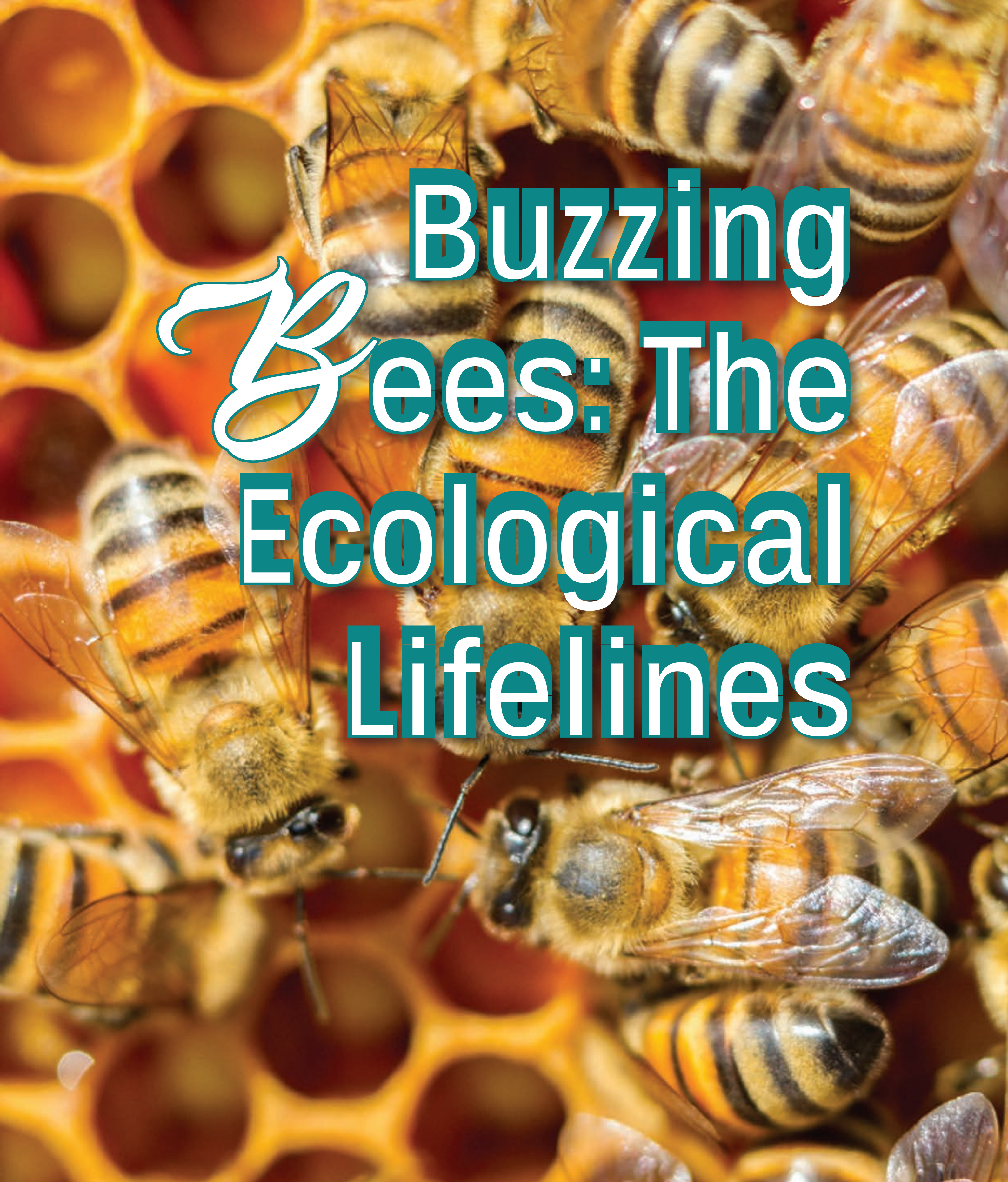

Buzzing Bees: The Ecological Lifelines

By Dinesh Rajendran

PAN ASIA PACIFIC
For a just and pesticide-free future

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A stingless bee hive.
Photos © Adrian Cheah

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Photo by OK-Photography.

