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# The NEH area of India's honeybee variety, pollination, entrepreneurship, and beekeeping situation

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## Research Article

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## Abstract

There is a lot of promise for beekeeping in northeastern India due to its varied feed supplies. *Apis dorsata*, *A. florea*, *A. cerana himalaya*, *A. mellifera*, *A. laboriosa*, and *Trigona iridipennis* are the species of honeybees found in the northeastern hill area. In order to meet its pollination demands, modern agriculture now heavily depends on bees. The predominant sporomorphs identified by pollen analysis from the northeastern hill area were *Brassica* sp., *Solanum* sp., *Helianthus* sp., *Wendlandia* sp., *Clematis* sp., *Adhatoda* sp., and *Mussaenda* sp. 107 plants from northeastern India were found to be bee flora. Beekeeping may foster a variety of entrepreneurial endeavours, such as raising honey bees, selling honey bee colonies, advising farmers on honey bee rearing, processing honey on a big scale, and marketing honey products. The information that is now available on the variety of honeybees, pollination, entrepreneurship, and beekeeping scenarios for sustainable agriculture in the northeastern hill area is examined and explored.

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## Key words:

NEH area, beekeeping situation, entrepreneurship, pollination, and variety of honeybees.

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## Introduction

During the middle Cretaceous, bees and plants coevolved. Because blooming plants supply sustenance in the form of pollen and nectar, bees rely on them. In a similar vein, plants rely on bees for pollination. The co-evolution of entomophilous angiosperms and anthrophilous insects was accelerated by their mutual dependency (Suryanarayana 1986). Bees and plants have been related since the Cretaceous period, about 100 million years ago. The 20,000 species of bees (Apoidea) include individuals that are solitary, non-social, communal, and really social, such as *Apis*, the contemporary honeybee (Hargasim 1974). In addition to providing farmers with immediate advantages like honey, beeswax, hive products, and job possibilities, integrating beekeeping with agriculture will also have significant indirect benefits via higher crop yields. It has been shown that almost all agricultural crops rely on pollinating insects to produce commercial fruit and seeds (Rao et al. 1980). Since only 5% of flowers are self-pollinated and 95% are cross-pollinated, insect pollination is crucial. Insects are responsible for 85% of the 95% pollination. Evidently, investigating the prospect of planned bee pollination is crucial for greater agricultural productivity and sustainable agriculture. With fewer natural pollinators and a greater demand for bees to pollinate crops, this creates a significant conundrum. As a result, modern agriculture now heavily relies on bees to meet its pollination requirements. Many plant families include blooming plants that bloom at various times of the year. Foraging bees' access to pollen and nectar varied according to the season and the

blossoming of various plant types. Not all of the honey-flora involved in the main honey-flow experience the blooming phase at the same time. Even the same nectar plant may bloom at different times depending on the kind of soil, climate, and vegetation habitat (Rodionov & Shaban shov 1986). Each of the honey plants that participate in the primary honey flow is limited to certain climatic conditions and geographical areas; they are not found everywhere. As a result, different varieties of honey are harvested in different parts of a nation. A list of plants beneficial to honeybees has been created by studying the blooming dates of some of the significant honey plants in Poland (Gromisz 1993). Additionally, beekeeping has grown to be a significant and sustainable source of income for marginal farmers, landless people, and other weaker segments of society, especially the tribal people of the northeastern area who live below the poverty line. The southern peninsula, the northeast, the Indo-Gangetic plains, and the northern hill region are the main geographical areas supporting the growth of beekeeping. Potential beekeeping locations included the northeastern region, sub-Himalayan forests, and cultivated areas with citrus orchards and oilseed crops (Thomas et al. 2001). According to earlier estimates, 40,000 beekeepers, mostly marginal with one or two hives, generate 5 lakh kg of honey yearly in the North East. The honey from this area comes from both farmed and wild bee colonies.

### **Honeybee's diversity**

The two primary subgroups of the superfamily Apoidea are Apiformes (bees) and Spheciformes (wasps). The presence of branching, often plumose hairs and the hind basitarsi, which are wider than the subsequent tarsal segments, are two characteristics that set bees apart from wasps. Generally speaking, the proboscis is longer than most sphecoid wasps. According to Michener's (2007) research, there are 17,533 species of bees in the world, arranged into seven families and 443 genera. Of these, reports from India included 633 species from 60 genera and six families. Apiculture has a lot of promise in the northeastern states with a variety of pasture supplies. The requirement for rigorous beekeeping development is wonderfully complemented by the climate, geography, and indigenous people who practise traditional beekeeping. The big honeybee (*A. laboriosa*), rock bee (*A. dorsata*), small honeybee (*A. florea*), Asian honeybee (*A. cerana*), European honeybee (*A. mellifera*), and stingless bee (*Trigona iridipennis*) are the several kinds of honeybees found in the northeastern hill area. The Asian honeybee subspecies *A. cerana himalaya*, which is found in the northeast, is somewhat different from *A. cerana cerana*, which is found in the northwest Himalayas, and *A. cerana indica*, which is found in South India. Additionally, the Naga and Mizo hills, the Brahmaputra valley, and the Khasi hills, the foothills of the northeast Himalaya, are home to ecotypes of the subspecies *A. cerana himalaya* with differences in their ecological and economic characteristics among the local people (Singh & Verma 1992). Native honeybees including *A. dorsata*, *A. florea*, *A. laboriosa* (not domesticated), and *A. cerana* (domesticated) are also found in the Hindu Kush Himalayas. These honeybees improve the lives of mountain people by producing honey and wax from their hives, in addition to providing ecosystem services like pollination (Ahmad et al. 2004).

