the bee population include frequent forest fires, habitat fragmentation, destruction of natural habitats, and undiscerning use of pesticides (Potts *et al*., 2010). The conservation, protection and promotion of wild bees becomes fundamental in this scenario because of their significance in maintaining ecological balance.

The presence of wild bees with greater abundance and rich diversity in a region facilitates pollination of the domestic crops and wild plants of the forests. Often these plants are the ones from which the local people collect their Non timber forest products (NTFPs). In Himalayan ecosystems people are highly dependent on these NTFPs for subsistence and they also serve as greater livelihood options. Furthermore, wild bees provide millions to the food economy of the world and are the basis of the agriculture sector. Their contribution to the forests, grasslands and wild flowers are though unfathomable but cannot be overlooked, completely (Thakur,2012). The Indian government id nowadays providing subsidies flower seeds and sampling to the farmers to encourage floriculture and thus side-by-side enhance the bee population. Despite various efforts in the agricultural sectors there is still a lot to be done in this direction as the lessening bee population could have adverse impacts on ecosystem functions (Biesmeijer, 2006 and Diaz *et al*., 2013).

In order to conserve and protect the wild bees, following are some suggestions for the Forest department, general public, tourists, farmers etc.

3.1 Suggested conservation measures for the forest department, tourists and public at large;

- Avoid trampling/ touching wild plants: The wild plants and flowers serve as food resource for the wild bees. The bees after emerging from hibernation start feeding on these inflorescence and gain strength for the pollination service they provide.
- Do Not Dump plastic wrappers outside the trash cans: The colorful plastic waste like wrappers, Tupperware, polybags etc. attract the bees and they confuse it for flowers. As it

is the pollination process is energy demanding for the bees, these plastic distractions wear them out without any fruitful nectar. To summarize, these plastics decreases the flower visitation rate and increase the time expenditure of the bees.

- Do not let the plastic wrappers/ bowls/ bottle caps sit outside the trash cans for long. If you find any of these wastes sitting outside the trash cans for long, please dump it inside the trash as over time the water gets collected in these plastic saucers and they act like pan traps which entrap the insects including bees and kill them.
- Bee-gardens with bee – friendly plants- The concept of bee gardens is not new to Indian diaspora. These gardens are grown and tended with various flowering species to which the bees are attracted. The aim is to create a habitat corridor with flowering plants that are rich in pollen and nectar. One can grow a bee-garden in their backyard, balcony, across yards and in window boxes, flower pots, and planters etc. One can also get involved with local bodies to find opportunities to enrich public and shared spaces. Marigold is common species of flowering plant that is omnipresent and is one of the favorites of bees.

3.1 Suggested conservation measures for the locals, farmers and beekeepers;

- Encourage organic farming & avoid pesticides; Whether it is gardening or agriculture one must avoid the use of synthetic pesticides, fertilizers, herbicides, and neonicotinoids, as they increase the risk of colony collapse disorder in bees. It is advised to the farmers not use acephate, carbendazim, thiamethoxam, triazofos, tricyclazole, buprofezin, carbofuron, propiconazole and thiophanate methyl on basmati rice and other crops. If possible, the farmers are suggested not to spray the pesticides on flowers directly as the chemical gets sequestered in the pollen. If the bloom needs to be sprayed, it should be done in the evening hours when bees are not actively foraging. Bt based pesticides have been found to be non-toxic to wild bees (Mader et al.2010).
- Grow native plant varieties as these varieties serve as food for the wild bees and more the native plant population is, more the bee population grows in the area.
- Trees for Bees: It is fascinating that bees get most of their nectar from tree. When a tree blooms, it provides hundreds, if not thousands, of blossoms to feed from. Trees are not only a great source of food but also an essential habitat for some bee species. Snag cavities make excellent shelters for bees and the leaves and resin of the healthy trees provide nesting material for bees. With deforestation and urbanization on the rise, one can help bolster bee habitats by caring for trees and joining tree-planting drive in your area.
- Mud-hives & Bee- Bricks: Traditionally beekeeping is done by preparing thick walls of mud with perforations for the bees to nest. Although this technique is widespread in the rural spaces there was no alternative in the urban architecture, until recently. In Europe, people have been using bee- bricks which are nothing but concrete Swiss cheese like blocks. These blocks have small perforations for the bees to nest and can be used to construct urban concrete houses.

