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Native Bees and Pollination in the Puducherry Bioregion

Ammel Sharon, Krishnamurthy Anupama, H el ene Guetat-Bernard, Srinivasan Prasad, Jean Lazar, Ayyanaar Indhu, Amuthavalluvan Varadharajan, Fr ed eric Landy, S. Narpavi, Julien Andrieu, et al.

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Science & Society-1

NATIVE BEES AND POLLINATION IN THE PUDUCHERRY BIOREGION

Written & Edited by **Ammel Sharon**

ifp

Research
on Culture,
Environment
& Society

Institut Français
de Pondichéry

Science & Society -1

Native Bees and Pollination in the Puducherry Bioregion

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Institut Français de Pondichéry

Institut Français de Pondichéry (French Institute of Pondicherry): Created in 1955 under the terms agreed to in the Treaty of Cession between the Indian and French governments, the IFP (UMIFRE 21 CNRS- MAE) is a research centre under the joint authority of the French Ministry of Foreign Affairs (MAE) and the French National Centre for Scientific Research (CNRS). It fulfills its mission of research, expertise and training in human and social sciences and ecology, in South and South-East Asia. Major research works focus on Indian cultural knowledge and heritage (Sanskrit language and literature, history of religions, Tamil studies etc.), contemporary social dynamics (in the areas of health, economics and environment) and the natural ecosystems of South India (sustainable management of biodiversity).

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Cover:

Apis cerana (Adukkutheni) on *Antigonon leptopus* (Kodi-Rose) an edible, perennial climbing weed that flowers almost all year long and offers a constant source of nectar to the bees.
Photo: Lazar Jean, IFP.

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CONTENTS

Acknowledgements	ii
Prologue	iv
Bees Around Us	viii
1. The Puducherry Bioregion	1
2. What is Pollination?	7
i. Flowers: Charles Darwin's 'Abominable Mystery'	
ii. All the Native Honeybees of Puducherry	
iii. Not Just Honeybees!	
iv. Are Pollinators Declining?	
v. What's In It for Farmers?	
vi. Economic Value of Insect Pollinators	
3. Let's Talk About Honeybees	19
i. What is a Honeybee?	
ii. What's going on in a Bee Colony?	
iii. Honeybees in Tamil Nadu & Puducherry	
4. Bees in Hives	26
i. Traditional Hives	
ii. Box Hives: Advantages over Traditional Hives	
iii. Pot Hives: Advantages over Box Hives	
5. Humans and Bees	33
i. Findings from the Field	
ii. Experience of Commercial Beekeepers	
iii. Reasons for Failure of Beekeeping Programmes	
6. How to Help Pollinators	48
7. Select Crops and Blooming Seasons in Puducherry	50
8. Afterword	53
Contact Information	54
References	54

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Prologue

This book is about the relationships between pollinators, flowers and agriculture in Puducherry, and how they sustain the incredible diversity of our region. In 1980, Thomas Lovejoy coined the term 'biodiversity'. Biodiversity refers to the variety of life sustained on our planet. By the end of the 1980s, 'biodiversity' framed the context of endangered species and declining diversity in the environment. Plants and pollinators that co-evolved over millions of years today face serious threat with consequences we are yet to fully understand.

The "Protection of pollinators and agroecological transitions in the Pondicherry region" (POLLIN) research project (January 2021-March 2022), funded by the French National Centre for Scientific Research, is set in the context of agricultural and ecological changes. It studies the role of pollinators, particularly native honeybees in the Puducherry region, foregrounding questions such as: Are bees adapting to changes in climate and habitat? How do farmers and beekeepers understand pollination – the crucial process that ensures reproduction in most plant life? This and other individual and collective initiatives, especially at Merveille, an eco-restoration site of Project Ecolake, Sri Aurobindo International Centre of Education (SAICE) near Ousteri, and the French Institute of Pondicherry (IFP) spurred this book.



Pollen from flower *Asystasia gangetica* (see next page) under light microscope x 1000. Photo: S Prasad, IFP.



Wild bee with pollen dust on *Asystasia gangetica* flower. Photo: Lazar Jean, IFP.

Insects are part of our cultural imagination. For instance, a Tamil Sangam poet reminds us that a lover is just like a honeybee,

Her confidante says to the heroine:

*Friend, live long. Listen.
Clusters of sweet-smelling kantai
bloom on our mountain range
bearing honey
which the bees drink,
and drinking it,
shift their place.
Your indifferent lover,
after stealing your stunning
and winsome beauty,
has come back now.*

(*Ainkurunuru*: 226,
[translation](https://bit.ly/3Fsn42r) by M. Nazir Ali,
<https://bit.ly/3Fsn42r>)

Indian poetry has been enamoured by the relationship of bees to flowers, though it often misgenders the female worker bee. In *Parag (Pollen)* published in 1937, the Kannada poet D.R. Bendre writes,

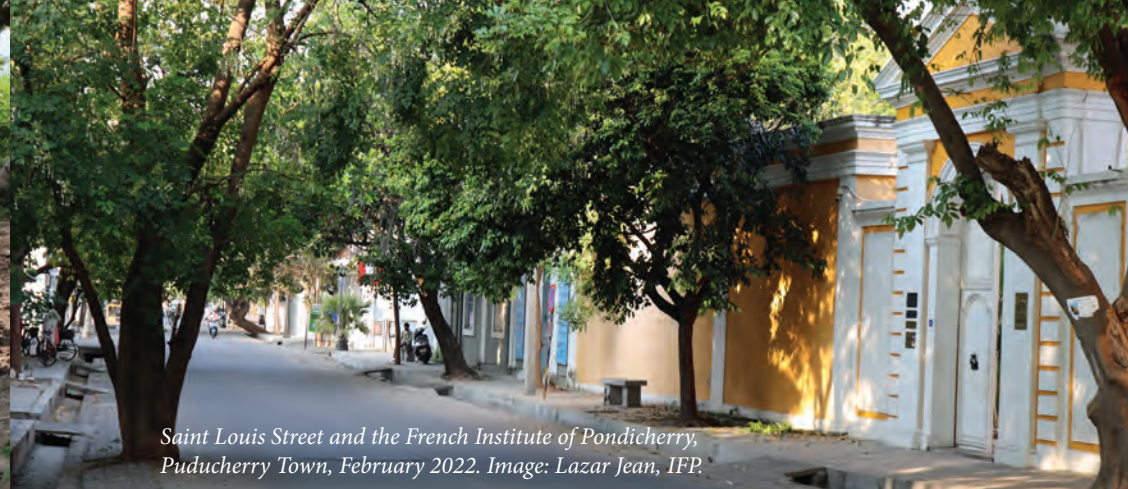
*the pollen waits on tiptoe
your slightest kiss is enough
for a new creation to show*

(from *Sakhigita*, [translation](https://bit.ly/3Hteb9L) by
Madhav K. Ajjampur,
<https://bit.ly/3Hteb9L>)


Reading these poems, we might ask: What's going on here? What is pollen? How old are flowers anyway? Can we bring knowledge from science and society together for environment friendly efforts? What can we do in Puducherry?



View of a Tropical Dry Evergreen Forest with species such as Phoenix pusilla, Syzygium cumini, Diospyros ebenum, Tarenna asiatica, Leucaena leucocephala, Dodonaea viscosa, Cassia siamea. Photo: Lazar Jean, IFP. Facing page, below: An agricultural farm at P. S. Palayam, Puducherry, February 2021. Photo: K Anupama, IFP.




Saint Louis Street and the French Institute of Pondicherry, Puducherry Town, February 2022. Image: Lazar Jean, IFP.

An illustration of a man in a yellow shirt and a checkered dhoti pointing upwards towards a large, golden beehive hanging from a tree branch. Another man in a blue striped shirt and white dhoti stands next to him, holding a smartphone. The background shows a lush green landscape with trees and a small house.

Anna, look up! That hive is not too high. Shall we get the honey? I'll bring the fire tonight.

Do you want honey? Wait. Let me call my friend, Selva. He has a better idea. Why disturb those rock bees? Let them eat their honey in peace.

Bees Around Us

An illustration of two men riding a motorcycle on a path through a green landscape. The man in the driver's seat is wearing a purple shirt, and the passenger is wearing a brown shirt. The background features stylized green trees and a large, golden beehive structure.

Appa, do you think there are 50,000 bees over there? I can hear that whoosh sound!

Maybe double than that! And they live in just one big comb. Do you see that corner bulging over there? That is where they store the honey. Most of the time people destroy the whole comb, but it's enough to cut just that part.

Appa is teaching me to become friends with the bees. He says they help us a lot.

Come and see – our honey bees, butterflies, ants on the moringa. What are they doing?

Bees are collecting nectar and pollen to take to the hive and make into honey. Selva has brought some domestic bees in boxes for us to take care of. They have travelled today. Let them settle down and become comfortable. It's cloudy today too. Bees like sunny weather. We will meet them tomorrow.

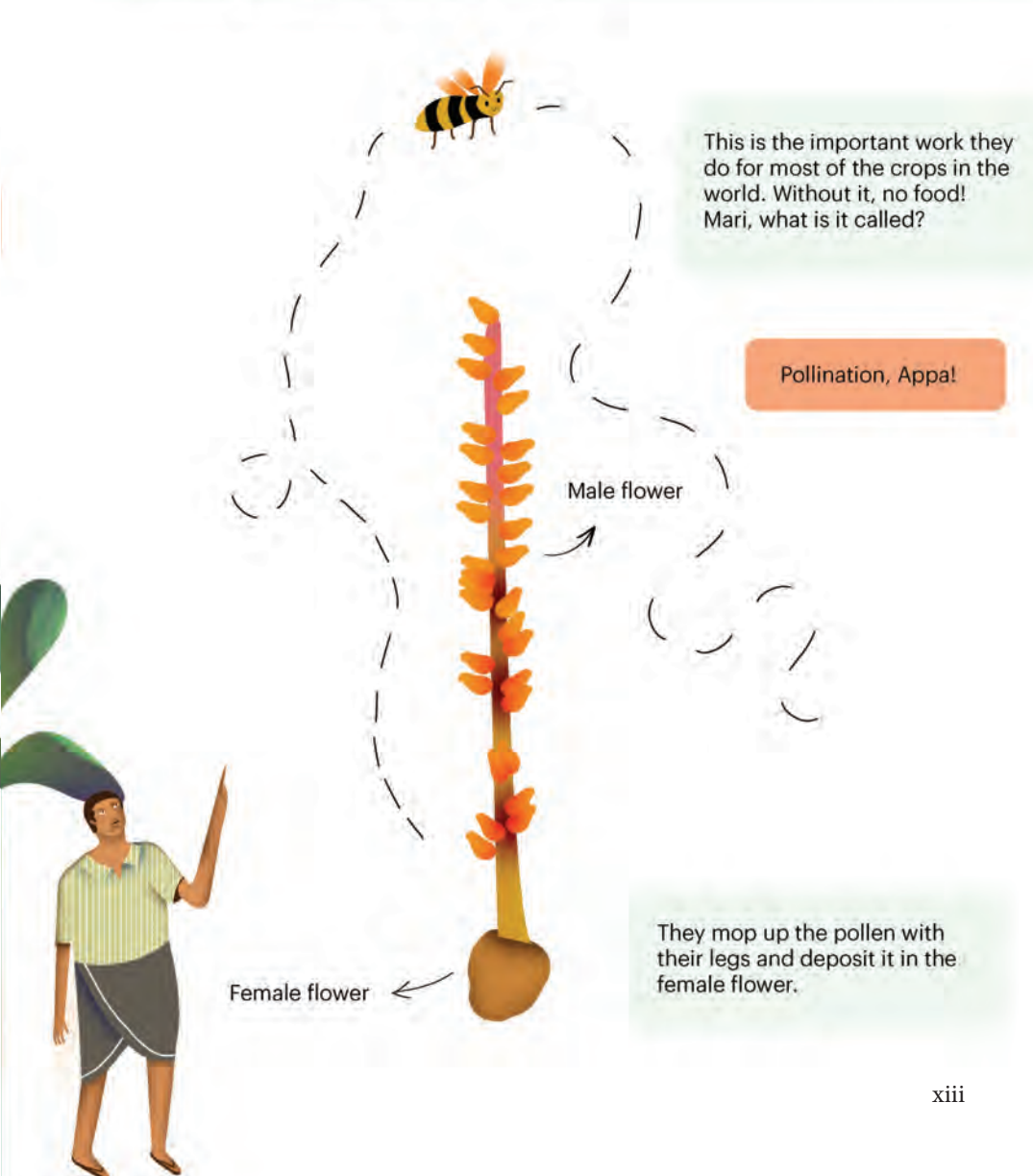


How's the farm? Your coconut trees have grown tall!