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Introduction

Bees are known to vital pollinators essential for the growth of many plants, including the fruits and vegetables we rely on for food. According to Pesticide Action Network North America (PANNA), honeybees play a crucial role in pollinating nearly 95 different kinds of fruits and nuts in North America which includes almonds, avocados, cranberries, and apples. However, these tiny creatures are facing significant challenges, and one of the biggest threats they encounter comes from pesticides – chemical substances designed to control or kill pests like insects, fungi, and weeds. The use of pesticides has become widespread in agriculture and pest control even in the remote areas of Asia. However, these chemicals can cause damage to human health and the environment and other unintended consequences, particularly for harming non-target organisms like bees. Pesticides can harm bees in various ways, affecting their behaviour, health, and even their ability to survive and reproduce.

Understanding the impact of pesticides on bees is crucial for protecting their populations and ensuring the health of ecosystems they support. Therefore, this article aims to shed light on the challenges they face especially due to pesticides and the solutions we can implement to safeguard their well-being. By examining the different types of bees, their behaviour, life cycles, and the importance of bees as pollinators, we can gain insights into the broader implications of pesticide use on ecosystems and food security and the threats posed by pesticides to bee populations, including the risk of colony collapse disorder and the role of pesticides in exacerbating other stressors such as climate change and habitat loss.

In addition, we seek to raise awareness about the urgent need to address the harmful impacts of pesticides on bees and inspire collective action to mitigate these threats. By advocating for sustainable agricultural practices, promoting pollinator-friendly policies, and fostering collaboration between stakeholders, we can work towards creating a safer environment for bees and ensuring their vital role in maintaining biodiversity and food production. In essence, this article serves as a call to action, inviting individuals, communities, and policymakers to join hands in protecting bees and preserving the ecosystems that depend on their invaluable services. Together, we can make a difference and secure a brighter future for bees and the planet as a whole.

... bees play a vital role in maintaining the delicate balance of ecosystems worldwide.

Identification of Different Types of Bees

There are estimated 20,000 species of bees present which are categorised into seven distinct families which are Andrenidae, Apidae, Colletidae, Halictidae, Megachilidae, Melittidae, and Stenotritidae, which can be further divided into two main groups based on their average length of tongue (short and long) which is also known as proboscis.

Bees belonging to the Andrenidae, Colletidae, Halictidae, Melittidae, and Stenotritidae families are characterized by having short tongues, whereas bees in the Apidae and Megachilidae families are known for their long tongues (Mader et al., 2010).

Short-Tongued Bees	Long-Tongued Bees
Andrenidae, or commonly known as mining bees, a petite to medium-sized physique, these bees showcase a diverse array of colours and patterns, often seen in shades of brown or black. While they are solitary by nature, certain species' females may nest in close proximity, forming aggregations within the same vicinity (Kilpatrick & López-Uribe, 2020). **Colletidae** bees, or commonly known as plasterer bees, or cellophane bees or even polyester bees typically exhibit a small to medium-sized stature and display a diverse range of colours and patterns. Some may even resemble wasps, sporting nearly hairless bodies with white or yellow markings on the face and other body parts. Despite their solitary nature, certain species' females may nest closely together, forming aggregations in the same vicinity (Kilpatrick & López-Uribe, 2020). **Halictidae** bees or commonly known as sweat bees normally have small to medium-sized bodies and these bees exhibit a wide array of colours and patterns, often resembling wasps with their nearly hairless appearance and black, brown, or metallic coloration, ranging from green to bronze and blue hues. The social structure within this family spans from solitary to communal, semi-social, or primitively eusocial, with variations influenced by climate, season, and nest location (Kilpatrick & López-Uribe, 2020). The **Melittidae** bees have typically small to medium-sized bodies and these bees are commonly brown or black in colour. They are exclusively solitary in social structure. Despite being rarely observed or collected, Melittidae species are known for their specialization, often feeding exclusively on pollen and nectar from specific plant species (Kilpatrick & López-Uribe, 2020). **Stenotritidae**, the smallest of all formally recognized bee families, comprises only 21 species distributed across two genera, all confined to Australia. These bees are characterized by their large size, dense hair covering, and swift flying capabilities.	**Megachilidae**, one of the most diverse bee families has a small to large body size. They are commonly referred to as mason bees and leafcutter bees, reflecting their nest-building materials – soil or leaves, respectively. Some species collect plant or animal hairs and fibres, earning them the name carder bees, while others utilize plant resins in nest construction and are accordingly known as resin bees. These bees exhibit a wide range of colours and patterns, often resembling wasps, with coloration ranging from black and brown to metallic hues such as green, bronze, and blue (Kilpatrick & López-Uribe, 2020). Members of the family **Apidae** encompass a diverse array of bee species, including honey bees, bumble bees, carpenter bees, long-horned bees, squash bees, digger bees, cuckoo bees, stingless bees, and orchid bees. Solitary species often construct tunnels in the ground or wood, while others nest in cavities, with preferences ranging from trees/buildings to underground spaces or dense vegetation. Social structures vary, with most species being solitary or semi-social, while some exhibit primitively or fully eusocial behaviours. (Kilpatrick & López-Uribe, 2020).