- Ground-nesting: It is fascinating that around 25000 bee species nests in underground tunnels, dead wood pieces, hollow stems and snags. Stimulation of floral blooming by burning the grasslands intensify the possible foraging sites, nevertheless burning activities may directly extinguish the larvae in stem or twig nests. Henceforth, needless mowing and burning should be avoided to prevent mortality. Disturbances to the habitat should be curtailed to the practical extent during nesting season (Young et al., 2016).
- Wild Flower Strips: A few studies have shown that simple conservation efforts, like addition of wild flowers as hedgerows around the field margins can provide additional income to the farmers as well as provide better foraging opportunities to the pollinators. (Delphia et al., 2019),(Pywell et al., 2012).

Chapter 4

NARRATING STORIES: Case Studies

4.1: Delhi's outskirts abuzz with efforts to bolster Capital's bee population[1]

To push apiculture as a livelihood option, in 2018, Qutubgarh in northwest Delhi, a quaint village covered in fields of mustard, was adopted by the Khadi Village Industries Commission (KVIC) along with Union minister Meenakshi Lekhi, springing a honey revolution of sorts after villagers were gifted over 100 bee boxes and provided training on bee-keeping. Four years on, the neighboring villages of Jatkhore, Jaunti, Katewara and Daryapur Kalan are also bee-keeping hubs now, with the next generation being taught the art of producing honey from bee boxes. **Locals said the number of boxes has risen to over 250 (each holding up to 50,000 bees) in the five villages.**

Experts feel Delhi's seven biodiversity parks and green spaces like Lodhi Garden, filled with flowering plants, water bodies and presence of certain tree species ideal habitat for bees to build hives, too have turned into a refuge for bees.

4.2 Leaf cutter bees & Alfalfa are best friends.

The challenges in utilisation of wild bees for pollination is a management tactics exist only for few species including leaf cutter bees and bumble bees. Leaf cutter bees (Megachilidae: Hymenoptera) have been used in large scale pollination of legume crops especially Alfalfa (Lucerne). The leaf cutting bee Megachile rotundata reformed the alfalfa seed industry by boosting its yields from 450 kg ha1 (when managed by honey bees) to an outstanding 1300 kg ha-1 (Thakur, 2012). This led to the exploration for utilization of other wild bees for their pollination services.

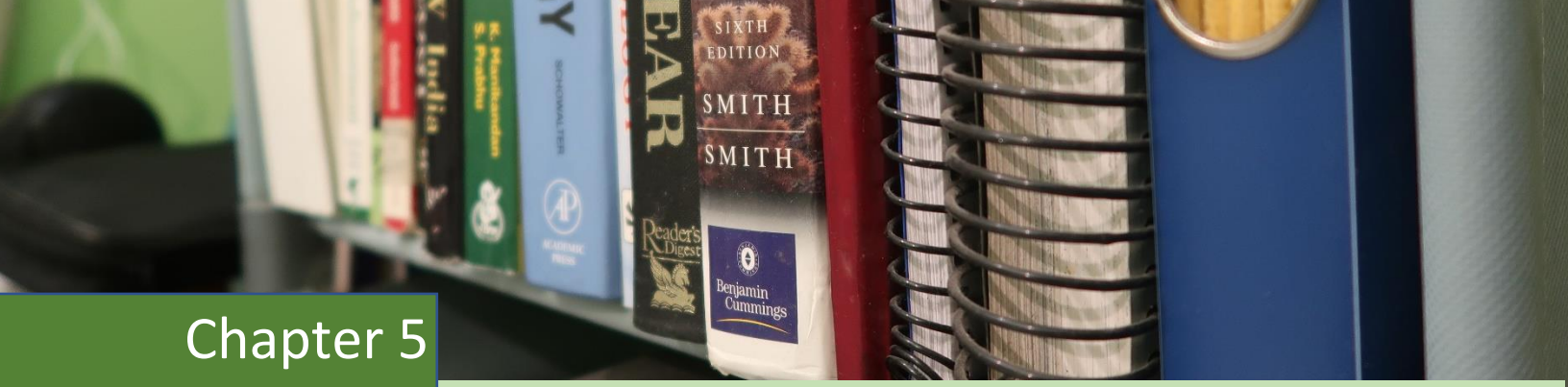
4.3 Project RE-HAB (Reducing Elephant-Human Attacks using Bees)