We have some gingelly and some coconut, but the yield is not so good. I don't know which is a good seed to buy, and the cost of fertilizer and pesticide is high. Every year, I try to find a better way. You know, a farmer can never retire!

Have you seen coconut flowers, Appa?

The coconut plant has many male flowers at the top portion of the spikelets and fewer female flowers at the base. See how close the flowers are. But an insect is needed to carry the pollen from the male flower to the female flower, from one plant to another. Otherwise, there will be no coconut and no seed.



This is the important work they do for most of the crops in the world. Without it, no food! Mari, what is it called?

Pollination, Appa!

Male flower

Female flower

They mop up the pollen with their legs and deposit it in the female flower.

CHAPTER I

The Puducherry Bioregion



Restored Tropical Dry Evergreen Forest at Merveille. Photo: Lazar Jean, IFP

Puducherry is a Union Territory bound by the state of Tamil Nadu in South India. The Puducherry bio-region contains one of the few Tropical Dry Evergreen Forest (TDEF) eco-regions in the world.

Along the Coromandel Coast, including in Puducherry, are patches of TDEF with species adapted to the long dry season and torrential cyclonic rains that come in gusts (intensely, rather than spread out over time), and many of them are protected as 'sacred groves' based on local beliefs. These patches of dry forests and the protected groves show good diversity of trees (102) and woody climbers (47) though the herb cover is often depleted by people in the sacred groves. Among the unique, dominant species are *Memecylon umbellatum*, *Tricalysia sphaerocarpa* and *Pterospermum suberifolium*. Many flowers are white in colour and scented, or they have berries, thus offering rewards of pollen, nectar and fruit to pollinators. Scientists have found that 68% of these species rely on bee pollination, typically in the hot, dry season.



Left to right: *Memecylon umbellatum*, *Tricalysia sphaerocarpa*, *Pterospermum suberifolium*. Photos: P. Uma Maheswari, IFP

Sacred groves are patches of rich, natural vegetation, protected in honour of deities, heroes or warriors. Imbued with cultural and religious significance, sacred groves are also biodiversity habitats and home to plants of medicinal significance. Sacred groves in Puducherry are known as “Kovil Kadugal”, often found in forest or community lands, temple lands and sometimes in private areas. Around 123 patches of sacred groves varying in size from 0.2 to 5.0 ha around temples have been identified in the Puducherry region. *Aiyandar*, *Pachaivazhiamman*, *Poraiyathamman*, *Celliamman*, *Kaliyamman* and *Maduraiveeran* are some of the deities to whom these groves are dedicated.

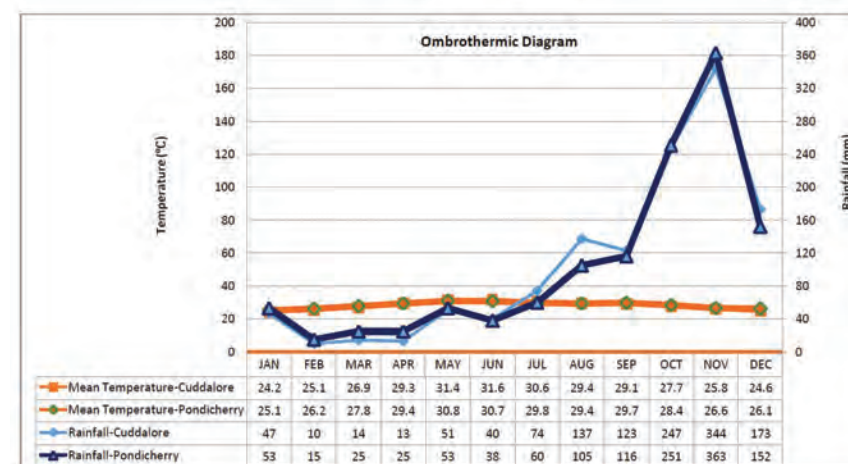


Keezh Puthupattu sacred grove, near Pondicherry University. Photo: Anbarashan M, IFP.

Apis cerana on cashew flower at Avani Thotam, Puducherry. This bee collects nectar from cashew flowers, while the stingless bee (*Tetragonula iridipennis*) collects pollen. Photo: Indhu Ayyanar, IFP.



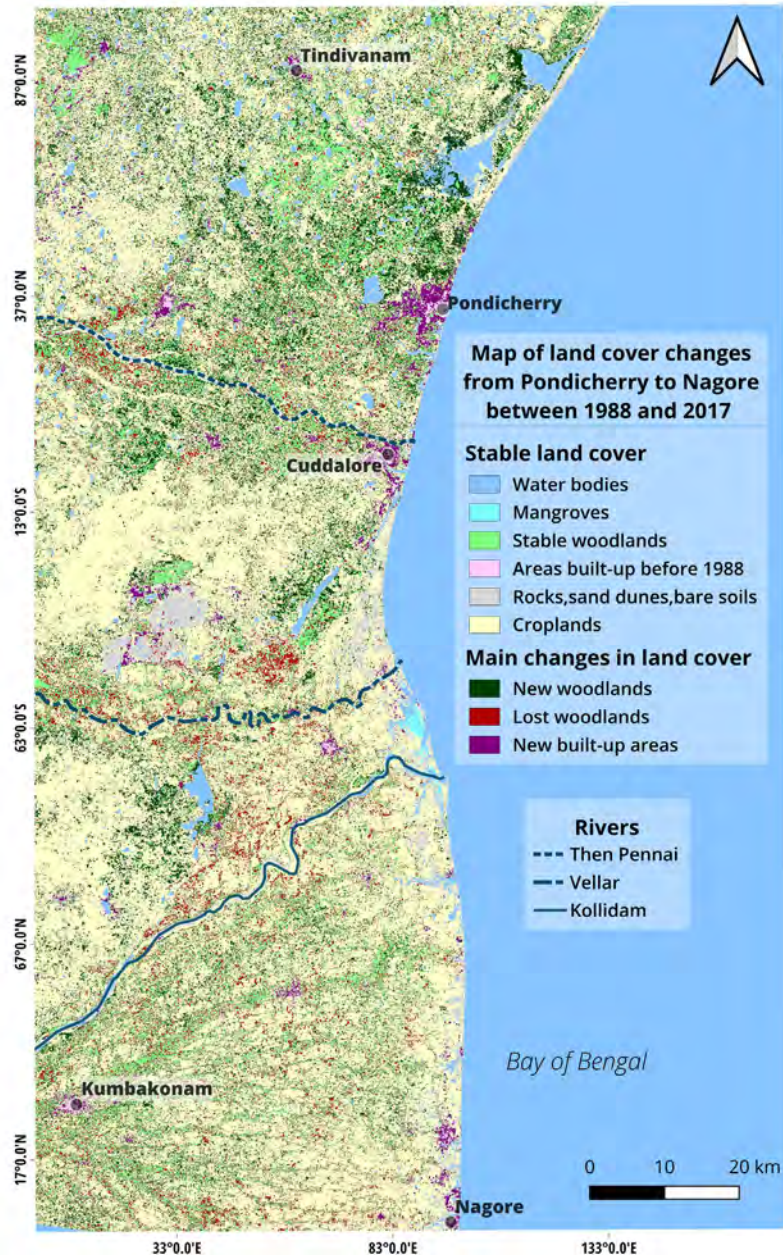
Seasons and rainfall have an impact on local pollinators, which are dependent on flowers for food. TDEF regions fall in rain shadow and have a long hot and dry season. Puducherry receives an average of 1282 mm annually. The dry season lasts between January and June with just 60 mm rainfall. Most of the rainfall is from the northeast monsoon between October and December, with little rainfall between June and September. Mean monthly temperature in this region ranges between 24.5 °C and 32.5 °C.



Graph showing rainfall and temperature pattern of the Coromandel coast based on data from Pondicherry (1914-1960) and Cuddalore (1945-1974). The dry season is interrupted by a very short rainy season in May which gives a dissymmetric pattern of rainfall in the region, says Meher-Homji (Figure 2. 1 from PhD thesis of Navya Reghu, 2019).

In these conditions, the main food crops grown in Puducherry are rice, maize, jowar (cholam), bajra (cumbu), ragi, and pulses (Bengal gram, red gram, green gram, black gram and horse gram). Prominent cash crops include sugarcane, cotton, oilseeds, coconut, gingelly, sesame and chillies, though cashew is also grown. The important horticultural crops are bananas and mangoes.

Land Use and Changes in Landscape over time in Puducherry



Satellites have mapped land cover since the 1970s. In the adjacent map, Shakti Narpavi & Julien Andrieu give us a view of the land cover of the Coromandel Coast, from the Kalivelli Wetlands (north of Puducherry) to Nagore, going up to 50 km westward.

The map first shows that in 2017, the region was mainly covered with fields, with 642,000 hectares (ha) of crop lands, corresponding to 70% of this area. At the time, various wooded land cover types amounted to nearly 207,000 ha. Mangroves in the Pichavaram region covered very little area. We find casuarina plantations in 4.5% of the region, and all other wooded land cover corresponds to 18% of the area. This includes coconut groves, cashew orchards, and tropical dry forests. The map also shows bare soils, sand dunes and rocky hills, altogether corresponding to 4% of the map. Wetlands comprise 1.5% of the surface areas and make up 1.8% of the built-up area.

Three distinct changes are visible between 1988 and 2017:

1. **A gain of 116,000 hectares of various woodlands** corresponding to 12% of the studied area.

This looks like a good sign compared to most tropical countries or regions where deforestation is the main driver of change. However, the woodlands include cashew orchards and coconut groves. Moreover, in 2017, casuarina plantations were three times more important than in 1988. Therefore, not all new woodlands are rich tropical forest. Most of these new woodlands are located north of Cuddalore and particularly north of Puducherry and around Auroville. Almost all these new woodlands were croplands in 1988. Therefore, it can also be seen as a loss of 54,000 hectares of total cropland surface, corresponding to 8 % of the area of croplands of 1988.

2. **The loss of 53,000 ha of woodlands** corresponding to 6% of the studied area.

Changes can be complex and contradictory; some places transform from croplands to woodlands, while other places change from woodlands to croplands because these woodlands have an agricultural function (orchards, for example) which were grown and cut at will between 1988 and 2017.