Mining bee or *Andrena flavipes* (Family Andrenidae).
Photo by Wirestock.

Leioproctus bee (Family Colletidae).
Photo by Macrophotos.

Bee from the Halictidae family.
Photo by Macrophotos.

Dasypoda hirtipes, or hairy-legged mining bee (Family Melittidae).
Photo by Wirestock.

Stenotritidae that are restricted to Australia. Photo by Gary Taylor.

Leafcutter bee (Family Megachilidae).
Photo by Macrophotos.

Bee from the Halictida Stingless bee (Family Apidae).
Photo by Vinícius Rodrigues de Souza.

Behaviour of Bees

Colony Life

Bees living in colonies, such as honey bees, exist within organised societies comprised of three distinct adult castes: queens, workers, and drones. Each caste possesses specific responsibilities crucial to the hive's survival and functioning. Queens, the reproductive females of the colony, exhibit a larger size compared to the workers, their abdomens adapted to accommodate well-developed reproductive organs. Queens usually have a slightly darker hue than the workers. The male members of the honeybees are known as drones. The number of drones produced by each colony is notably lower than the quantity of workers. The majority of colonies are comprised of a single queen, along with a multitude of workers and a substantial presence of drones. The queen's sole duty within the colony is egg-laying, and she serves as the mother to all the workers residing in the colony. Workers undertake various hive maintenance tasks, encompassing the care of brood (including eggs, larvae, and pupae), cleaning, foraging, and the production of honey. These responsibilities are distributed among workers according to age, a phenomenon referred to as temporal or age-related polyethism. Drones are generated specifically for mating purposes with queens from other colonies, thus their production is confined to the reproductive season (Egelie et al., 2015).

"Each caste **possesses specific** responsibilities crucial to the hive's survival and functioning."

Solitary Life

Solitary bee species, including carpenter bees, mason bees, and certain sweat bees, lead distinct lifestyles separate from their social counterparts. In these species, the adult female operates independently, carrying out all tasks typically divided among hive members in social settings. Nest construction varies among solitary females, who may choose underground burrows, plant hollows, rock crevices, or utilise self-made materials resembling plastic. Notably, solitary females are less defensive of their nests and may vacate rather than confront intruders. Some solitary species adopt a strategy of usurpation, taking over existing nests for egg laying instead of building new ones. Solitary bees have relatively short lifespans, with much of their time spent in larval and pupal stages. Adult lives span just three to eight weeks, during which solitary males focus solely on mating. These males often spend nights sleeping in flowers while competing for mating opportunities with nearby females (Wagner, 2022).

Life Cycle

The life cycle of bees, be it a solitary or social species undergoes holometabolous development (complete metamorphosis), a process that involves four distinct life stages: egg, larva, pupa, and adult. The number of eggs laid varies significantly among species, ranging from as few as eight or fewer in some solitary bees to over a million in highly social species. Larvae emerge from their eggs after a few days. Upon completing pupal development, the emergent adults break through their capped cells.