### **Giant honeybee, *A. laboriosa*:**

Numerous researchers, including Sakagami et al. (1980), have previously documented these bee species in high mountainous regions of the Himalaya, including northeastern India, Nepal, Bhutan, and China (Tibet and Yunnan) (Trung et al. 1996). The northeastern strip of the Arakan Mountains in eastern Arunachal Pradesh, the Shillong Hills in Meghalaya, Nagaland, Manipur, and Mizoram (India), and Matupi in west-central Myanmar were further mapped and confirmed to represent the geographic range of *A. laboriosa*. The typical elevation range for this species of honeybee is 1000–3000 MSL. While *A. dorsata* has many orange or yellow anterior abdominal segments and black thoracic hairs, *A. laboriosa* has an entirely dark abdomen and lengthy golden thoracic hairs (Kitnya et al. 2020). Because of the

geography of northeastern India, Himalayan honeybees—also known as cliff honeybees—are essential for pollinating mellitophilous plants at higher elevations. Despite exhibiting seasonal migratory behaviour, *A. laboriosa* does not nest at the same time as *A. dorsata*. Additionally, Otis (1996) delineated the Himalayan cliff honeybees' range in regions of northern Myanmar and northeastern India. The morphology of drones from the two sympatrically extant species obtained in northeastern India showed interestingly different morphometric variations (Kitnya et al. 2020).



#### **Rock honeybee, *A. dorsata*:**

*Apis dorsata* is commonly referred to as the „Rock bee“ owing to its large body size. It is considered as key stone species in the forest ecosystem as it plays a crucial role in the tenance of forest flora and fauna. The combs of this species measure 1.5 to 2.1 m from side to side and 0.6 to 1.2 m from top to bottom. The nests are not easily accessible as they are located on cliff faces located far above the ground and on the underside of branches of tall trees (Dyer & Seeley 1994). They produce good lot of wax and honey, and are migratory in nature. Being very ferocious and inflicting painful stings these are not normally good for domestication. Existing in sympatric to Himalayan cliff bees (*A. labriosa*), the rock bees were found majorly in Eastern, southern and western Arunachal Pradesh (Sakagami et al. 1980; Kitnya et al. 2020). The state of Nagaland to promote the conservation of these indigenous bees, a collation on “Rock bee” is also formed by the Nagaland Beekeeping and Honey Mission (NBHM). Nevertheless, *A. dorsata* migrates long distances along river valleys into the mountains during the summer months, thus being existent throughout the northeastern stretch of India. The hives are made more on the crown branches of the *Tetrameles nudiflora* and trees (Kitnya et al. 2020).

#### **Italian honeybee, *A. mellifera*:**

Originally from Africa, Europe, and the Middle East, *Apis mellifera* was brought to India in the late 1970s and early 1980s, first to Punjab, Haryana, and Himachal Pradesh, and then to South Indian states. It is bigger than *A. cerana* and produces larger combs with more honey storage capacity than its Indian equivalent. Additionally, this species has much greater and quicker rates of fecundity, brood rearing, and colony build-up (Atwal & Sharma 1968; Rana & Goyal 1994). The races of *Apis mellifera* have evolved as a consequence of ecological adaptation and geographic isolation (Al-Ghamdi et al. 2013). The European bee, *A. mellifera*, likes an altitude of 1500 m AMSL and produces an average of 25–40 kg of honey per colony. For commercial beekeeping, these alien bees must travel by floral mapping (Tej et al. 2017). It was effectively introduced in India's northern and eastern plains because it is utilised for commercial beekeeping (Parihar et al. 2020). The capacity to adapt to both chilly temperate zones and even semi-desert tropical regions has increased its worldwide spread. Originally from western Asia, Africa, and Europe, people brought it to the remainder of Asia, Australia, and America since it was an excellent pollinator and honey producer.