*Facing page: Map: Shakti Narpavi & Julien Andrieu
Source: Landsat data downloaded from USGS*

3. A gain in built-up areas of 12,000 ha corresponding to little more than 1% of the total area.

Densely built-up areas can be mapped (unlike small houses). For these built-up areas, an increase of 1% of the total mapped area is little, but the built-up areas in 2017 are three times the built-up area in 1988, which is a substantial difference. Hence, we see that the Puducherry bioregion is a dynamic and changing area, susceptible to climate variations as well as human intervention. In this book, we take both into consideration and observe their worrying impact on pollinators, particularly honeybees. We also suggest concrete measures to ensure their wellbeing and ours.



Apis cerana on *Derris ovalifolia*: At Merveille, where TDEF was successfully restored (image beginning of this chapter) *D. ovalifolia* produced seeds because this restoration project introduced pollinators while in other places it was not seeding.

Photo: Lazar Jean, IFP



CHAPTER 2

What is Pollination?



Henna (Lawsonia inermis) has fragrant red and white flowers to attract pollinators like *Tetragonula iridipennis* as in this case. Photo: Lazar Jean, IFP.

Simply, pollination is the transfer of pollen grain from the male part of a flower to the female part. Plants reproduce through pollination, and they often depend on animals, birds and insects to do so, though wind also helps. To attract such 'vectors', plants offer rewards to them. Key crops like wheat, rice, maize and corn are self-pollinating or use water and wind to pollinate. Self-pollination refers to the pollination of a flower by pollen from the same flower or another flower on the same plant.

While self-pollination may ensure reproduction, it can also lead to in-breeding and a loss of genetic diversity. Perhaps, this is why plants have developed inventive ways to ensure cross-pollination, where pollen is exchanged between individual plants of the same species and reproduction is possible. Pollination sustains

ecological systems and ensures biological diversity. More narrowly, it ensures that we have coffee to drink in the morning, cotton clothes to wear, and vegetables to eat. Among the great variety of plants, we will talk here about flowering plants that produce seeds.

Pollinators are vital contributors to biological diversity. Human hands cannot pollinate at this breadth and scale. However, in parts of rural India some hands do pollinate vegetables as is shown at the end of this chapter. In nature, pollinators ensure food for herbivores and, having consumed pollen and nectar, become rather nutritious food themselves for birds, bats, spiders and others.

Flowers: Charles Darwin's 'Abominable Mystery'

Why do we find flowers beautiful? Is it because some flowers are imbued with cultural associations? Or do their bright colours, symmetry and scent appeal to our senses? Is this why pollinators are attracted to flowers too? Not really. Insects look for pollen or nectar, and associate the characteristics of the flower with availability and access to food. It seems like flowers too have developed characters to identify themselves, and be distinguished from others, to attract pollinators.

Charles Darwin, who believed that life evolved gradually and not in great leaps, was puzzled about how flowering plants appear to have suddenly accelerated in reproduction and diversity about 100 million years ago, so much so that today they constitute the majority of the plant world, including grasses and crops. In a letter to a friend dated 1879, he called this sudden domination an "abominable mystery". Scientists have still not been able to explain the reasons for the widespread occurrence of flowering plants which number an estimated 350,000 recorded species (in comparison, there are only about 1000 species of non-flowering gymnosperms). How did flowering plants become dominant among the plant species? Did you know that even grasses have flowers?

Several scientists and naturalists have observed that in the tropics most species are adapted to multiple pollination syndromes. Flowers are good indicators of plant identification. They can also sometimes indicate how they are pollinated and by whom. For instance, a species with flowers that bloom in the night will attract moths by releasing a special scent while the species whose flowers bloom in the day will attract bees.

Scientist Jeff Ollerton suggests an exercise:

"Observe the plants that are in flower and whether or not they are visited by insects. Look at the flower morphology. Are they drab with exposed stigma and anthers, or brightly coloured, perhaps tubular? Do the flowers have a scent or bright petals to attract insects? When you shake the flowers, does the pollen billow out in a big cloud, to be caught on the wind? Or is it sticky, adhering to the anthers until it's caught on a foraging insect?"

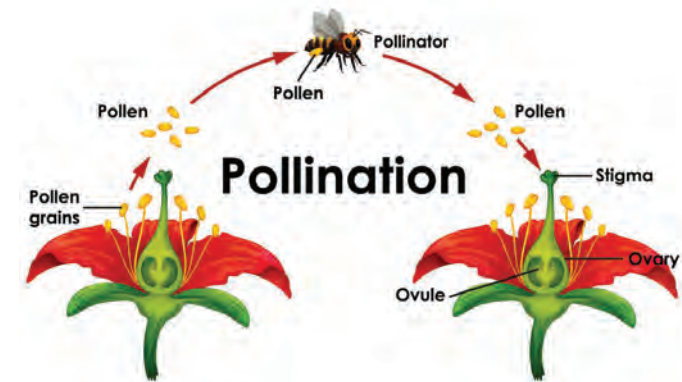
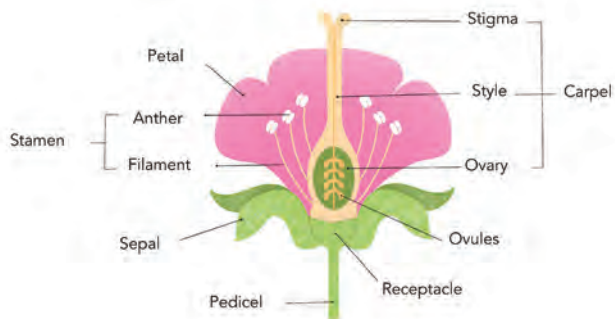


Image: www.freepik.com

Next, compare two flowers around you. They probably look very different, but there are similarities too. The sepals and the petals are the outer parts of the flower. The sepals are usually green because they make food, and provide protection during the bud stage, and from animals and weather. The petals attract pollinators with their colour and scent. The male parts of a flower are called the stamens which contain anthers. The anthers contain the flower's pollen. The female organ of a flower is known as the pistil, consisting of three parts – the stigma, style, and ovary. Pollinators carry pollen from the male anthers to the pistil. When the pollen arrives on the stigma, the sex cells developed within the pollen go down the style and into the ovary, and fertilize the female sex cells called ovules. Though pollinators play a role in the transfer of pollen between plants, once the pollen passes through the style, fertilization of the ovule and the development of the seed depend on the plant.



Parts of a Flower. Image: Kiran Joan

Why does all this variety in flowers matter? By observing how flowers respond to and manipulate pollinators, we acknowledge their active role in pursuing pollination. This *behaviour* or *associative learning*, as some scientists call it, encourages us to pay attention to the small, crucial and co-dependent ways of biological life, and the consequences of environmental disruption.

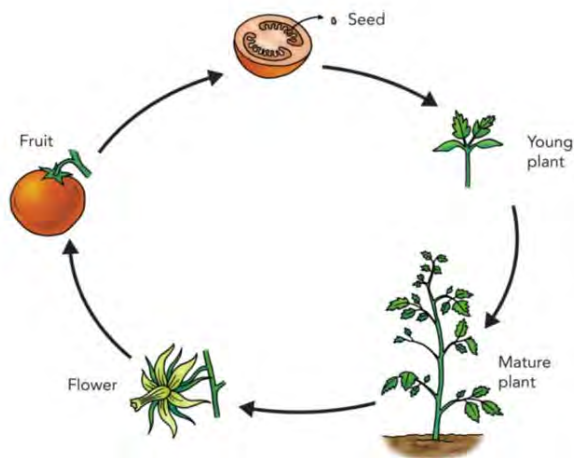
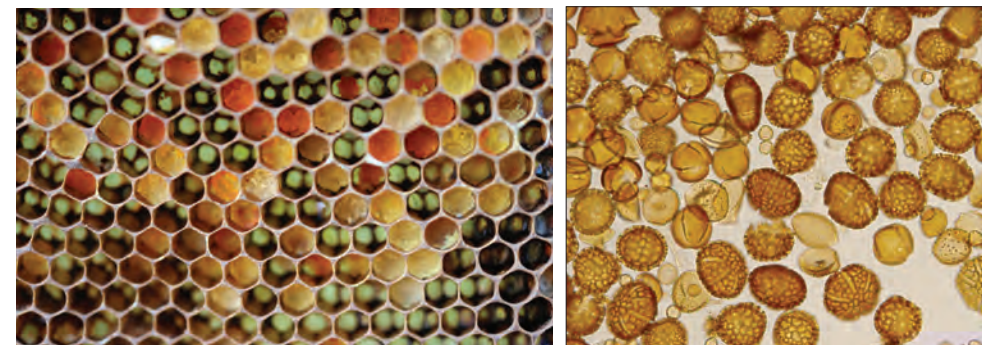


Image: Project Hero, <https://bit.ly/3cnotep>

Pollination is both an activity of chance and a time-tested evolutionary behaviour which changes in relation to changing conditions. It encourages us to ask more questions: which pollinators come to which flowers and why? How have flowers in our localities adapted to attract pollinators over time? Do we observe differences in their production of pollen and nectar between hybrid and native plants? What effect would these differences have on pollinators in our environment? How does the environment affect the behaviour of the pollinators?

To begin to answer some of these questions in the Puducherry bioregion, POLLIN researchers analysed pollen loads as well as honeycombs from the *Apis cerana* bee boxes and pot hives installed in various locations. They also analysed pollen collected by *Tetragonula iridipennis* (the stingless bee) in the pollen pots in their hives. Since this collection of pollen depended on what plants were flowering and when, they also conducted regular surveys to record the phenology (cyclic phenomena) of flowering at the various sites, and timed surveys to note which insect pollinator was visiting which plant (plant-pollinator surveys) parallel to pollen analyses. In the laboratory, the bee pollen loads were examined directly under the microscope and after chemical processing using well established methods (see Jones 2014).



Apis cerana comb with pollen loads of different colours (left) and multifloral pollen field under light microscope x200 showing pollen taxa such as *Lamiaceae*, *Delonix/ Peltophorum*, *Borassus*, *Leucaena/ Prosopis*, *Ziziphus*, *Cocos* (right).
Photos: Lazar Jean & S Prasad, IFP.

Pollination often occurs by accident, which is why plants try very hard to attract pollinators. Consider the carpenter bee (*Xylocopa latipes*). Its hair can mop up a lot of pollen from a flower, which adhere to its body while in flight. Though its hair makes for an efficient pollen mop, its pollination activity is not deliberate. The bee's hair is an insulator which protects it in the cold. The bee does not intend to pollinate the flower; it goes to the flower seeking its food.

Among crops, plants produce different kinds of flowers and their modes of reproduction vary. Plants like ginger reproduce asexually. So, the flowers become agriculturally irrelevant and no pollinators are required. Since the male and female gametes do not mix, they are genetically identical to the parent plant. In contrast, there is variety among plants that reproduce sexually. For instance, tomato, pepper, cucumber, watermelon, eggplant and hibiscus have hermaphrodite flowers, where male and female reproductive organs are within the same flower. They are sometimes called bisexual or perfect flowers!



A carpenter bee (*Xylocopa latipes*) on bamboo at IFP garden. Photo: K. Anupama, IFP.



Peltophorum pollen collected by the carpenter bee (*Xylocopa latipes*).
Photo: S. Prasad, IFP.

Pollinators and wind help tomato flowers in a unique way. The flowers must be vibrated to ensure that the pollen is released. This is called 'buzz-pollination'. Carpenter bees are especially good at it; they place their upper body near the anthers and vibrate their flight muscles.