Importance of Bees

Bees as Pollinators

Bees like honeybees are excellent pollinators and are known to be the major pollinators for angiosperms (flowering plants). According to Food and Agriculture Organization of the United Nation, (FAO, 2018) approximately 75% of the crop species worldwide rely, to some extent, on bees and other pollinators. They also account for 9.5% of the total economic value in agricultural production directly used for human food, as indicated by Gallai et al. in 2009. In North America, honeybees play a crucial role in pollinating over 100 commercial crops (Hristov, et. al., 2020) and it was also reported that Honeybees satisfy 34% of the pollination service requirements in the United Kingdom (Breeze, et al., 2011). Both honey bees and wild bees were also found to be economically significant for sunflower seed production. Bees also play a vital role in preserving biodiversity by pollinating many plant species that depend on an essential pollinator for fertilisation.

Both honeybees and wild bees were also found to be economically significant for sunflower seed production. The study by Greenleaf and Kremen in 2006, have shed light on wild bees and honey bees that not only doubled pollination rates but also significantly boosted the prevalence of hybrid sunflowers by five-fold. Bees also play a vital role in preserving biodiversity by pollinating many plant species that depend on an essential pollinator for fertilisation. The economic significance of bee pollination is also evident in smallholder farming systems, such as those in Kakamega, western Kenya, where pollination dramatically enhances the production rate of green gram, beans, cowpea, sunflower, tomato, groundnut, passion fruit, and capsicum, contributing to almost 40% of the annual crop production in the region (Kasina, et al., 2009). The process of plant pollination benefits significantly from the diversity of bee species involved, including honey bees, carpenter bees, stingless bees, bumble bees, long-tongued bees, feral bees, social bees, and solitary bees. When multiple bee species participate in pollination activities, it enhances the efficiency and effectiveness of the pollination process, leading to better vegetation outcomes (Khalifa, et al., 2009).

> Bees like honeybees are excellent pollinators and are known to be the major pollinators for angiosperms **(flowering** plants).

Bees as Preys

Bees like carpenter bees, honeybees and stingless fall prey to a variety of insect, mammalian, and avian predators. According to Oldroyd & Nanork, 2009, some bird species, like the Orange-rumped honey guide (*Indicator xanthonotus*), the Malaysian honey guide (*Indicator archipelagicus*), the Oriental honey buzzard (*Pernis ptilorhyncus*), and the Barred honey buzzard (*Pernis celebensis*), are specialist hunters of honeybees. They also mentioned that there are other bee-eaters like *Merops* spp. and drongos (*Dicrurus*), opportunistically target honeybees. Predators like the Gray wall jumper spider (*Menemerus bivittatus*), Daddy longlegs spider (*Pholcus phalangioides*), Eastern Garden Lizard (*Psammophilus dorsalis*) and South Indian Rock Agama (*Calotes versicolor*) are known to be predators to stingless bees as well (Gopinatha & Basavarajappa, 2022). If bees were to face extinction, these species would either be at risk or driven to extinction themselves.

Stories From the Field

India

Sajayakumar's journey into beekeeping began as a means of survival during his teenage years. Initially employed as a beekeeper by a neighbour in 1979, he soon became fascinated by the intricate workings of the bees. Observing their behaviour closely, he marvelled at their ability to produce honey seemingly out of thin air. This curiosity led him to delve deeper into beekeeping, eventually establishing his own beekeeping operation called Bharath Bee keeping Centre. His beekeeping activities are divided into three main stages corresponding to the lifecycle of bees. During the famine period, when rains hinder nectar collection, Sajayakumar supplements the bees' diet with sugar syrup to sustain them. He also takes measures to protect the hives from ants by applying cashew nut oil to the hive boxes. In the growing periods, he splits hives to prevent overcrowding and ensures the development of new queen bees. In the final production phase, he strategically places frames with few grubs into the honey chamber to maximize honey production.