#### **Indian honeybee, *A. cerana himalaya*:**

Indigenous communities around the Asian continent have been raising Asian honey bees (*A. cerana*) for up to 2,000 years. One of the most well-known bee species in India is the Asian honeybee, *A. cerana*, which was initially described by Fabricius in 1793 from China. China and Japan have large populations of *A. c. cerana*. It was domesticated for honey and

other byproducts because it was the only *Apis* bee species that could be raised for commercial beekeeping in India prior to the arrival of *A. mellifera*. Both small-scale and large-scale beekeeping may benefit greatly from *A. cerana*. In fact, maintaining and enhancing *A. cerana* beekeeping is essential to the species' survival. Although it is bigger than dwarf or tiny bees, it is comparatively smaller than Italian and rock bees. Parallel combs, which are built in clay pots, logs, walls, and tree openings, have qualities like non-aggression and a preference for closed spaces. These bees store honey in the upper portion of their hive, just like other species of bees. The super chamber, also known as the honey chamber, is a feature of the Langstroth bee boxes that allows for easy extraction and storage of honey (Tej et al. 2017). Each colony produces around 7–9 kilogram of honey annually. Ruttner (1988) further focused on two types of *A. cerana* found in India: the bigger "hill" variety and the smaller "plains" kind. The variability in genetic composition and habituation of these bees further opened the way for Ruttner (1988) to categorise *A. cerana* into subspecies *A. c. cerana*, *A. c. indica*, *A. c. japonica* and *A. c. himalaya*. A morphometric comparison was undertaken between *A. cerana* located in the northeast Himalayan areas and the northwest and central himalayas and the size considerably. In the North-eastern hill area, a different subspecies of Asian honeybee, *Apis cerana himalaya* existed, which diverged from *Apis cerana cerana* of North-west Himalayas and *Apis cerana indica* of South India. Additionally, the subspecies *A. cerana himalaya* has three locally adapted populations or ecotypes that match geographic distributions in (1) the Naga and Mizo hills, (2) the Brahmaputra valley and Khasi hills, and (3) the foothills of the northeast Himalayas (Singh et al. 1990; Singh & Verma 1992). There are several ecological and economic characteristics that set these ecotypes apart from one another.



The exotic European honeybee, *A. mellifera*, was brought to Assam and Meghalaya for commercial beekeeping in 1978 as a result of an epidemic of Thai sacbrood disease on *A. cerana himalaya* in the northeastern hill area (Meghalaya, Assam, and Nagaland). Thus, Ruttner (1988) came to the conclusion that bees from South India (*A. cerana indica*) and the western Himalayas (*A. cerana cerana*) were different from those from the eastern Himalayas (*A. cerana himalaya*). There are two morphotypes of the subspecies *A. cerana indica*: the black-colored "hill bee" and the yellow-colored "plain bee" (Ramchandra et al. 2012). Compared to *A. cerana indica*, the native northern subspecies *A. c. cerana* and *himalaya* are bigger and have deeper colours (Ahmad et al., 2003). In the Asian tropics and northeastern Asia, the Asian honeybee is the only social species that lives at high altitudes and is crucial for pollination (Said et al. 2015). These are the primary source of revenue for mountain farmers. The agricultural techniques in the marginal, mountainous regions and the climate at 3000 meters make it difficult for the imported bee species to flourish. Different blooming and nectar production cycles are caused by the dynamic weather circumstances seen in mountainous regions. In order to guarantee the pollination of mountain crops, the native bee species of the hill areas are well adapted. Backyard bees pollinate kitchen garden crops, which are often the major source of vegetables, primarily rapeseed mustard (Ahmad et al. 2003).



### **Capturing the honey bee colony of *A. cerana cerana* from forest area**

#### **Little honeybee, *A. florea*:**

It is indigenous to Southern and Southeast Asia, and since it prefers warm climates, it is widely distributed over low latitudes. Because of their little size, these Asian wild bee species are sometimes referred to as tiny or dwarf bees. According to Hepburn et al. (2005), it may be found farther east in Vietnam, Southeast China, and Peninsular Malaysia, as well as west in the Plateau of Iran and Oman, throughout continental Asia, and along the southern boundary of the Himalayas. A worker's body length is usually between 7 and 10 mm, and its general colour is red-brown. They produce just a few hundred grams of honey from a healthy colony and are wild and untamed (Sivram 2012). These bees are essential for pollinating the wild flora, particularly the tiny melitophilous plants like weeds and herbs that the bigger bees neglect to visit, even though they produce little honey. A worker bee that is foraging returns to the hive to share the good news with the rest of the colony after she discovers a flower patch that is rich in resources.



The waggle dance is a special kind of communication used to accomplish this. The dance encodes information like the resource patch's orientation and distance. *A. florea* often performs its waggle dance in the horizontal plane near the top of the exposed hive (Hepburn et al. 2005). In addition to fleeing dangerous predators, *A. florea* may decide to leave their nest and flee when unfavourable circumstances arise at their present nest location, such as a shortage of food, parasitism, or loss of shade. When a new queen emerges, migration from the nest may be seen. The young queen will inherit the old hive and start her own colony once the elder queen moves to a new location with some worker bees (Oldroyd & Wongsiri 2006).

vary between one hundred and thousands or more (Michener 2000). In contrast to other honeybees in the *Apis* genus, *Trigona* combs have elliptical cells rather than hexagonal ones. Unlike other honeybees, the primary material utilised to make combs is resin rather than wax. *Trigona* is simpler to domesticate, but the amount of honey produced is much lower. Dark and bitter, the honey is highly prized and said to have therapeutic benefits. The nests are constructed in tree trunks, logs, cracks in walls, or under house roofs. There are two types of cells in the nest: one set of bigger "sacs" for storing honey and pollen, and another group of individual cells for raising brood.