Some crops require cross-pollination, that is, pollen has to be carried from the male flower to the female flower of another plant of the same species. This can be achieved by wind (for sugarcane and wheat), but many other plants require insect pollinators, including gingelly, mustard, sunflower, cotton, onion, alfalfa, coriander, cardamom, lady finger, beans, cauliflower, oil seeds, all kinds of citrus and fruit trees as well as ornamental flowers.

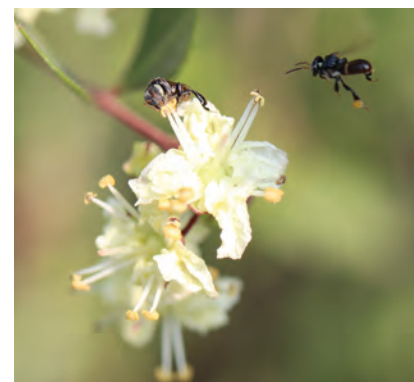
All the Native Honeybees of Puducherry



Apis cerana on *Coffea arabica*



Apis dorsata on *Turnera subulata*



Tetragonula iridipennis on
Lawsonia inermis



Apis florea on *Antigonon leptopus*
Above four Photos: Indhu Ayyanar & Lazar Jean, IFP. Below: Hand pollination of Vanilla: Photo: coorgstories.wordpress.com

Not Just Honeybees!

Which insects, birds and animals have you observed on flowers? Amateur observers can help to understand the effectiveness of pollinators. We know more about wasps, butterflies and bees but less about moths and bats because they visit flowers at night, and fewer studies are undertaken at that time. Some insects like bees live in nests, but not all insects are social. Humans are pollinators too, and have been for a long time. For instance, Vanilla requires hand pollination.



A small sample of other pollinators



Tirumala limniace (Blue Tiger butterfly)
on *Sapindus trifoliatus*



Junonina lemonias (Lemon Pansy)
on *Tagetes erecta*



Lasius niger (Black ant)
on *Moringa oleifera*



Ceratina nigrolateralis (Wild bee)
on *Averrhoa carambola*



Eristalinus arvorum (Hover fly)
on *Antidesma shaesembilla*



Ceratina sp (Small carpenter bee)
on *Celosia argentea*



Ceratina nigrolateralis (Wild bee)
on *Sphagneticola trilobata*



Amegilla cingulata (Blue-banded bee)
on *Asystasia gangetica*



Augochloropsis sp (Metallic bee)
on *Vigna mungo*.



Eupeodes sp (Flower fly)
on *Porana volubilis*



Ceratina sp (Small carpenter bee)
on *Jacquemontia pentantha*



Nomia sp (Wild bee)
on *Centratherum punctatum*

Some butterflies, an ant, some flies, several wild and solitary bees seen on a variety of flowering plants during pollinator surveys in the Puducherry region.

Photos: Indhu Ayyanar & Lazar Jean, IFP

Are Pollinators Declining?

It's hard to say because we don't have sufficient studies to make a definite claim about a 'crisis' of pollinator decline. Nevertheless, farmers have observed a significant decline in numbers of wild pollinators and, in some parts of the world, a decline in domestic bees. All the people interviewed by the POLLIN project stated that bees have become less and less numerous. There is considerable worry in India:

1. Land use has changed as natural and planted vegetation is cleared for land "development". Look around you: tamarind and neem trees along our roads are disappearing quickly. It has led to a loss of habitat for wild pollinators especially with the destruction of these natural, living fences which were ideal housing for them. Pollinators also require wild habitats to forage for food. Not all flowers are suitable to all pollinators, given differences in size and shape. Some flowers are too small for large pollinators to insert their proboscis and suck nectar from. Some flowers are too high on trees for small pollinators to reach. In general, a lack of flowers, especially the wild flowers, can endanger the life of forests.

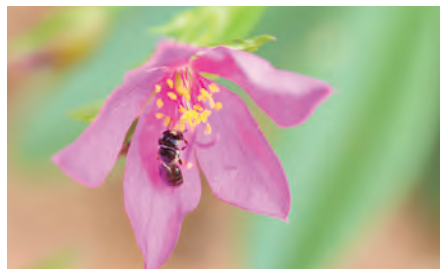
2. Pesticides are a complex problem too. Farmers are concerned about insects destroying their crop, but liberal application of pesticides can kill off insects, including the ones that pollinate flowers and help agricultural production. Different insects respond differently to decline. For instance, when some honeybees die, the colony ensures that it produces more honeybees, but not all pollinators respond this way. Not all pollinators live in such well-organized social structures.

3. Climate change results in the disruption of long established 'resilience of food systems'. Climate change is projected to limit the ability of plants to reproduce. Research now expects disruption in seasonal activity for crop pollination after 2050. Climate modifications include change in the wind direction, strength, seasonality and also erratic rains that fall at the wrong times, too heavy in some places and too scanty in others.

4. Introducing pollinator species without corresponding attention to how they affect local regions can be disastrous. For instance, over 85% of commercial honey that we buy in India is made by the *Apis mellifera* honeybee. This European bee was imported specifically to support commercial beekeeping and provide small farmers with an additional means of livelihood. However, it has been observed in some parts of North India that its aggressive hunger might be crowding out local pollinators. Moreover, transmission of pollinators in bulk for commercial purposes can also result in disease transmission. Hence, when we talk about 'local honey', we must also keep in mind *which honeybees?*

What's In It for Farmers?

Everyone knows that there is no single type of farmer. When it comes to land holdings, 92% of farmers in Tamil Nadu are small and marginal land owners, who own less than 2 hectares. Agriculture accounts for 45% of employment, which includes landless labour. What does pollination have to do with such a large section of people? Of 160 million hectares of cropped area, 55 million hectares of cultivation in India are dependent on bees and other pollinators. Depending on the availability of pollen and nectar, each hectare should have about three bee colonies near the plants to increase productivity.



Tetragonula iridipennis
feeding on an edible green
(Kozhi kaal keerai), *Talinum*
portulacifolium.
Photo: Lazar Jean, IFP

Major crops like paddy and sugarcane do not need insect pollinators. But cashew, groundnut, cotton, millet, gingelly, castor and banana do. Vegetables require insect pollination and habitats for them to forage for pollen and nectar. Puducherry does not grow enough vegetables for its consumption and depends on Bangalore city for its needs. Among local foods are cultivated *keerai* (leafy vegetables) and wild, edible *keerai* which are important in the daily diet of rural and urban consumers. Bees also forage on the flowers of wild *keerai* but the use of pesticides has led to less weeds and *keerai* in the fields. The nutrition benefits of these *keerai* came to light during the Covid-19 pandemic. Their existence also depends on insect pollinators. Much of the knowledge about identifying these *keerai* comes from women who forage in remaining wild patches for them.

Economic Value of Insect Pollinators

The importance of pollinators to agricultural production and their impact on the economic value of agriculture have been studied by Nicola Gallai, who estimated the annual market value of pollination services to be between \$235 billion-\$577 billion worldwide in 2015. In on-going research, Gallai found that the value of Indian agriculture increased fourfold since 1991, from \$100 billion to over \$400 billion in 2019. Over the same period, Gallai also calculated the value of pollinators, which is a function of the producer price of crops, the quantity produced and the dependency ratio of a crop vis-à-vis insect pollinators. This value increased by more than 700%, from \$5 billion to \$37 billion.

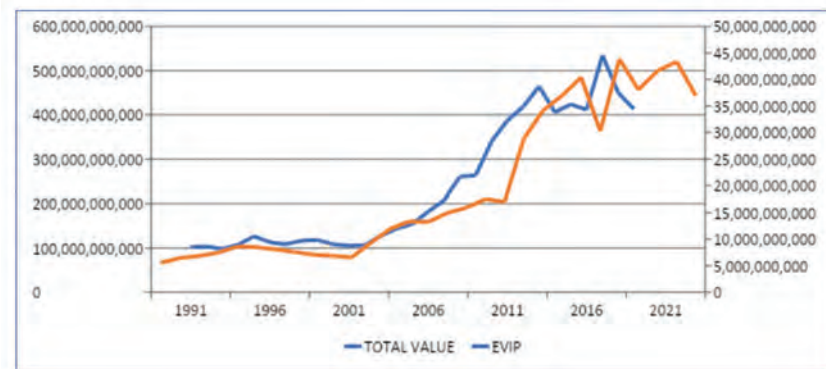


Figure 1— The evolution of the total economic value of the Indian agriculture (TOTAL VALUE in Blue and left axis) and the Economic Value of Insect Pollinators (EVIP in orange and right axis) from 1991 to 2019.

This impressive development shows that pollinators have become increasingly important in Indian agriculture over the past two decades. It raises the issue of the vulnerability of agriculture caused by a decline in these insect populations. Indeed, since in India, pollinated crops increased more than crops that are not in need of pollination, Gallai's research shows that vulnerability has increased over this period, from 5% to 9%.

When we zoom in on elements that make up the macroeconomic picture of growth, the findings are equally complex. In an article for the *People's Archive of Rural India* (PARI), S. Senthilir narrates how seed production in Karnataka requires hand-pollination to ensure cross-pollinated, quality seed for vegetables such as okra, tomato, ridge gourd and cucumber. The painstaking, dexterous work is carried out by the most vulnerable section of Indian society, Dalit women, who are underpaid and compelled to live in a vicious cycle of debt without protection or benefits. By making visible the social and caste dimensions of work involved in the seemingly 'natural' activity of pollination, Senthilir alerts us to the matrix of unequal power relations involved in food production.



Above: Ratnavva S. Harijan picks the gandu hoovu (male flower) from the pouch tied to her waist to pollinate the okra flowers. **Left:** Ratnavva gently spreads the pollen from the male cone to the stigma and ties the flower with a thread held in her left hand to mark the pollinated stigma. **Left below:** Pollen powder is applied on the stigma of a tomato plant flower from a ring. Photos: S. Senthilir / PARI. www.ruralindiaonline.org

CHAPTER 3

Let's Talk About Honeybees

Everyone has heard the buzz of a bee, on its way from one flower to another. Some of us have even seen bee swarms, in flight or settled on a branch somewhere. We might have observed that not all bee combs are the same. Some are larger than others, like the single bee comb we see high up on a tree or building. We might also have noticed that there is great variety in bees themselves. Within the family, Apidae, which is related to insects like wasps and ants, we find a range of bees including carpenter bees, leafcutter bees, mason bees, sweat bees and others. Some bees like the honeybees are social insects while others are solitary. What makes the honeybee quite special is that it lives in communities.

Six legs – Four Wings – Five Eyes

PARTS OF A BEE

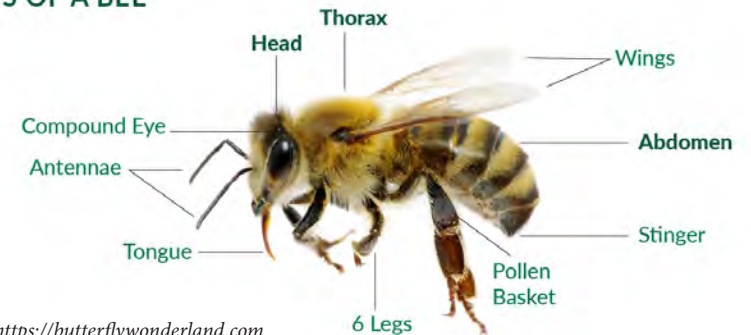


Image: <https://butterflywonderland.com>

The bee's body has three sections: the head, the chest or thorax, and the abdomen.