A pilot project **RE-HAB (Reducing Elephant-Human Attacks using Bees)** has been launched in Karnataka which entails installing bee boxes along the periphery of the forest and the villages to mitigate human-elephant conflict. These spots are located on the periphery of Nagarhole

[1] https://www.hindustantimes.com/cities/delhi-news/delhis-outskirts-abuzz-with-efforts-to-bolster-capital-s-bee-population-101645378995475.html

National Park and Tiger Reserve, which is a known conflict zone. It is intended to create “bee fences” to thwart elephant attacks in human habitations using honeybees. The bee boxes will dissuade elephants without causing any harm to them. This technique is extremely cost-effective as compared to various other measures such as digging trenches or erecting fences. The initiative will increase honey production and farmers’ income.

This Project is an initiative of the Khadi and Village Industries Commission (KVIC). It is a sub-mission of KVIC’s National Honey Mission.



Chapter 5

Multiple agencies, Government schemes, policies & ongoing project.

5.1 Implementation of bills

The Farm Bill is used to channel federal funding for habitat restoration and is governed by the Natural Resource Conservation Service and the Farm Service Agency, in the U.S. Introduction of farm bills/ Acts to fund habitat restoration on agricultural lands can help protecting and enhancing the wild bees population. In the European Union, the government sponsors agricultural land conservation through Agri Environment Schemes (AES).

The Environmental Quality Incentives Program (EQIP) and the Wildlife Habitat Incentives Program (WHIP) had pollinators as a priority taxon (Vaughan and Skinner, 2008). Strict management policies regarding the introduction of managed bees into nonnative regions should be implemented to prevent spill-over of pathogens such as chalkbrood infections to the native wild bees (Pitts-Singer and Cane, 2011). Such strict bills are much needed to conserve bees.

Keeping in view the food security concerns and its economic impact, the United Nations general assembly on December 20, 2017 declared 20 May as the World Bee Day to commemorate the birthday of Anton Jansa, a pioneer beekeeper who was born in 1734.

5.*2 Efforts in India*

- **Honey Mission**: The KVIC has launched the Honey Mission to provide awareness, training and ‘Bee Boxes’ along with Bee Colonies to the farmers. The mission was launched in August 2017 in line with the ‘Sweet Revolution’. The 'Sweet Revolution' was launched in 2016 to promote beekeeping and associated activities.
- **National Bee Board**: The Ministry of Agriculture, Govt. of India launched a Central Sector Scheme titled ‘Development of Beekeeping for Improving Crop Productivity’ during the VIII plan (1994-95). The Department of Agriculture Cooperation (DAC) facilitated formation of the National Bee Board as a Registered Society under Societies Registration Act in July, 2000 and was promoted by the Small Farmers’ Agri-Business Consortium (SFAC). In May

2005, beekeeping has been included as a supplemental activity under National Horticulture Mission (NHM) for promoting cross pollination of horticultural Crops.