**Black dwarf honey bee, *Apis andreniformis*:**

The black dwarf (*Apis andreniformis* Smith 1858), a small, dark honey bee, is found throughout Southeast Asia. Along with its sister, the red dwarf honey bee, *Apis florea*, it is one of two species of honey bees in the subgenus *Micrapis*. They are thought to be the most basic species of honey bees because of their small colonies and open-nest construction (Raffiudin & Crozier 2007). The solitary comb nest of *Apis andreniformis* is smaller than that of *Apis florea*. Because it contains a mid-rib above and below the twig holding the nest, it resembles a crest (Rinderer et al. 1996). Tropical and subtropical areas of Southeast Asia are home to *Pis andreniformis*. This bee may be found as far north as the eastern Himalayan foothills, as far east as the Philippines, and as far south as Sundaland. Geographically, it is found in a number of countries, including Malaysia, Indonesia, Vietnam, Thailand, Laos, Southeast China, India, and Myanmar. *Apis andreniformis* is the smallest and darkest species of honey bee. It is mostly black in hue and ranges in length from 6.5 to 10 mm (.25 and .39 inches). It may be identified by physical traits, especially male (drone) genitalia and colour, even if it is sometimes confused with *Apis florea*. The female worker bees of *Apis andreniformis* have a yellow scutellum (dorsal rear part of the thorax) as opposed to the black scutellum of *Apis florea* (Rattanawanee et al. 2007). The female worker bees of *Apis andreniformis* also have black hairs on their rear legs, unlike *Apis florea*, which have white hairs (Smith 1858).

**Dammer bee or stingless honeybee:**

The Apidae *Trigona* genus, which has 500 species overall, seven other genera, and fifteen sub-genera, includes the dammer bees as members of the sub-family Meliponinae (Wille 1983). Stingless bees may be found locally anywhere, although they are most common in southern India and along the Bay of Bengal coast. The heartland plains of India provide the least ideal circumstances for stingless bees. The southern parts of Bangladesh, Nepal, Bhutan, and Pakistan seem to be home to stingless bees as well. The Indian subcontinent is home to the northernmost distributed stingless bees in the world, despite the fact that their precise distribution is only partly known. The fact that a social insect with limited adaption to cold temperatures may survive in such northern latitudes for extended periods of time, even below freezing for many days, should spur further behavioural and physiological studies in India's northern areas. They construct their nests using body-produced wax and dammer, a kind of resin. These little bees protect themselves by biting intruders even though they lack stings. The number of bees in a colony might



differ by hundreds of thousands or more (Michener 2000). Trigona combs feature elliptical cells instead of hexagonal ones like other honeybees in the *Apis* genus. In contrast to other honeybees, the main substance used to create combs is resin instead of wax. Although trigona is easier to cultivate, far less honey is produced. The honey, which is bitter and dark, is highly valued and thought to have medicinal properties. The nests are built in logs, tree trunks, wall gaps, or under roofs. The nest is made up of two different kinds of cells: a collection of individual cells for developing brood and a set of larger "sacs" for storing honey and pollen.

#### **Pollen and nectar yielding plants in NEH region**

Because of its abundance of woods and horticultural and agricultural commodities, the northeastern hill area offers enormous potential for the growth of beekeeping. Unfortunately, this business has not made much development so far, perhaps as a result of a lack of awareness about the resources of honey plants and contemporary bee management technologies. The predominant sporomorphs of *Brassica* sp., *Solanum* sp., *Helianthus*, *Wendlandia* sp., *Ageratum* sp., *Clematis* sp., *Adhatoda* sp., *Mussaenda* sp., and *Papilionaceae*, *Rubiaceae*, *Rutaceae*, and *Zingiberaceae* members were identified by pollen analysis of honey samples taken from the northeastern hill region. *Litsea* sp., *Ocimum* sp., *Caesalpinia* sp., *Parkia* sp., *Bauhinia* sp., *Senecio* sp., *Polygonum* sp., and members of the families *Asteraceae*, *Bignoniaceae*, *Euphorbiaceae*, *Lamiaceae*, *Lauraceae*, *Malvaceae*, *Myrtaceae*, *Papilionaceae*, *Polygonaceae*, *Ranunculaceae*, *Rosaceae*, *Rubiaceae*, *Rutaceae*, *Scrophulariaceae*, and *Zingiberaceae* were the minor sources of pollen (Singh et al. 1994; Singh 1999).