Head: For its size, the bee has a large brain (1 mg). It also has five eyes! It has two big compound eyes, one on each side and three small, simple eyes in front. Its two feelers are keen organs of smell and touch, guiding and distinguishing between flower petals and fragrances. It also has a pair of jaws and a tongue. Only the worker bee can gather nectar from the flowers with its tongue, the drones cannot.

Thorax: To this portion are attached the legs and wings. One pair of legs in the front, another in the middle, after which come one pair of wings, two hind legs and a second pair of wings. Bees carry pollen on their hind legs which have two “pollen baskets” lined with hair. Only the worker bees have these pollen baskets which enable them to gather and store pollen from flowers before carrying them home.

Abdomen: This is the largest section of the bee’s body. A worker bee has wax plates beneath its abdomen through which it secretes wax. She also has a honey-sac, from where she can transfer the honey to the comb cells. The worker bee has a sting at the end of her abdomen which is connected to the poison-sac. The angrier the bee, the more poison that is injected into the wound. The sting is the little bee’s only defence to save its colony from predators and destruction. The drone doesn’t have a sting, but the queen bee does, which she uses against a rival queen bee.

What’s Going On in a Bee Colony?

Honeybees live in an organized colony. There are different members that we have to get acquainted with. Most visible are the few thousand female worker bees, some male drones who look different from the workers and one queen bee.

The single **Queen Bee** is a prominent part of the colony. She is larger than the other bees, and unlike the female worker bees, she is able to lay eggs. The queen is fed special food by the nursing worker bees when they are rearing her. The queen mates with a drone bee and spends her life laying eggs in the colony. She lays two types of eggs: fertilized eggs produce females and worker larvae, while unfertilized eggs produce male, drone larvae. The queen herself is born in a special, long cell and is fed a substance called ‘royal jelly.’ Queens can live between two and four years.

The **Worker Bees** are the highest occurring members of a hive. Their life span extends between two and six months, depending on the season and amount of work. They attend to the queen bee, feeding and cleaning her. They also maintain the temperature of the hive. Worker bees are female artisans. They build the comb, nurse the brood, make the honey, forage and gather the pollen and nectar and guard the hive. They take on each of these roles as they grow and develop, with the youngest bees nursing and cleaning, while the oldest ones gather pollen and nectar.

The **Drone Bees** are male and their only job is to mate with the queen. They have the largest-sized eyes in the colony to locate the movement of the queen bee. Once the queen has mated, the worker bees drive the drones out of the colony.

When the queen is ready to mate, she releases pheromones on her flight up above the colony. This draws the drone bees to her, and with each mating the poor drone bee is disembowelled. The sperm the queen receives will suffice for her whole life, and she lays about a thousand eggs a day from then on. When the queen gets old, worker larvae will be reared to become queens, though a colony can only have a single queen.

Honeybees in Tamil Nadu & Puducherry

People have observed and domesticated bees for a long time in India so, understandably, we find old texts – like the *Sushruta Samhita* and the *Bhavaprakasha* (in Sanskrit) - that systematize the varieties of bees and honey. We find evidence in ancient Tamil literature too. But here we will discuss contemporary classifications which you will find useful when speaking with another bee keeper, a government official or your friends.

Latin name/ English name	Tamil names*
<i>Apis dorsata</i> / Rock bee	<i>Periya ii, Periya kolave, Kattu ii, Malai Theni</i>
<i>Apis florea</i> / Dwarf bee	<i>Kombu theni, Nattu Theni, Chinna Theni</i>
<i>Apis cerana indica</i> / Indian honeybee	<i>Kilai Theni, Putthu Theni</i>
<i>Tetragonula iridipennis</i> / formerly <i>Trigona iridipennis</i> / Stingless bee	<i>Kosu Theni, Kutta Theni, Chinna Theni</i>
Honeybee	<i>Theni, Kolavi, ii, Theni Poochi, Then vandu, Vandu</i>
Nectar	<i>Irasayana Thiravam, Then</i>
Pollen	<i>Irasayana Podi, Manjal Podi, Magarantham</i>
Pollination	<i>Makaranthacherkai, Karuvuruthal</i>
* Collated from fieldwork by Amuthavalluvan V, IFP.	

***Apis dorsata* (Giant honeybee)**

About 17-20 mm in length, these giant bees build a single comb away from the ground, up on cliffs, trees or buildings, thus earning themselves the moniker 'rock bee'. Though they make a lot of honey, they are also aggressive. They are wild bees and cannot be domesticated. In the Bengal Sundarbans, there are often so many *Apis dorsata* hives that they begin to build closer to the ground as well.



Above: *Apis dorsata* on *Hugonia mystax*.
Photo: Indhu Ayyanar, IFP.

Right: *Apis dorsata* comb.
Photo: Lazar Jean, IFP.

Apis florea

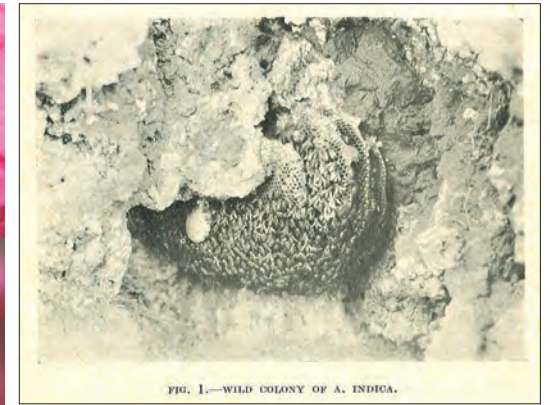
Sometimes called the little bee, it is distinguished by a white band on its abdomen. It also builds a single comb but closer to the ground, in bushes or branches of trees.



Left: *Apis florea* on *Jacquemontia*. Photo: Indhu Ayyanar, IFP. **Right:** *Apis florea* hive in a home garden in Puducherry town, March 2021. Photo: Lazar Jean, IFP.

***Apis cerana* (Indian honeybee)**

This Indian honeybee builds multiple, parallel combs and can be domesticated. You may find it in the hollows of trees or in abandoned boxes and shelters. These bees don't like to get wet, and they make their homes in sheltered places. It is a calm bee; with some practice and experience it quickly becomes a beekeeper's delight. The queen bee can live up to 3 years while the lifespan of a male drone and female worker bee is about 50-60 days.



Left: *Apis cerana* on *Antigonon leptopus* Photo: Lazar Jean, IFP. **Right:** An early 20th century photo of *A. cerana* in the wild. Image from Ramachandran (1938)



Above:
Bees like to live in the hollows
of tree trunks.

Right:
Apis cerana bee combs in a fallen tree trunk.
Photos: Amuthavalluvan V., IFP

Below:
Tetragonula iridipennis on
Ziziphus xylopyrus
Photo: Lazar Jean, IFP



Tetragonula iridipennis

This tiny bee builds its home in crevices, in tree hollows that produce resinous substances or in switchboards in cities. Its hive, with cup-shaped architecture, is different from other bees. It does not fly very high, drawing pollen and nectar from small flowers and those of the ground cover. It is also known as dammar bee or stingless bee. The *Tetragonula iridipennis* stores its eggs, honey and pollen in unique pots made from

propolis. Propolis itself is made from a mixture of substances including resin, wax and fatty acids.



Top:
Pollen and honey stored in the stingless bee
(*Tetragonula iridipennis*) hive.
Photo: Lazar Jean, IFP.

Above:
Stingless bee (*Tetragonula iridipennis*)
hive in fallen tree trunk.
Photo: Amuthavalluvan V, IFP.

Left:
Tetragonula iridipennis hive in a clay pot.
Photo: Lipi Das, Merveille, Project Ecolake,
SAICE.

CHAPTER 4

Bees in Hives

Honeybees have been kept by humans from very early times. What makes these bees special is that they are not wholly wild nor wholly domesticated – they remain somewhere in between..

Early hives

Traditional hives are artificial ways to rear bees. Bees were housed in baskets, earthen pots, logs of wood and such dark enclosures. A common method found in the hills of North India is to fix a pot into the wall of the house. People apply smoke to drive the bees away, and then take out the comb. Bees and their larvae often die in the process.



Photos: Wikipedia



Modern Hives

The box hive developed by Reverend Langstroth in 1850 is the most common bee friendly hive used all over the world today. In India, slight variations have resulted in the Janata hive and the Newton hive. These hives house the *Apis mellifera* and the *Apis cerana* honeybees.

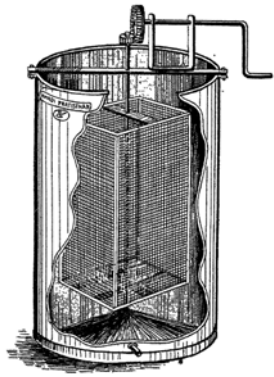
The box hive mimics natural bee hives. It has two chambers placed one upon the other. The lower chamber has the 'Brood' where the queen bee lives, and the eggs are laid. Bees store their surplus honey in the upper chamber. Each chamber has a number of parallel frames within which bees build their combs.



Left: A modern hive. Image: www.beverlybees.com **Right:** Hive on stand with water readily available for the bees. **Below:** *Apis cerana* bees on their wax comb. A wooden frame from a bee box with *Apis cerana* bees. Yellow pollen is visible in the cells.

Photos: Lazar Jean, IFP.





To extract honey from the comb, shake the bees off gently, cut the cap of the cells with a knife and place the frame in a 'honey extractor'. By winding it, the honey is extracted but the comb remains intact. Place the empty comb back in the hive. The bees don't have to rebuild their combs and can continue to collect nectar, pollen and produce honey.

Bee boxes are usually made of painted wood to withstand the rain, and this makes them expensive. A bee box with bees costs about Rs. 4000. Is there an inexpensive way of encouraging bees to stay on the farm?

Honey extractor. Image from The Romance of Scientific Beekeeping.

Clay Pot Hives for Pollination

Instead of using expensive wooden boxes, a clay pot can be a bee-friendly and environment friendly alternative. Clay pot hives are effective and budget friendly ways to encourage pollination. A clay pot with bees is much cheaper than a wooden box hive. This simple way will benefit both the farmer and the bees.

Use clay pots to encourage pollination:

- Tie pots to trees with the mouth facing the ground. You can rub some beeswax inside them to encourage bees to enter.
- Pots with wide mouths are well-ventilated and make for a bee-friendly home. They protect bees from the rain and keep the inside cool in summer.
- The round shape also mimics the natural shape of the bee comb, and can accommodate large hives.
- Tying multiple pots will create natural habitats so when the bees swarm they will find new homes to move into.
- Clay hives benefit farmers, gardeners and bees by encouraging pollination and providing the beekeeper with a little honey.
- Clay pot hives require very little maintenance and protect against wax moth and disease.



Top: Wild Apis cerana swarm in a pot tied up on a tree. Below: A split clay pot hive with stand for water. Photos: Lazar Jean, IFP.

Make a Split-Pot Hive

Take a big thick clay pot and cut the top portion with a sharp, long blade to make a lid. Place the frames in this wide space. Cut a small hole below which will be the entrance.

Set the pot on a stand. Keep two sticks on one side for bees to enter. Bees require shade and protection from rain. Tie the split pot hive with jute sacks and shade it with palm leaves.

Moving a comb from a wooden box to a clay pot keeps the hive naturally cooler. Bees work less to regulate the temperature in the hive.

Where do bees store their surplus honey in a pot hive?