Sajayakumar primarily works with two bee species, *Apis cerana indica* (Indian honey bee) and *Tetragonula iridipennis* (Indian stingless bee), which can be cultivated in boxes. However, he notes that other species, such as *Apis florea* and *Apis dorsata*, which work in the open, cannot be cultivated. Over the years, Sajayakumar has become one of the most respected beekeepers in Kerala, receiving national award in 2006 and state awards in 2008 for his contributions to beekeeping. In 2017, he was also declared and awarded the title Honey Man by the Indian government. Despite challenges such as climate change and the decline in available nectar sources, he remains dedicated to his craft. In addition to managing his own beekeeping operation, Sajayakumar is committed to passing on his knowledge to others. He provides free training to aspiring beekeepers and has trained numerous individuals in the art of beekeeping. Although he faces obstacles in promoting beekeeping, he continues to advocate for the importance of this practice. With around 4000 bee hives under his care, Sajayakumar is not only preserving bees but also generating income through honey sales. His passion for beekeeping is evident in his experiments, such as surviving on a diet of honey alone for six months, which earned him recognition from the state government.

Despite facing setbacks such as a devastating virus attack in 1991 that claimed the lives of 300 hives, SajayaKumar remained resilient, adapting his practices to overcome challenges. Following the footsteps of their father, his sons, Nature and Nectar are also actively involved in the beekeeping activities. As part of raising awareness on the critical role honey bees play in our ecosystem and underscores the importance of apiculture, Nature, has also made headlines by setting a Guinness World Record, spending over four hours with his head covered in bees. Sajayakumar and his sons' dedication and perseverance serve as an inspiration to all who value the vital role bees play in our ecosystem.

Sajayakumar proudly showing his honey bees.

Beekeeping in India.

** This story was obtained through the collaboration with our partner, Pesticide Action Network India (PAN India).*

Bangladesh

Abdur Rashid, a 61-year-old beekeeper from Sirajganj, Bangladesh, has turned his humble beekeeping endeavour into a thriving business known as the Ashar Alo Bee Farm Project. Rashid actively promotes beekeeping as a means of agricultural sustainability and food security, engaging with his community through workshops, demonstrations, and outreach initiatives to raise awareness about the significance of bees and advocate for bee-friendly policies.

Initially starting beekeeping in 1988 on a small scale, Rashid found it unprofitable until he received training in 1997 and transitioned to box culture honey keeping. Now, he manages over 300 boxes, meticulously monitoring queen bee performance daily, primarily working with the *Apis mellifera* species. With 27 years of beekeeping experience, Rashid has witnessed a significant decline in bee populations over the past two years, attributing it to chemical pesticides used in nearby fields. To mitigate this issue, Rashid suggests phasing out harmful pesticides and scheduling spraying sessions after noon or from 3 pm onwards, as bees are active during the day for honey collection and pollination. He emphasizes the importance of habitat conservation, bee-friendly agricultural practices, and ecosystem restoration efforts to address the decline in bee populations.

Despite these challenges, Rashid's Ashar Alo Bee Farm Project has seen remarkable success, with him starting from just two boxes to owning 300 and running a thriving bee farm. He receives pre-orders for honey and plans to explore royal jelly processing in the future. Rashid's efforts have not only optimized honey production and generated income for his family but also created job opportunities for community members. Rashid urges the agriculture department to regulate chemical pesticide use and promote bee farming due to bees' critical role in the food system. Through his dedication to sustainable beekeeping practices and advocacy efforts, Rashid continues to make a significant impact on bee preservation and environmental conservation in Bangladesh.

Abdur Rashid showing his bee colony.

** This story was obtained through the collaboration with our partner, Shikkha Shastha Unnayan Karzakram (SHISUK), formed a collective enterprise of beekeepers with the members of North Bengal Beekeeper Association called "North Bengal Honey Community Enterprise".*

Vietnam

Bac Thi Hoa, a dedicated beekeeper from Ban Bon, Bon Phang commune, Thuan Chau district, Son La province, Vietnam, has been actively involved in preserving bees and their habitats for the past eight years. Hoa's beekeeping activities primarily involve the natural cultivation of honey bees using hollow wooden trees converted into bee nests. With over 30 beehives distributed across her home garden and nearby fields/forests, Hoa emphasizes the importance of minimal intervention in beekeeping, allowing bees to thrive in their natural habitat. The bees Hoa raises are indigenous honey bees caught from the forest, continuing a tradition passed down from previous generations in her village. Her purpose in raising bees extends beyond personal interest to supplementing her family's income through the sale of honey, contributing to the local economy.