- The National Bee Board (NBB) was reconstituted in June, 2006 including private sector. The main objective of the National Bee Board (NBB) is overall development of beekeeping by promoting scientific beekeeping in India to increase the productivity of crops through pollination and increase the honey production for increasing the income of the beekeepers/farmers.
- Objectives of NBB:
  - Overall development of scientific beekeeping in India by popularizing state of the art technologies through the governmental schemes of National Horticulture Mission and Horticulture Mission for North East and Himalayan States in the country.
  - Development of nucleus stock production, capacity building programmes and training of bee breeders and beekeepers, processing, research work, etc. and conducting of seminars.
  - Dissemination of information on technological advancement in the field of beekeeping through its various publications and the quarterly magazine "Bee World"
  - Initiating steps for quality honey production and other bee hive products for overseas and domestic markets besides enhancing productivity of various crops through bee pollination.
  - Increasing the employment opportunity in rural sector and thus enhancing the ancillary income of the beekeepers & farmers.[2]

5.3 Other organizations:

- United Nations Environment Program
- International Union for the Conservation of Nature
- Under the Mango Tree, India
- Bees for Development, United Kingdom
- BEES for the World, Germany
- Elephant and Bees Project, Kenya
- Federation of Nepal Beekeepers, Nepal
- Purple Hive Project, Australia
- World Bee Project, England

[2] https://nbb.gov.in/Bdc.htm

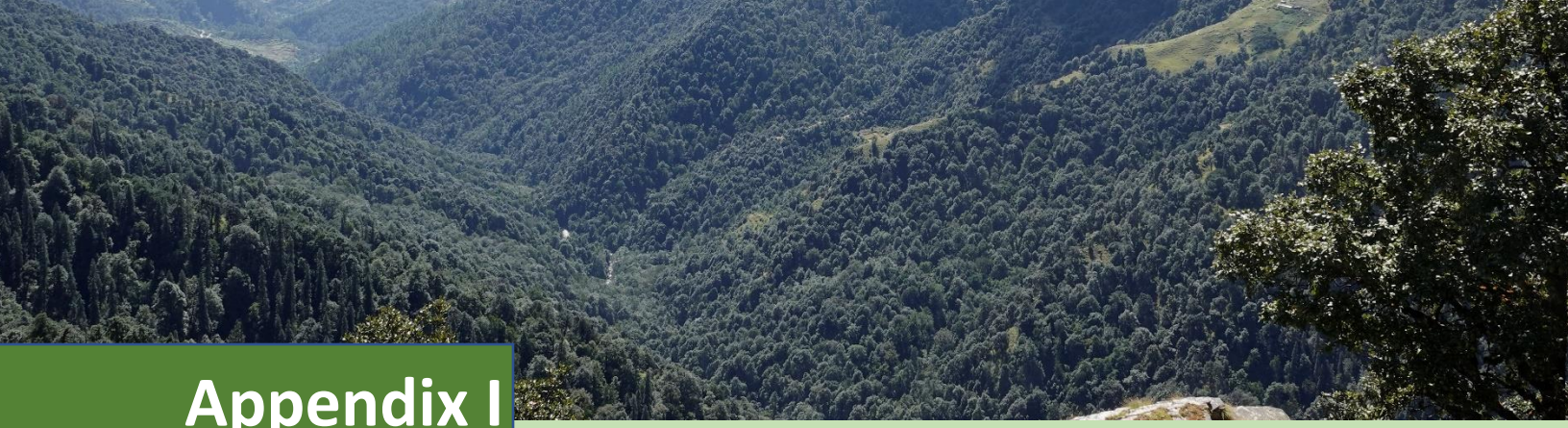
Chapter 6

Cross-sector coordination & way forward

The conservation and protection of wild species has now become a multidisciplinary subject. Likewise, the efforts for conservation must be multi-dimensional. In case of wild bee conservation there's a fundamental need for cross sectoral coordination. Following are some suggestive measures;