**Table 1.** Monthly calendar for honeybees pollen and nectar yielding plants for Manipur region

| <b>January</b>        | <b>February</b>          | <b>March</b>             | <b>April</b>              | <b>May</b>                     | <b>June</b>                 |
|-----------------------|--------------------------|--------------------------|---------------------------|--------------------------------|-----------------------------|
| <i>Tagetes erecta</i> | <i>Calendula</i>         | <i>Mangifera indica</i>  | <i>Lannea</i>             | <i>Helianthus annuus</i>       | <i>Terminalla chebulla</i>  |
| <i>Lathyrus</i>       | <i>officinalis</i>       | <i>Butea</i>             | <i>coromandelica</i>      | <i>Cucumis sativus</i>         | <i>Tamarindus indica</i>    |
| <i>odoratus</i>       | <i>Brassica oleracea</i> | <i>monosperma</i>        | <i>Thevetia peruviana</i> | <i>Vigna unguiculata</i>       | <i>Polygonum species</i>    |
| <i>Pisum sativum</i>  | <i>Raphanus sativa</i>   | <i>Delonix regia</i>     | <i>Helianthus sp.</i>     | <i>Allium cepa</i>             | <i>Stellaria media</i>      |
| <i>Prunus persica</i> | <i>Pisum arvense</i>     | <i>Dalbergia sisso</i>   | <i>Cucumis melo</i>       | <i>Allium sativum</i>          | <i>Lonicera japonica</i>    |
| <i>Eclipta alba</i>   | <i>Morus alba</i>        | <i>Moringa oleifera</i>  | <i>Citrullus lanatus</i>  | <i>Grewia subinaequalis</i>    | <i>Berberis manipuriana</i> |
| <i>Rosa sp</i>        | <i>Prunus communis</i>   | <i>Medicago sativa</i>   | <i>Citrus aurantium</i>   | <i>Cucumis melo</i>            | <i>Rhus semialata</i>       |
| <i>Nerium indicum</i> | <i>Prunus persica</i>    | <i>Melia azadarch</i>    | <i>Citrus sinensis</i>    | <i>Solanum melongena</i>       | <i>Datura stramonitum</i>   |
|                       | <i>Salix tetrasperma</i> | <i>Clerodendrum</i>      | <i>Litchi chinensis</i>   | <i>Acacia nilotica</i>         | <i>Mentha sylvestris</i>    |
|                       | <i>Nicotiana tabacu</i>  | <i>infortunatum</i>      | <i>Coriandrum</i>         | <i>Meliaazadirach</i>          | <i>Humulus lupulus</i>      |
|                       |                          | <i>Callistemon</i>       | <i>sativum</i>            | <i>Bombax ceiba</i>            | <i>Phoenix dactylifera</i>  |
|                       |                          | <i>lanceolatus</i>       | <i>Daucus carota</i>      | <i>Cassia fistula</i>          | <i>Momordica charantia</i>  |
|                       |                          | <i>Rubus ellipticus</i>  | <i>Bougainvillea spp.</i> | <i>Terminalia arjuna</i>       | <i>Lagenaria ciceraria</i>  |
|                       |                          | <i>Citrus paradisi</i>   | <i>Caltha palustris</i>   | <i>Luffa cylindrical</i>       | <i>Calotropis gigantean</i> |
|                       |                          | <i>Citrus reticulata</i> | <i>Cucurbita</i>          | <i>Albizia lebbek</i>          | <i>Cucumis sativus</i>      |
|                       |                          | <i>Vitis vinifera</i>    | <i>moschata</i>           | <i>Asparagus officinalis</i>   | <i>Helianthus annuus</i>    |
|                       |                          | <i>Argemone</i>          |                           | <i>Lagerstromia speciosa</i>   | <i>Cucurbita moschata</i>   |
|                       |                          | <i>Mexicana</i>          |                           | <i>Cedrella toona</i>          | <i>Cucumis melo</i>         |
|                       |                          |                          |                           | <i>Acacia catechu</i>          |                             |
|                       |                          |                          |                           | <i>Psidium guajava</i>         |                             |
|                       |                          |                          |                           | <i>Syzygium cumini</i>         |                             |
|                       |                          |                          |                           | <i>Nymphaea sp.</i>            |                             |
|                       |                          |                          |                           | <i>Lycopersican esculentum</i> |                             |
|                       |                          |                          |                           | <i>Vitex negundo</i>           |                             |
|                       |                          |                          |                           | <i>Pyrus communis</i>          |                             |
|                       |                          |                          |                           | <i>Citrullus vulgaris</i>      |                             |