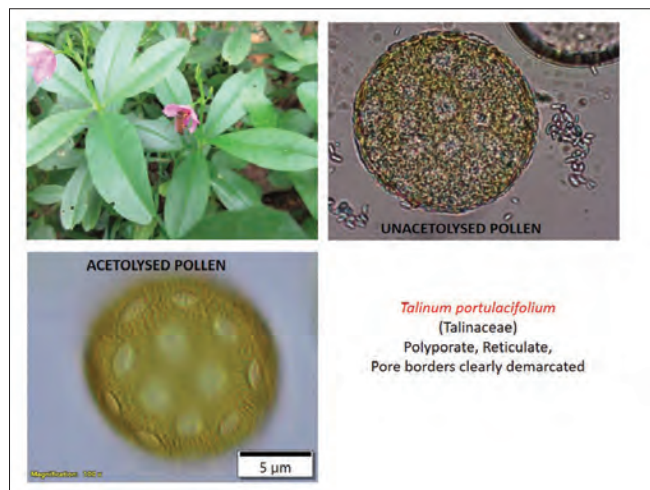
A partly open pot hive of Apis cerana. Pot hive of Apis cerana and collection of comb material for pollen studies. Photos: Lazar Jean, IFP.



Clockwise from top: The super chamber of a pot hive with honey combs which is easy to handle for farmers. Pot hive of Apis cerana. A split-pot hive tied on a tree. Photos: Lazar Jean, IFP.

As part of the study, POLLIN researchers placed bee hives on numerous farms and agricultural sites in Puducherry. They were curious: which flowers do bees go to and in which season? Researchers studied pollen grains collected by the bees to determine bee preference: by analyzing the pollen loads carried back by the bees to the box or clay pot-hive it was possible to know, across time and space, which plant and crop species the bees preferred and collected pollen from. By making surveys of flowering phenology and plant-pollinator surveys in parallel, researchers hope to make sense of the complex networks of interaction between bees and plants that have co-evolved over several millennia. They also want to understand how the bees adapt to the pressures of land cover transformations and climate change that can threaten these plant-pollinator networks, endangering both natural and agricultural ecosystems.

Look at the common *Talinum* flower in the picture below. Tiny grains of pollen are collected from the flower and viewed under the microscope. You can see a magnified view in the unacetolysed pollen picture below. To clear the organic material and see the cell wall clearly, it is put through acetolysis, that is, it is treated with a chemical mixture. What is left is Sporopollenin, a highly resistant organic substance which can withstand high temperature, strong acids and alkalis.



Apis cerana collecting pollen on *Talinum portulacifolium* & Pollen microphotography.
Image: Lazar Jean, IFP.

In this chapter, we studied the honeybee world up close, and also suggested ways in which farmers can become environment friendly beekeepers on a budget through the use of claypot hives. In the next chapter, we will speak to a range of people and gauge the social knowledge about bees in Puducherry.

CHAPTER 5

Humans and Bees



Focus Group Discussion about Local Knowledge. Photos: Amuthavalluvan V., IFP.

The social sciences researchers of the POLLIN project interviewed different farmers (organic and non-organic), workers, city dwellers, tribals and bee keepers to understand how people live with bees. Asking them simple questions such as: have you observed the bees around you? Did you spot some honey combs somewhere? What we found was a wealth of community knowledge, keen observations about changes in agriculture and the impact on insects.

Irular and Bees: A Practical Knowledge



With members of the Irula: Chellamma, Nagaraj and Selvaraj.
Photo: Amuthavalluvan V, IFP.

Interviews with Irula communities revealed a deep familiarity with bee behaviour. The Irula are expert hunters, able to read animal paw prints, locate wild animals and trap them. Men and women work together to do so. Irula experience is also called upon by landowners who want to protect their grain from rats.

Chellamma is 65 years old and lives in a settlement with seventeen families near the Vathanur Lake. She identified four kinds of bees, and does not disturb the big Malathen (*dorsata*). The Irula have a distinct way of spotting the *Apis cerana* bee. Chellamma's brother Nagaraj explained that while catching rats, they might see bees entering and leaving a termite hill. They use a crowbar to dig the side, and ward off the bees with smoke.

"We never use fire and kill bees. Because bees are like human beings; we have to care for them like we care for our children. Bees also give birth like us, that is why no one in our community kills bees."

Once a comb is destroyed and the queen bee dies or leaves, the bee larvae will not be able to survive on their own. Chellamma knows that life of the hive is organized around the queen bee. But the problem is not just people deliberately destroying bee hives: Chellamma has noticed a visible decline in bee populations too.

"When I was young, I would graze animals near the lake. We could count many honey combs in the bushes. We would collect the honey and eat it there, but now there is nothing. We have to search a whole day for a single comb. Bees watch us carefully. If a little boy throws a stone at bees when they are building a hive, they will leave immediately. It takes 3-4 months to build a big hive. You have to wait. The longer you wait, the more honey you get. Today people disturb the bees too much. A hive is like a house for bees: there is a dining hall in the upper part, full of honey against food scarcity, there is a separate place like the living room, the bottom will be full of larvae, it looks like our house!"

The Irula call honey 'Nei' (ghee). Nei means something that is extracted. Just as cow ghee is extracted from butter, bees extract nei from the flower too, she told us. The Irula know what bees prefer. Bees love the kambu (millet) blossoms. Bees forage on flowers of small millets, tamarind, neem, groundnut, mango, wild plants like kelakai, surakai, and weeds/greens (keerai). They love the coconut tree too. During the paddy season, clouds of pollen powder are noticed, even though paddy is self-pollinated. Besides eating honey, the Irula use honey on special occasions like a baby-naming ceremony and for medicinal purposes. *Bees are like a folk-medicine shop, with plenty of medicine available.* Honey is also given as a gift to relatives and neighbours.

Earlier, they would go from street to street to sell honey. It used to be an important source of income. Sometimes a rich household would buy honey in bulk. Siddha doctors would buy some honey too. Cobblers asked for beeswax. But things are different today. Catching snakes and hunting - Irula traditional occupations - have been prohibited. The Irula have become agricultural labourers. Honey hunting is collective work and bargaining to sell is tiring. Ultimately, each person may receive only a hundred rupees after all their effort, which is insufficient today.



Sons learn to collect honey from their fathers. Chellamma explained how the Irula pass knowledge to the next generation:

"We don't train or teach! They learn when they come hunting and gathering with us from the time they are young. They see our methods. Sometimes we tell them, 'Don't kill the bees. Clear the comb with smoke. If you kill the bees, you won't get honey next time.'"

Farmers and their Conditions of Work

Farmers are uniquely placed to provide input and support to bee policy. They spend a lot of time in bee habitats, observing their crops and plants. The majority of farmers in India and Puducherry have



Top: Sale of honey. **Above:** Interviews with the Irula. Photos: Amuthavalluvan V, IFP.



*POLLIN researchers worked with farmers to introduce bee boxes on farms (at PS Palayam).
Photo: Lazar Jean, IFP.*

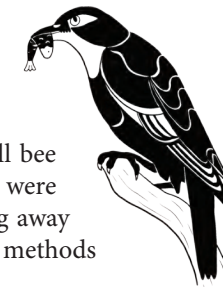
small and marginal landholdings, that is, they hold less than five acres of land. Small farmers tend to multi-crop; they grow different crops in the same piece of land during one growing season which is favourable for pollinators and the bees specifically because they can forage a diversity of flowers. Large farmers tend towards mono-cropping where one crop is grown intensively. This drains the health of the soil, increases reliance on fertilizers and threatens the survival of bees. POLLIN researchers spoke to a range of farmers about their experiences and their knowledge of pollination.

The Green Revolution and the Forgotten Effects on Pollinators

The long-term effects of the Green Revolution are being felt by farmers. Murugan, a large farmer, switched to organic farming after observing his brother's experience. As a boy, he had watched the introduction of new practices,

"In 1978, people were using the 'latest technology'. I have seen representatives from pesticide companies come to our village with spray equipment, offering free demonstrations to farmers. For them all insects were pests. The target of the Green Revolution was high yield, and for this reason chemicals were applied indiscriminately. I used to grow groundnut and cotton, so nine out of twelve months, I was using pesticide. Our cultivation patterns have also changed. We used to have trees and bushes in the fields. But with the introduction of tractors, the trees and bushes became an inconvenience. So, the trees were cut, and pollinators lost their habitats."

Gopi is an engineer who owns four acres of land in Poothurai. He does not depend on farming for his livelihood, but is interested in growing organic and healthy food. Looking around him, Gopi realized that current farming practices kill bee populations. Before chemical pesticides were used, plants were pollinated naturally. Now, pesticides increase yield by driving away pests but also pollinators. Hence, he chooses to use organic methods and lets bees pollinate his plants naturally.



Organic Methods: A Gentle Attitude towards Bees

Organic farmers are more aware of the importance of pollinators. Many of them are trained by some institution or participated in workshops by Nammalavar's movement. Nammalvar was a well-known Tamil agricultural scientist and environmental activist who trained and organized organic farmers. For instance, Veerappan hails from an agricultural family. His grandfather practiced natural farming, but his father shifted to chemical farming. When his father fell ill, Veerappan began to read about the benefits of organic farming in books. He left his job in the private sector and joined his brother to farm three acres. They hire farm labour during the harvest season and grow paddy, banana, papaya, raises cattle and keep an acre for fodder. He received training and institutional support from NABARD and an NGO, Ekoventure, which approached him when they heard about his organic farm. At a bee-keeping workshop, he learnt that bees forage wild flowers, which he observed for the first time. He remembers seeing many bees as a youngster, and regrets that he would destroy the hives to take the honey. Now his organic farming attitude has made him interested in connections in nature.

Both farmers learnt about "good and bad insects" during Nammalavar workshops. Chemical sprays unnecessarily kill harmless beetles, spiders, and dragonflies. Sprays are more effective in the mornings and evenings, they observed. Now, Sanjay, who is the son of an organic farmer (he inherited three and a half acres), grows traditional varieties of paddy, groundnut, black gram, horse gram, gingelly, papaya, guava, banana, and cattle fodder. He prefers traditional varieties which are healthier, and require less water. He uses an organic spray. He has noticed that bees do not like mixtures made of leaves against pests. But a mixture of garlic and ginger does not affect the bees. Another popular method against ants, recommended by Nammalvar, was not to water the tree directly, but to dig a trench at the circumference of the outer leaves and water it there. Trenches serve multiple purposes including rainwater harvesting, composting, preventing evaporation and soil erosion.

Awareness about organic farming is slowly taking root for its multiple, long-term benefits. Venkat is a retired school teacher and owns four acres of land on which he grows casuarina in rotation with paddy. He prefers rotation cropping to soften his clay soil: three years of casuarina followed by a year of paddy. He grows two varieties of paddy: Samba which takes six months and Kuruvai which takes three months, leaving his land fallow for three months. Casuarina doesn't require much maintenance or manpower, and is in demand for its timber. The Krishi Vigyan Kendra (KVK) Farmer's Development Centre has trained farmers in the application of fertilizer and organic farming, and Venkat is considering the harms of chemical fertilizer.

"When I spray chemicals, all the insects die. Today the government restricts farmers from spraying those chemicals for the sake of our future generations. There are good insects who go from flower to flower, covered in pollen."