Bac Thi Hoa's bees' nest in hollow wooden trees.

However, Hoa acknowledges the challenges faced in beekeeping, particularly the decline in bee populations observed during certain seasons, primarily due to natural factors like aggressive behaviour during swarming and environmental stressors such as pesticide exposure. Despite these challenges, Hoa remains resilient, implementing measures to mitigate bee colony decline, including regular hive inspections, queen bee replacements, and protection against ants. To ensure successful beekeeping, Hoa emphasises the importance of maintaining clean hive environments, providing adequate shelter from the elements, and fostering resilience in the face of bee stings – a testament to her dedication to bee preservation. Through her efforts, Hoa not only contributes to honey production and economic stability but also plays a crucial role in maintaining biodiversity and ecosystem health in her community. Her experiences serve as a valuable lesson in the importance of coexisting harmoniously with nature to safeguard the future of bees and agriculture.

** This story was obtained through the collaboration with our partner, Centre for Sustainable Rural Development (SRD).*

Malaysia

Captain Zakaria Kamantasha, a 58-year-old former military man turned organic rice farmer at Sri Lovely in Sik Kedah, shares a compelling story from his decade-long journey as a beekeeper specializing in stingless bees. Despite facing challenges such as hive theft, Captain Zakaria has seen remarkable growth in his bee colonies, expanding from three to twelve. He attributes this success to his commitment to organic farming practices, which avoid the use of chemical pesticides. Emphasizing the critical role of bees as pollinators, Captain Zakaria advocates for a shift towards agroecological methods to safeguard bee populations and ensure the continued productivity of agricultural systems. Advocating for the phase-out of pesticides and promoting organic farming, Captain Zakaria highlights the critical need for a healthy food system and environment. He also advises young people to actively engage in organic farming, advocating for a shift away from reliance on the corporate food system towards self-sustaining organic farming practices to bolster food security. His story underscores the importance of reducing pesticide usage to protect vital pollinators like bees and promote ecological sustainability in farming practices.

Stingless bee in Sri Lovely, Kedah.

** Sri Lovely is a Field Learning Site for PANAP's International People's Agroecology Movements (IPAM).*

Bees Products

Honey is widely recognized as one of the most common products obtained from bees. Due to its antibacterial and antioxidant attributes, honey finds extensive application in traditional medicine. Moreover, honey plays a crucial role in supporting the livelihoods of rural and indigenous communities worldwide. According to FAO, bees hold significant cultural and economic importance for indigenous peoples such as the Ogiek of Kenya, the Kulung honey-hunters of Nepal, and the Kawaiweté of the southern Brazilian Amazon. Bees are deeply ingrained in their identity, economy, and culture, highlighting the vital role of honey and beekeeping in sustaining these communities.

Left to right: bee pollen, beeswax, honey and propolis from honeybees.
Photo by Grafvision.

Products such as beeswax that are used as a lubricant, glaze, polish, or waterproofing agent by us, propolis that are normally used for treating wounds, skin ulcers, and rashes and bee pollen that are often marketed dietary supplement, with assertions of possessing anti-inflammatory and antibacterial properties (NIDDK, 2012) are also products of bees that can be harvested with consideration on maintaining the hives integrity.

Threat to Bees

Although bees significantly contribute to both humans and the environment, they face the threat of population decline. A survey by Theisen-Jones & Bienefeld in 2016, highlighted the decline of honeybees in 16 Asian countries that they surveyed which includes China, India, Japan, Vietnam and others. Several factors contribute to this decline in bee populations like pesticide use, parasites, diseases and climate change. Indeed, as widely recognised, pesticides have a direct detrimental impact on bee especially honeybee populations. However, it's essential to acknowledge that the usage of pesticides not only affects bees directly but also indirectly contributes to climate change. This, in turn, adversely affects bee colonies and makes them more susceptible to attacks by parasites and diseases. As quoted by Dowler in his 2020 Greenpeace article, "We are losing wildlife, particularly insects. The crisis is driven by a combination of factors but there is no doubt that pesticides are harming pollinators".

"Several factors contribute to this decline in bee populations like pesticide use, parasites, diseases and climate change."