|                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                               |
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|                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                 | <i>Capsicum frutescens</i><br><i>Rubus nivens</i><br><i>Ranunculus scleratus</i><br><i>Punica granatum</i><br><i>Portulaca grandiflora</i><br><i>Artemissia nilagirica</i>                                   |                                                                                                                                                                                                                                                                                                                               |
| <b>July</b>                                                                                                                                                                                                                                                                                                                                         | <b>August</b>                                                                                                                                                                                                                                                                                                    | <b>September</b>                                                                                                                                                                                                                                                                    | <b>October</b>                                                                                                                                                                                                                                                                  | <b>November</b>                                                                                                                                                                                              | <b>December</b>                                                                                                                                                                                                                                                                                                               |
| <i>Sonchus oleraceus</i><br><i>Carica papaya</i><br><i>Ipomaea palmate</i><br><i>Phyllanthus emblica</i><br><i>Zea mays</i><br><i>Sesamum indicum</i><br><i>Cannabis sativa</i><br><i>Nelumbium speciosum</i><br><i>Zinnia elegans</i><br><i>Acacia nilotica</i><br><i>Cucumis sativus</i><br><i>Helianthus annuus</i><br><i>Cucurbita moschata</i> | <i>Celosia argentea</i><br><i>Commelina bengalensis</i><br><i>Ricinus communis</i><br><i>Magnolia glandiflora</i><br><i>Gossypium hirsutum</i><br><i>Gossypium arboreum</i><br><i>Fagopyrum esculentum</i><br><i>Dolichos lablab</i><br><i>Cajanus cajan</i><br><i>Acacia nilotica</i><br><i>Cucumis sativus</i> | <i>Crotalaria juncea</i><br><i>Musa paradisiaca</i><br><i>Zizyphus mauritiana</i><br><i>Gossypium arboreum</i><br><i>Musa paradisiaca</i><br><i>Cajanus cajan</i><br><i>Asparagus officinalis</i><br><i>Vigna unguiculata</i><br><i>Cucumis sativus</i><br><i>Helianthus annuus</i> | <i>Brassica campestris</i><br><i>var toria</i><br><i>Citrus aurantifolia</i><br><i>Musa paradisiaca</i><br><i>Crotalaria juncea</i><br><i>Cajanus cajan</i><br><i>Dolichos lablab</i><br><i>Fagopyrum esculentum</i><br><i>Asparagus officinalis</i><br><i>Luffa cylindrica</i> | <i>Glycine max</i><br><i>Eucalyptus spp.</i><br><i>Dahlia variabilis</i><br><i>Brassica campestris</i><br><i>var toria</i><br><i>Citrus aurantifolia</i><br><i>Cajanus cajan</i><br><i>Solanum melongena</i> | <i>Euphorbia pulcherrima</i><br><i>Phlogacanthus thyrisiformis</i><br><i>Justicia adhatoda</i><br><i>Brassica juncea</i><br><i>Fragaria x ananassa</i><br><i>Coriandrum sativum</i><br><i>Foeniculum vulgare</i><br><i>Vicia sativa</i><br><i>Lindernia ciliata</i><br><i>Verbena officinalis</i><br><i>Chrysanthemum spp</i> |

## **Role of honeybees in crop pollination**

Several Hindu Kush-Himalayan nations are now working feverishly to increase the amount of land under cultivation and improve resource management in order to become self-sufficient in food production. These include using higher-quality crops and livestock, cultivating more wasteland, using herbicides and fertilisers, and increasing irrigation. However, for certain farmed crops, food output has stagnated during the last ten or so years. In order to boost the production of different farmed crops, future emphasis should be placed on making the most of underutilised resources and services, such as improved pollination services provided by honeybees. It is sometimes overlooked how important honeybees are to the pollination of several agricultural and horticultural crops. In actuality, pollination is the primary function of honeybees and beekeeping, whereas hive products like honey and beeswax are of secondary significance (Verma 1992; Thapa 2006). This is shown by the fact that using honeybees for crop pollination generates much more revenue from agriculture than using them to create honey and beeswax (Verma & Dulta 1987). Without honeybees and other wild insects cross-pollinating their blossoms, many cultivated crops do not produce seeds or fruits. One of the most efficient and affordable ways to boost the production of entomophilous crops is by honeybee cross-pollination. Without the usage of honeybees to increase the production levels of various farmed crops via pollination, other agronomic techniques like the use of manure, fertilisers, pesticides, and irrigation may not provide the required results. Crosspollination is necessary not just for self-sterile cultivars or variations, but also for self-fertile forms that, when pollinated by honeybees, provide more and higher-quality seeds and fruits (Verma & Dulta 1987). In the northeastern hill area, only a few efforts have been undertaken to identify significant insect pollinators and evaluate the pollination needs of horticultural and agricultural crops.

### **Rapeseed and mustard:**

The Asian honeybee, *Apis cerana himalaya*, and the flower fly, *Episyrphus balteatus*, were the primary pollinators of rapeseed and mustard, accounting for 72 and 26 percent of the total pollinator population, respectively, according to surveys carried out at twenty oilseed-growing locations across six districts of Manipur. Rock bees (*Apis dorsata*), bumblebees (*Bombus tunicatus*), cabbage butterflies (*Pieris brassicae*), houseflies (*Musca* sp.), and alkali bees (*Nomia curvipes*) were among the other visitors to the crop, but their numbers are insufficient (Singh et al. 1993). It was noted that A.c. Himalaya began foraging around 0800 hours and stopped at 1600 hours. Foraging bee populations peaked between 0900 and 1100 hours. The bees foraged at a pace of ten flowers per minute, spending an average of 6.4 seconds per bloom. The number of nectar collectors grew throughout the day from morning to evening, but the pattern for pollen collectors was the opposite. A single foraging excursion lasted 8.6 minutes on average, and at 1200 hours, the highest pollen load per bee was 9.6 mg (Singh et al. 1998b). In a similar vein, Mahanta and Rahman (1997a) discovered that bee-pollinated rapeseed produced 437.5% more than self-pollinated rapeseed in Assam.