- The forest department can assist and train the local farmers and forest-dependent households to identify basic wild plant species and avoid trampling/ touching them. They can also embolden them to grow native species in the area. A community outreach programme can also be planned once in a while to educate the youth and women of the area.
- The municipalities and other urban local bodies can encourage the youth to participate in plantation drives. They can keep time-to-time competitions/ awards / fundraisers to install bee-baths in the shared spaces. Sign boards can also be installed in areas where underground nesting of bees is in place. Installation of trash cans in every 2km can also be done.
- The local panchayat and Anganwadi block can cooperate and encourage the farmers to avoid pesticides and direct them on how they can enhance the yield by innovative farming techniques.
- The tourism department can install signboards and posters in bus stands and railway stations depicting the conservation measures tourists can take to avoid disturbing the hives in the area.
- A by- monthly meeting can also be organized along with representatives from each department and stakeholders to discuss and communicate the challenges and draw out solutions.

New practices for integrated management of both honey bees and wild bees assemblages will enhance global crop yields. Scientific research will continue to be an imperative component of wild bee conservation programmes. There is a need for intensive studies on floral and nesting habitats of lesser-known species, taxonomic identification of bees and location-specific studies. To monitor the population trends, a more reliable and direct standardized monitoring method should be developed. There is a need to evaluate the effectiveness and safety of trap nests from competitors and parasites.



Appendix I

Further readings…

Allen P R, Allen P C. 1990. How many plants feed the world? Conservation Biology 4(4):365 74. Ascher J S, Pickering J. 2020.https://www.discoverlife.org/mp/20q?guide= Apoidea_ species & flags=HAS.Accessed on December 2, 2020.

Biesmeijer J C, Roberts S P M, Reemer M, Ohlemu¨ ller R, Edwards M, Peeters T, Schaffers, Potts S G, Kleukers R, Thomas C D, Settele J, Kunin W E. 2006. Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands. Science 313: 351-354. Breeze T D, Bailey A P, Balcombe K G, Potts S G. 2011. Pollination services in the UK: How important are honeybees? Agriculture, Ecosystem and Environment 142: 137-143.

Delphia C M, O'Neill K M, Burkle L A. 2019. Wildflower seed sales as incentive foradopting flower strips for native bee conservation: A cost-benefit analysis. Journal of Economic Entomology 112(6):2534-2544.

Diaz S, Purvis A, Cornelissen J H C, Mace G M, Donoghue M J, Ewers R M, Jordano P, Pearse W D. 2013. Functional traits, the phylogeny of function and ecosystem service vulnerability. Ecology and Evolution 3: 2958–2975

Garibaldi L A, Steffan-Dewenter I, Winfree R, Aizen M A, Bommarco R, Cunningham SA, Kremen C, Carvalheiro L G, Harder L D, Afik O, Bartomeus I, Benjamin F, Boreux V, Cariveau D, Klein A M. 2013. Wild Pollinators Enhance Fruit Set of Crops Regardless of Honey Bee Abundance. Science 339: 1068-1611.

Holzschuh A, Steffan-Dewenter I, Tscharntke T. 2008. Agricultural landscapes with organic crops support higher pollinatordiversity. Oikos 117(3): 354-361. Maclvor J S, Packer L. 2015. 'Bee Hotels' as Tools for Native Pollinator Conservation: A Premature Verdict? PLoS ONE 10(3): e0122126. https://doi.org/10.1371/journal.pone.0122126

Mader E, Spivak M, Evans E. 2010. Managing alternative pollinators: a handbook for beekeepers, growers, and conservationists. SARE Handbook 11, SARE and NRAES, New York. 170 pp.

Palmer M A, Ambrose R F and Poff N L R. 1997. Ecological theory and community restoration ecology. Restoration Ecology 5:291–300.

Pitts-Singer T L. 2008. Past and present management of alfalfa bees. In Bee Pollination in Agricultural Ecosystems. Oxford University Press, New York. 232 pp. Pitts-Singer T L, Cane J H. 2011. The alfalfa leaf cutting bee, *Megachile rotundata*: the world's most intensively managed solitary bee. Annual Review of Entomology 56: 221-237.