It is difficult to be an isolated organic farmer, surrounded by farms that use chemical fertilizer and pesticide. Venkat's choice of crop is determined by what his neighbours grow. Small farms are compelled to depend on neighbouring farms. Next year, he may cultivate paddy, but paddy requires care and cattle, so he will plant paddy if his neighbours do so as well. This is also why organic farming cannot be an individual effort, but must be organized at a collective, block level. Farmers also face two other challenges: i) marketing organic crops, since their price may tend to be very high for consumers; ii) increase of working time, since compensating chemical inputs needs more labour. Hence, sometimes their farm is only partly organic: either only a section of the holding is cultivated organically, or they mix organic and chemical inputs.

Farmers have their ways of gauging the health of the soil. Organic farmers who refrain from chemical fertilizers bring back insects into their ecosystem. Earthworms in the field, farmers say, indicate a good yield. Top soil visibly improves. Mud balls created by earthworms and found during the harvest of paddy promise a profit. And with the return of pollinators comes the dispersal of pollen and more biodiversity.

A Specific Experiment around a School, an Orchard and Nature

Individual efforts like gardens also go a long way in encouraging pollinators and pollination. An Ashram for HIV positive children near Puducherry turned to organic methods to provide much of its food. On a three-acre orchard, they grow coconut, banana, papaya, lemons, pomelo, cucumber and watermelon. The gardeners make compost from layers of cow dung and leaves. To keep pests away, they combine bitter leaves like neem (or leaves that goats avoid eating)



The Yazhi integrated farm at Kunichampattu where its owner Veerappan participated with enthusiasm in finding a location to install a clay pot hive on a Ziziphus tree.

Photo: Lazar Jean, IFP.



Insects in the ecosystem: Xylocopa latipes collecting pollen from Sesbania rostrata, a plant which fixes nitrogen in the soil on Yazhi farm. Photo: Indhu Ayyanar, IFP.

with cow urine that is soaked for seven days. The mixture is sprayed early in the morning and it works for red beetles, green and white worms and butterfly moths. Sometimes, they mix in turmeric as well.

As gardeners, they have never been stung, *"We are not afraid. It was more dangerous when we went as children to destroy natural bee hives to eat honey! But we don't go any more, that's for youngsters."* The children are able to distinguish the varieties of the bees, and recognize flying aphids, worms and termites. There are eight bee boxes in the garden. Two young girls said:

"Honeybees have increased our vegetable yield; we have more tomatoes. We also have brinjal, onions, broccoli, carrot, beetroot, rosella and bitter gourd. Everything has benefited! We teach the younger children not to throw stones at bees and disturb them. Pollination is as important as honey. We see the pollen that the bees collect. Three years ago, we kept bee boxes but we failed. We had no experience and the bees went away. This time two people came to train us: how to not be afraid, and not to disturb them. We see two kinds of wild bees, but the bees we have in our boxes are different."



Left: Focus Group Meeting with SHG Women. **Right:** Interviewing a banana farmer in Pudhukuppam village. Photos: Amuthavalluvan V, IFP.

Farmers who desire to keep bees often face the problem of bees abandoning the boxes. Valluvan kept four boxes in 2019, but the boxes were soon empty. Farmers have begun to notice changes in flowering seasons as temperatures rise accompanied by unexpected rainfall that affects the bees. Keeping bee boxes is high maintenance and involves high costs.

“Farming is not profitable. Expenditure is high because of hybrid seeds which cannot be stored for the future. I need Rs. 20,000 for fertilizer for 4-5 months. If I get a profit of Rs. 15,000-20,000, that is only Rs. 4,000-5,000 per month, I cannot afford to buy a box with this money. The ordinary farmer risks a great financial loss if the bees leave the box or if someone steals it. The hardship is doubled because in Tamil Nadu, small farmers work in their fields and as coolie labour outside the village. They work in the field when necessary, and depend on the other job. It becomes difficult to purchase expensive bee boxes and learn about beekeeping.”

Farmers with larger landholdings depend on farm labour. Mithra used to keep 20 hives before the cyclone hit. However, farm workers refused to work near the beehives. She felt that it was possible to inform and train permanent workers who would be more appreciative of bees, but most farms employ temporary workers. Honey extraction in Tamil is called ‘*then azithal*’, i.e. “honey-hunting”. Mithra observed that bees in South Indian cultural imagination are not domesticated, but live in the wild. The idea of putting bees in boxes and domesticating them requires training and removing the fear from farmers’ and workers’ minds.

Suresh recalled a training session on beekeeping that he attended. The trainer was talking about the rainy season period when flowers are scarce. Suresh suggested that instead of feeding bees with refined sugar, they could try jaggery syrup. The trainer cautioned him saying that jaggery would give the bees a stomach

problem; he discouraged artificial feeding to yield honey, and suggested providing flowering plants for bees to forage all through the year. Hence, Suresh decided to grow more vegetables on his land with a mixed cropping pattern that includes flowers throughout the year.

Becoming Bee Keepers



Training farmers to be beekeepers. Photo: Amuthavalluvan V, IFP.

Sateesh, a 70 year-old farmer, started keeping bees in 1980 after a Khadi Gram Udyog representative organized 30 members in their area and gave them a week-long training. He bought a smoker, veil and extractor and five boxes, but the bees abandoned them. When he took up a job as a bus conductor, he bought five boxes again and divided the colonies himself to make ten boxes out of them.

“Bees are sensitive to smell. The threat is not only pesticide but humans applying smoke and fire to combs. They are also sensitive to habitats. Bees will leave fields if there is only one crop without pollen or nectar.”

He says that the difference in habitats lies in the difference between big and small farmers. Small farmers tend towards multi-cropping while big farmers prefer paddy and sugarcane. However, if they cultivate gingelly, cotton, *thakkapoond* and *sanappai* (green manure), this will benefit pollinators too.

“After the sugarcane is cut, you find bees visiting the field to suck the sugar syrup. So, bees can be found in sugarcane fields as well. You also find bees making their homes in the sugarcane fields.”

He feels there are three deterrents to successful beekeeping: 1) Government support lacks foresight (if the government gives only one subsidized box, there is a high risk of loss for the farmer if the bees abandon the box); 2) Habitat loss due

to the cutting of big trees on the road. Flowers have reduced; 3) Farmer preference for paddy and casuarina.

Antony learnt about bees in school and installed beehives when he became unhappy with his coconut tree yield. He has noticed that the presence of bees has increased his production. From four to five coconuts in a bunch, the yield increased to fifteen to twenty.

“My neighbouring farmers think it is because of the fertilizer but I realize that this is all because of bee pollination. Earlier I would sell coconuts for Rs.1,500-2,000, but now I sell coconuts for Rs. 8,000 from 36 trees. Each coconut sells for Rs. 10. This is a notable growth. I observe my coconut trees carefully. Before I installed my hives, most flowers would fall to the ground. But they stopped falling after. I planted chikoo (sapota) ten years ago, and it began to flower after four years. It gave me many good fruits. Then the fruiting decreased. Once I brought in the bees, I resumed getting fruits, and look at my trees now - full of fruits! I see the same result with my mango trees.

And the issue is not restricted to honeybees, since it concerns other species of pollinators as well. See the fig trees: we have a saying, “kandu kaikaikum, kaanamal poo pukkum”, meaning “we can see the bud, but we don’t see the flower.” [Unlike other fruits, fig flowers bloom internally. If you cut a fig, what you see is a maze of flower inflorescence. Figs attract small wasps for pollination which become trapped inside.]

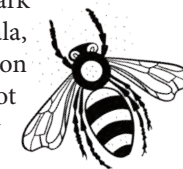
Bee keepers are trained to work with domestic bees. They serve as a connection between government policy and an interested public. Many beekeepers are also trainers whom the public can contact for bee boxes and information. Nadesan is the master beekeeper for the KVIC Southern Region and a commercial beekeeper. He said, “Everybody wants honey but nobody wants to look after bee boxes!”

Nadesan trained 750 self-help groups (SHGs) and NGOs in 2019, through an income generating initiative of the Puducherry Cell for women. Demand for training



Opening a bee box. Photo: Amuthavalluvan V., IFP.

also comes from botany and entomology students who study a compulsory paper in apiculture. In the past, he has trained tribal groups in Jawadhu Hills, Kolli Hills and Kalrayan hills, to encourage safe bee keeping, to discourage cutting branches and using smoke. He keeps 50 colonies of *Apis mellifera* at a drumstick plantation in Aravakurichi, and many more boxes of *A. cerana* elsewhere. Bees have to be loaded in his vehicle at night, because they return home from foraging in the evening. Hence, it has to be dark when moving the beehive. Driving 300 km at night, across Kerala, Karnataka, Andhra and Tamil Nadu, he has to provide ventilation and smooth passage. When he reaches his destination, he does not open the boxes immediately, but lets the bees take rest in their new place. After a few hours, he opens the gate of the hive. Bees can get agitated with this movement, and an experienced bee keeper should undertake this task. Agitated bees will disturb the public. A beekeeper needs to be patient and attentive. The beekeeper’s priority is to nurture bees and observe their needs.



Through the entire lockdown during the Covid-19 pandemic, Nadesan got an e-pass to ferry his bees because pollination is an essential service. He was exposed to bee keeping through KVK as a young boy, and later went to the Central Bee Research Training Institute (CBRTI) in Pune for a three-year course. As a bee trainer, he finds that government programmes in the Agriculture department need better coordination to be effective. Subsidized beekeeping equipment is not distributed in January which is the honey flow season. Instead, orders are placed in May-June when the lean period begins. This means that the bees are unable to forage and the boxes remain empty. Subsidies are not easy to avail either. Often, bee trainers are not paid for their services. Though the KVK department under ICAR does a diligent job, it lacks funds. Salaries are provided by the state government, while the funds for programmes come from the central government. Though the government attracts people by doling out Rs. 300/- day at training, officials do not follow up. This is a waste of resources.

Before honey came to be manufactured on an industrial scale, it was considered a precious commodity that was used in small quantities and bought only when needed. It was used for medicinal purposes, or given to a child with the belief that it would encourage speech. These days, there are efforts by the KVK to create value-added products where dates, raisins and almonds are soaked in honey to enhance immunity and blood circulation.



Top: At Molasur private forest. Photo: Amuthavalluvan V, IFP. **Left:** Selvakumar training Jawadhu Hill Malayali tribe persons in Chinnapagandai. Photo: Indhu Ayyanar, IFP. **Right:** Interviewing an organic farmer at Sorapet. Photo: Frederic Landy, IFP.

Why Do Bee Keeping Programmes Sometimes Fail?

Through interviews, researchers found several gaps in the implementation of beekeeping schemes:

1. Bees are treated as an agricultural input, and not a vital part of our ecosystem. Hence, the needs of pollinators are neglected. The focus should go from the hive to the whole landscape where the swarm lives. Bees are pollinators, not only producers of honey.
2. There is little awareness about bee-keeping. This makes people afraid of bees and their sting.
3. Government subsidizes bee boxes but there is no follow-up, hence inexperienced farmers are unable to prevent bees from abandoning the boxes.

4. There are several government schemes, distributed between central and state government. They need to be streamlined and bee-trainers paid on time.

The future though looks promising and many avenues have not yet been explored. In South India, what is called “service apiculture” is very limited. A few farmers host somebody else’s boxes. But this practice is still relatively rare; it should be developed, since many farmers told the POLLIN team that they would like to maintain bees in their fields, but they had given up the idea because of lack of time and labour. They could explore the option of inviting beekeepers on their farm, in a mutual, win-win agreement.