Furthermore, at least five bee visits per flower are necessary for effective pollination in rapeseed, according to Singh and Devi (1997). Siliqua setting, length, quantity of seeds per siliqua, and seed weight were all improved by the bee-pollinated crop. It's interesting to note that, in comparison to self-pollinated and naturally pollinated plants, the oil content in the seeds of bee-pollinated plants rose by 21.3% and 4.1%, respectively. Additionally, bee-pollinated plants had 50.9% more seed germination than self-pollinated plants and 2.5% more seed germination than plants pollinated by natural insects (Singh et al. 1998a).

### **Sunflower:**

The Asian honeybee, *Apis cerana himalaya*, and the rock bee, *Apis dorsata*, were the most common pollinators of sunflowers under Manipur's agroclimatic conditions, accounting for 46 and 42 percent of the overall pollinator population, respectively. Little bees, *Apis florea*, bumble bees, *Bombus haemorrhoidalis* and *B. tunicatus*, carpenter bees, *Xylocopa aestuans*, alkali bees, *Nomia curvipes*, leaf cutter bees, *Megachile umbripennis*, sweet bees, *Halictus albescens*, drone flies, *Schiodon scutellaris* and *Episyrphus balteatus*, and cabbage butterflies, *Pieris brassicae*, are among the insects that visit the crop in sufficient numbers. During the winter, *A. c. himalaya* was seen to begin foraging around 05:19 and stop at 06:08. Bees foraged all day long, but their activity peaked between 0600 and 0900 hours, when they spent an average of 53 seconds per flower head at a pace of two flower heads per minute. Nectar collectors grew in quantity throughout the day from morning to evening, but pollen collectors showed the opposite pattern. Bees' foraging trips lasted an average of 3.4 minutes, with a maximum pollen load of 5.8 mg per bee around 1400 hours (Singh et al. 1998b). In comparison to self-pollinated and naturally pollinated sunflower crops, bee pollination increased seed output by 801% and 12%, respectively. Additionally, it was shown that bee-pollinated plants had 2343% and 18.3% more seed setting than self-pollinated and naturally insect-pollinated plants, respectively. Bee-pollinated seeds may also have higher oil content and a higher germination rate (Singh et al. 1998a).

### **Niger:**

In Assam, bees such as *Apis cerana*, *A. dorsata*, *A. florea*, *A. mellifera*, and *Chalicodoma lanata* were seen pollinating niger crops. *A. cerana*'s peak foraging activity was seen between 1000 and 1200 hours. The amount of time needed to gather pollen per capitulum varied from 4.89 to 7.23 seconds, and the amount of sunlight and temperature had a direct impact on how many foragers visited flowers. Five *A. cerana* colonies per hectare were advised, and the seed production in bee-pollinated plots increased by 120.2% (Rahman 1993). Citrus: Bhuyan and Bhattacharyya (2002) investigated honeybee foraging activity on Assam lemons and found that individual honeybees visited more frequently in the morning and less frequently in the evening, while the duration of their visits was longer in the morning than in the middle of the day. The pollination requirements of citrus species and cultivars vary significantly. Cross-pollination mainly benefits sweetlime and mandarin oranges. on their 2002 research on the impact of honeybees on Assam lemons, Bhuyan and Bhattacharya discovered that 77% of fruit set on honeybee-pollinated trees compared to 46% in naturally pollinated ones. They found that bee pollination increased Assam lemon output by 52.2% and suggested four *A. cerana* colonies per hectare for maximum yield. According to a research by Gogoi et al. (2007) on Assam lemons pollinated by *A. cerana*, bee-pollinated crops produced 52.17% fruit set, whereas open-pollinated and self-pollinated plants produced 40.80% and 27.35%, respectively. *A. cerana* pollination resulted in yields that were 214.79 percent higher than those of the self-pollinated treatment. In comparison to fruits from open-pollinated and self-pollinated plants, the average fruit length, girth, weight, and juice content of *A. cerana* pollinated plants were 12.93 cm, 17.40 cm, 199.46 gm, and 655.99 cc, respectively.

### **Litchi:**

In the sub-Himalayan area, litchi is a prominent fruit plant because of its pricey fruit. It is a major source of nectar for bees and blooms between February and March. Wind pollination does happen, however insect pollination produces a larger fruit set, whereas selfing produces little to no fruit set. Over 90% of floral visits are honeybees and stingless bees. According to Mahanta and Rahman's (1997b) research on litchi, *A. cerana* visits peaked between 0900 and 1100 hours of the day. The frequency of flower visits peaked between 1500 and 1600 hours of the day, whereas the average number of bees peaked between 1000 and 1100 hours. The ideal yield of litchi was produced by five colonies of *A. cerana* per hectare, with a production increase of 123.97% above self-pollination.