Potts S G, Biesmeijer J C, Kremen C, Neumann P, Schweiger O, Kunin W E. 2010. Global pollinator declines: Trends, impacts and drivers. Trends in Ecology and Evolution 25: 345–353. https://doi.org/10.1016/j.tree.2010.01.007

Pywell R F, Heard M S, Bradbury R B, Hinsley S, Nowakowski M, Walker K J, Bullcok J M. 2012. Wildlife-friendly farming benefits rare birds, bees and plants. Biology Letters 8: 772–775.

Thakur M. 2012. Bees as pollinators – biodiversity and conservation. International Research Journal of Agricultural Science and Soil Science 2(1): 01-07.

Vaughan M, Skinner M. 2008. Using Farm Bill programs for pollinator conservation. US DANRCS National Plant Data Center, online:https://plants.usda.gov/pollinators/Using_Farm_Bill_Programs_for_Pollinator_Conservation.

Veereshkumar, Belavadi V V, Gupta A. 2015. Parasitisation of leaf-cutter bees (Megachilidae: Apoidea) by Melittobia species. Entomon 40 (2): 105-112.

Young B E, Schweitzer D F, Hammerson G A, Sears N A, Ormes M F, Tomaino A O. 2016. Conservation and Management of North American Leafcutter Bees. Nature Serve, Virginia. 24 pp.

Appendix II

Our partners

The Rufford Small Grants

The Rufford Foundation seeks to fund people whose work makes a pragmatic, substantial and long-lasting contribution to nature conservation. Such work often includes other elements such as sustainable development, public education and environmental campaigning. Rufford Small Grants are designed to provide accessible and flexible funding for those who want to bring about change. Conservationists from any country working anywhere in the developing world are welcome to apply. Projects in the First World will not normally be considered for funding.

More information about the Rufford Foundation and previous Award and Grant recipients may be found on the Foundation's website at www.rufford.org

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Established in 1982, Wildlife Institute of India (WII) is an internationally acclaimed Institution, which offers training program, academic courses and advisory in wildlife research and management. The Institute is actively engaged in research across the breadth of the country on biodiversity related issues.

More information about the Wildlife Institute of India (WII) & ongoing projects and departments may be found on the institute's website at https://wii.gov.in/

Appendix III

Our Team

Dr. V P Uniyal, Scientist-G, Wildlife Institute of India (WII)

Dr. Uniyal has been involved in ecological studies on high altitude insect diversity and identifying insect indicators for biodiversity monitoring. His research interests include the systematics and diversity of the entomofauna, arachnids and ecological monitoring in the Himalayan region. His specialization includes ecology and systematics of insects; bioindicators; biodiversity surveys; ecological monitoring in protected areas. Currently, he's involved in many projects and assignments related to insects.

Mr. Ritesh Kumar Gautam, Project lead

Ritesh is pursuing his PhD in Wildlife Sciences from WII, Dehradun. He has been working on Bees for past four years. For his master's thesis he also closely studied social parasitism among Bumblebees. He strives to integrate his research findings into a well catalogued bee database for world wide accessibility of the information. His long-term plan is to conduct research in the field of bee ecology & behavior, especially focusing on Bumblebees for their assessment and conservation. He's also a general trivia enthusiast.

Ms. Kratika Goswami, Project Intern

Kratika holds a master's degree in Environment Management from Forest Research Institute, Dehradun. She has three years of comprehensive experience in wildlife research and conservation across various taxa over northern India. She has aworked under GIZ and MoEFCC on Human-wildlife conflict mitigation project. She has also worked on Rhesus macaques as a model species to understand road ecology as part of her Master's thesis. Currently, she's coordinating the community outreach programme aimed to inspire stakeholders for the protection and conservation of wild bees. She's also a caricature artist and an avid birdwatcher.