Note that given the crises caused by commercial beekeeping with *A. mellifera* to ecology and agriculture in many parts of the world, the emphasis should be on beekeeping with our native, hiveable bees (*A. cerana* and *T. iridipennis*). Recently there have been efforts at Chidambaram to hive *A. florea* as well. A final innovation to this model of win-win for the farmers and the bees is the introduction of the clay-pot hives that we have introduced in this book earlier - they are less expensive and practically maintenance free.



Banushree and Veerappan during their training with Selvakumar. Photo: Lazar Jean, IFP



POLLIN WORKSHOPS



Selvakumar explaining beekeeping with *Apis cerana* in wooden box hives to participants at the first POLLIN workshop, 2021. Photo: K.Anupama, IFP.



Selvakumar demonstrating the use of a live clay-pot hive. Photo: Lazar Jean, IFP.



After the transfer from a wooden hive to claypot hive. Photo: Lazar Jean, IFP.



Above: Lipi Das demonstrating the function of a clay-pot hive, September 2021. Photo: Lazar Jean, IFP. **Right:** A workshop participant having a closer look at the brood chamber. Photo: K. Anupama, IFP.



POLLIN workshop group discussion after training and fieldwork at P.S. Palayam. Photo: K. Anupama, IFP.

CHAPTER 6

How to Help Pollinators?

You too can create a Bee Atmosphere!

Anyone can take up beekeeping but it is advisable to wear the requisite protective gear while handling bees - the pictures show highly experienced beekeepers demonstrating what is possible with experience and patience while handling bees.

Diversify Farming Systems

Crop rotation and inter-cropping for local conditions can protect and encourage pollinator habitats. Compare pollinator visits between hybrid crops and native varieties.

Plant bee-friendly flowering plants in your garden

Plants depend on a range of insects to pollinate them because not all insects can pollinate particular plants. The diversity of insects in size and shape means that they depend on wild flowers as well. Bees need to feed throughout the year. Which flowers will you plant?



Introducing children to beekeeping.
Photos: K. Anupama and
Amuthavalluvan V, IFP.

Appreciate Weeds

Are pollinators coming to weeds and feeding on them? Don't weed them out! Create space for wild flowers. Often, commercial interests determine what food gets priority. Weeds can also be nutritious crops.

Restore biodiverse sites

Reduce disturbance to your unique bioregion and nurture saplings in your communities.

Tie some clay pots to the trees on your farm to attract bees

Rubbing some beeswax inside the pots will attract bees by providing the familiar smell of home.

Avoid Chemicals

Look for alternatives to manage pests that won't kill insect populations.

Become a Local *Apis cerana* Bee-Keeper

Call a bee trainer near you and get some experience working with bees. Consider housing a hive of *Apis cerana* bees. Make sure they are in a quiet and dry space. Clean your hive regularly to prevent wax moth predators and observe the health of the hive. Small ponds provide moisture in the environment, as well as decrease the effort of pollinators who go in search of water.

Local Bee-Keeping Associations

Local groups can bring together people, spread information, including among young students, and train them to handle bees responsibly.



Create a Bee Atmosphere. Bees love *Antigonon leptopus*. Photo: Amuthavalluvan V, IFP.

CHAPTER 7

Select Crops and Blooming Seasons of Plants Foraged by Bees in Puducherry

Sl No.	Crop	Sowing	Harvest
1	Sornavari - Paddy	May – June	Aug - Sept
2	Samba/ Kharif crops- Paddy	Aug – Sept	Jan - Feb
3	Navarai - Paddy	Dec – Jan	Mar - Apr
4	Kuruvai / Rabi - Millets	Dec – Jan	Feb - Mar
5	Kuruvai / Rabi – Pulses	Dec – Jan	Feb - Mar
6	Kuruvai / Rabi – Groundnut	Oct – Dec	Mar - Apr
7	Sugarcane	Nov – Feb	Oct – Apr
8	Thai Pattam – Vegetables	Jan – Feb	Mar – Apr
9	Aadi Pattam – Vegetables	Aug – Sept	Oct - Dec

Observe which plants and trees are in bloom in particular seasons and whether the flowers attract bees.

Cocos nucifera (Tennaiaram)

Coconut blossoms offer pollen and nectar throughout the year to bees and are a popular source of food for bees.



Apis cerana & *Apis florea* honeybees on coconut flower.
Photo: Media Space,
<https://youtu.be/kcduLTz2Zoo>

Dichrostachys cinerea (Vedathalam)

It offers pollen and is a minor source of nectar from June onwards.

Thespesia populnea (Puvarasam)

The Portia tree offers pollen to bees throughout the year.

Moringa oleifera (Murangai), Sesamum indicum (Ellu), Vigna mungo (Ulundu)
Drumstick, sesame and black gram offer pollen and nectar to bees in the early months of the year from January.

Citrus aurantifolia (Elumichai) and Citrus vulgaris (Tennipalam)

Key lime and bitter orange offer pollen and nectar from March for a few months. *Catunaregam spinosa* (Mullukkarai, matukkarai, mruk kana) is a major source of nectar in April, May and June.

Tamarindus indica (Puli) and Acacia nilotica (Karuvelei)

Tamarind and acacia flowers offer pollen and nectar in May, June and July.



Apis florea on
Tamarindus indica flower.
Photo: anearthian.wordpress.com

Sorghum vulgare (Cholam), Cucurbita pepo (Poosanikai) and Benincasa hispida (Neer poosani) offer pollen and nectar from August for a few months.

Borassus flabellifer (Panai Maram)

Unlike coconut, the toddy palm offers pollen and nectar for the bees during the months of February, March and April.



Apis florea on *Ixora finlaysoniana*,
Photo: Indhu Ayyanar, IFP

Ixora finlaysoniana (Vetchii)

The West Indian Jasmine offers both nectar and pollen to bees with much nectar flow during the summer season.

Dodonaea viscosa (Viraali)

The Hop Bush offers pollen and nectar from August-November and February-April and is a preferred source of food for bees.



Apis florea on *Syzygium cumini*,
Photo: Lazar Jean, IFP

Syzygium cumini (Naaval maram)

Jamun offers both nectar and pollen for bees from March to May.

Mimosa pudica (Thottal sinungi)

Touch Me Not offers pollen for the bees throughout the year.

***Eucalyptus spp* (Thaila maram)**

The stringybark trees offer a good source of pollen for the bees from September-December

Coffea arabica

Coffee offers pollen source for bees from March-April.

***Cyanotis axillaris* (Vazhukai Pul)**

The tropical spiderwort offers pollen to bees from June to October.

***Psidium guajava* (Koyya maram)**

Guava offers both pollen and nectar to bees from March-May.

***Capsicum annum* (Milagai)**

Chilli offers nectar for bees throughout the cropping season especially during January-February, June-July and September-October.

***Momordica charantia* (Paavakai)**

The bitter gourd offers both pollen and nectar source for the bees during the cropping season especially in summer.

***Solanum torvum* (Sundaikai)**

The turkey berry offers both pollen and nectar source for the bees during the cropping season especially during July-March.

***Anacardium occidentale* (Mundhiri)**

Cashew offers nectar for bees during June-December.



Apis cerana on *Cyanotis axillaris*.
Photo: Indhu Ayyanar, IFP.



Tetragonula iridipennis on *Psidium guajava*,
Photo: Lazar Jean, IFP.



Nomia sp. on *Solanum torvum*,
Photo: Lazar Jean, IFP

Afterword

Night pollinators: how moths help the Himalayas

These insects have so far received less scientific attention than bees and butterflies

SHIY SAHAY SINGH
BOLGAON

Moths are vital to pollination in the Himalayan ecosystem of northeast India, reveals a recent study. The study establishes 91 species of moths as potential pollinators of 21 plant families in Sikkim and Arunachal Pradesh in the northeastern Himalayas.

The results assume significance as a majority of the pollination-related studies are based on diurnal pollinators (bees and butterflies) and the role of nocturnal pollinators have so far received less scientific attention.

The details of the study were recently published in *Scientific Reports*, a publication from the *Nature* group of journals.

"In the present study about 65% moths (91 species) carried sufficient quantities of pollen grains to be considered as potential pollinators. *Telliphasa* sp. (*Crambidae*) and *Cuculia* sp.



An eribid moth on a flowering plant. *SPECIAL ARRANGEMENT

(*Noctuidae*) are found to carry the highest quantity of pollen," the paper reads.

Navneet Singh, lead author of the study, said that *Geometridae* (geometer moths) and *Erebidae* (eribid moths, tiger moths, lichen moths, among others)

turned out to be the most important moth families for pollen transportation in the Himalayan region.

"We also found frequent interaction of moths with *Betulaceae*, *Fabaceae*, *Rosaceae* and *Ericaceae*. Though the *Betulaceae* is predomi-

nantly a wind-pollinated plant family, some recent studies indicate that wind-pollinated plant families also benefit from enhanced dispersal by insects," Dr. Singh, who is associated with the Zoological Survey of India (ZSI), added.

Mutual benefit

Another interesting outcome of the study is that the moth species *Achaea janata* (a well-known pest of various economically important plants) was identified as a potential pollinator of three plant families, indicating that moths can provide net benefits as pollinators even when acting as larval herbivores of the same species.

According to Dr. Singh and his fellow authors, the research, which is part of a project funded by the Ministry of Environment, Forest and Climate Change, was among very few large scale studies at a global level

where the research team studied the effect of various seasons and different altitudes on the pollination ecology of moths.

The research is based on the field work conducted in the Himalayan terrains, from the foot hills to elevations up to 3,000 m. Along with Navneet Singh, the other contributors to the publication are Rajesh Lenka, Palab Chatterjee and Dipayan Mitra.

Dhriti Banerjee, Director of ZSI, said that generally moths are considered mysterious denizens of nights, and for a long time they were better known as pest species. "This study revealed the importance of moths in nature. When we are sleeping in our bedrooms, they are tirelessly working for the ecosystems to work, on which our survival is invariably dependent, and are helping in a great way towards food security," Dr. Banerjee said.

Just as we were finishing this book to send it off for printing, the article above appeared in *The Hindu* on Sunday, 20th February 2022. As studies like these take off in other parts of India, we hope to continue our work in Puducherry too. The POLLIN project is only a beginning in a collaborative effort involving farmers, beekeepers, gardeners, social scientists, scientists, ecologists and interested persons to study and support pollinators in an increasingly precarious environment.

This book, in the framework of our ongoing studies on honeybee pollinators, will be made available online with updates from our research on www.ifpindia.org.

We have endeavoured to show that honeybees are very interesting insects, but only one part of a wider pollinator world. We also wished to shift our readers' notions from bees-for-honey to *bees-for-pollination*. Towards this end, we encourage the use of environment friendly and inexpensive clay-pot hives and the creation of a pollinator-friendly environment in Puducherry.

Contact Information

Agriculture Department, National Honey Mission Scheme

Mr. Govindan, Agricultural Officer: 9488623763

Central Bee Research and Training Institute (CBRTI), Pune

The CBRTI provides short and long-term residential training. It has also published an all-India, district wise crop calendar, with month-wise distribution of when crops are rich in pollen and nectar. This calendar will be useful for farmers and honeybee keepers: 020-25675865

Krishi Vigyan Kendra (KVK), Puducherry

Dr. Purushothaman, Principal :9442525675

Khadi and Village Industries Commission (KVIC)

Provides financial aid to beekeepers through loans. It runs the National Honey Mission, set up in 2017, to support farmers, Adivasis and unemployed youth in rural India.

KVIC Puducherry: 097915 65762

Dr. N. VijayKumar, Head: 0413-2271292

Ekoventure NGO

Ms. Pushpalatha: 9443459366, 0413-2275812

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