### **Cucumber:**

Islam (2007) investigated how *A. cerana* forages on cucumbers and how this affects fruit set and productivity in Assam. Asian honeybees, *Apis cerana*, European honeybees, *Apis mellifera*, rock bees, *Apis dorsata*, carpenter bees, *Xylocopa leucothorax* and *X. fenestrata*, wasps, *Polystis habrius* and *Vespa magnifica*, peacock pancy, *Junonia almanaa*, lemon butterflies, *Papilio demoleus*, gray count, *Euthalia lepidae*, houseflies, *Muscadomestica*, and ants, *Oecophylla smaragdinae*, were among the pollinators that visited the cucumber flower. *A. cerana* was shown to be the most common pollinator among them, making up 51.4% of the overall population. *A. cerana*'s foraging activity peaked between 0800 and 0900 hours of the day. *A. cerana* pollination of the cucumber crop increased fruit output by 25.21% and 48.6%, respectively, compared to self-pollination and natural insect pollination. For maximum productivity, seven *A. cerana* colonies per hectare were advised. In a similar vein, bee-pollinated plants had the highest fruit set (19.2%) compared to self-pollinated plants (5.5%) and plants pollinated by natural insects (12.8%).

### **Entrepreneurship through honeybees**

- Honey bees rearing
- Sale of honey bees colonies
- Consultancy to farmers for honey bee rearing
- Processing of honey at large scale
- Marketing of honey products

### **Beekeeping scenario in NEH region**

Honeybee species, distinctive floral resources, and favorable weather for beekeeping are all abundant in northeastern India. However, the possibility of becoming a "honey capital" has not yet been investigated. Lack of knowledge, a lack of synergy between beekeeping and agriculture, a lack of competent labor, and commercialization might be the causes. The number of native bees in the area is declining, despite their significance for pollination. The survival of native bees is seriously threatened by habitat loss due to changes in land use, a propensity for monoculture, and careless use of pesticides and herbicides (Ahmad et al. 2003). According to the ICIMOD report, the region's *A.*

*cerana himalaya* population density is decreasing due to a number of factors, including the public and private sectors' widespread inclusion and promotion of *A. mellifera* species through developmental intrusion, changes to their habitat and biodiversity, careless use of pesticides, attacks by diseases and parasites, etc. (Said et al. 2015). As Sikkim, in northeastern India, was recently proclaimed the country's first organic state, the adoption of organic farming is smart in reducing the usage of pesticides. (Sharma et al. 2014; Bansal et al. 2013) In 1978, *A. cerana himalaya* in the northeastern hill area was decimated by the Thai sacbrood disease. As a result, *A. mellifera*, an exotic European honeybee, was introduced for commercial beekeeping. Since *A. mellifera* is more productive than Asian bees, it has been used for commercial beekeeping in many areas of the nation. Unfortunately, the livelihoods of mountain farmers have been jeopardized by introduction to the northeastern hill areas. Native bee species have difficulties due to competition for nectar in these regions, as well as vulnerability to illnesses and dangerous parasites. Additionally, these extensionists are pushing the introduction of *A. mellifera* in the regions where *A. cerana himalaya* originated, which poses a continual risk to the native beekeepers. However, *A. mellifera* is a less successful pollinator since it is less adapted to the local climate and native plants (Ahmad et al. 2003). One of the most important aspects of managing natural resources is the conservation of native species. It is necessary to protect the wild bees, *A. dorsata* and *A. laboriosa* and *A. florea*. The Asian hive bee, *A. cerana himalaya*, on the other hand, has to be fostered by breeding and selection in cooperation with local populations. The ecological and financial advantages of this genetically valuable and well-adapted species should be maximized by encouraging local Asian honey bees and using breeding methods similar to those for *A. mellifera*. However, there hasn't been much breeding done with *A. cerana himalaya* recently, and instrumental insemination is challenging. Through its ecology, the *A. cerana himalaya* bee species continues to show promise as a pollinator in preserving the northeastern region's biodiversity services.



Locally made bee hives of *A. cerana himalaya*



Locally made bee hives of stingless bees

Tribal people in the northeastern area are mostly better at locating feral colonies of domesticated bee species, particularly *A. cerana cerana* and *A. cerana himalaya*, for the production of honey. However, honeybee conservation is not aided by the traditional beekeeping methods used by the tribes in the northeast area. They are unfounded since they are not supported by a scientific method. Bee populations are declining as a result of the devastating technique of gathering wild bee honey. The pollinator-agriculture phase, which involves location-specific research, requires immediate conservation actions. To improve the beekeeping situation in the northeastern areas, appropriate training and awareness campaigns on the significance of feral colonies and their pollination services must be implemented.

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