Pesticide Use

The use of pesticides has long been linked to the decline in bee populations. Although there is ample literature available regarding the sublethal impacts of insecticides on bees within controlled laboratory settings, there is a scarcity of information on sublethal effects at the colony level within natural conditions. Common insecticides like neonicotinoids and pyrethroids have been demonstrated to influence honey bees' learning abilities, foraging behaviours, and nest site orientation when exposed to sublethal doses (Spivak, et al., 2011).

Neonicotinoid pesticides, among the chemicals utilized, have been identified as having severe consequences for bee populations. Bees especially honey bees encounter neonicotinoids regularly which acts as potential stressors that could contribute to colony failures. In 2016, the study conducted by Brandt, et al., discovered that neonicotinoids such as thiacloprid, imidacloprid, and clothianidin, when present at field-realistic concentrations, can impact the immunocompetence of adult worker honeybees. Changes in the immune system could have serious implications for the disease resistance abilities of honey bees. While neonicotinoids pose serious threat to bees, other pesticides are known to affect bees as well.

A report in 2020 made by Kumar et al., it was found that organophosphates and carbamates posed threat to bees apart from neonicotinoids. Sublethal pesticide exposure, encompassing fungicides and herbicides, frequently induces stress in animals as they try to metabolise and eliminate these toxic substances swiftly, expending substantial energy in the process. Fungicides were discovered to induce harmful effects on honeybee brood, evident through the presence of deformed and often flightless pupae, as well as newly emerged adult bees (Kumar et al., 2020). The list of fungicides and herbicides that are harmful to honeybees are shown in Table 02. According to DeGrandi-Hoffman, et al., (2013) honeybee larvae, when subjected to prolonged exposure to pollen contaminated with chlorpyrifos, displayed markedly reduced production of queens. Pesticides, including fipronil, are recognised as hazards to bees. Guerin reported in 2021 a distressing incident in Cambodia where a beekeeper encountered a substantial loss of 70 bee colonies due to exposure to fipronil in a longan orchard.

An Asian honeybee colony killed by pesticides poisoning in Cambodia.
Photo credit: Eric Guerin.

Table 01. List of some pesticides classes that has high risk of poisoning bees and their symptoms (Kumar et al., 2020; Shepherd et al., 2021)

Pesticides	Toxic Symptoms to Bees
Organophosphates 1. Chlorpyrifos 2. Diazinon 3. Dicrotophos 4. Dicholorvos 5. Fenitothion 6. Malathion 7. Methidathion 8. Methyl Parathion 9. Paraoxon 10. Parathion 11. Phorate 12. Phosmet 13. Phosphamidon	1. Vomiting of consumed food 2. Disoriented movements 3. Distended abdomens 4. Erratic movement of the bees 5. Wings hooked together, held away from body 6. Prolonged proboscises 7. Death of the bee
Carbamates 1. Oxamyl 2. Mehomyl 3. Carbaryl 4. Carbofuran 5. Aldicarb 6. Bendiocarb 7. Aminocarb	1. Erratic movement of the bees 2. Stupefaction (numb) 3. Immobilization 4. Break in brood cycle 5. Queen ceases egg laying 6. Emergence of replacement queen bees 7. Extensive colony mortality
Neonicotinoids 1. Imidacloprid 2. Thiamethoxam 3. Clothianidin 4. Dinotefuran	1. Impairing the ability of foraging honey bees to return to the hive 2. Reduced motor function, 3. Disoriented movements 4. Erratic movement of the bees 5. Tremors

Pyrethroids 1. Bifenthrin 2. Cyfluthrin 3. Esfenvalerate 4. Fenpropathrin 5. Gamma-Cyhalothrin 6. Lambda-Cyhalothirn 7. Permethrin 8. Pyrethrin + PBO 9. Pyrethrum 10. Zeta-cypermethrin	1. Vomiting of consumed food 2. Erratic movement of the bees 3. Immobilisation 4. Many bees die between foraging area and colony

Table 02. List of herbicides and fungicides that are harmful to bees (Kumar et al., 2020)

Herbicides	Fungicides
1. 2,4-DB acid 2. 2,4-DP-P, dimethylamines 3. Trifloxysulfuron-sodium 4. Pendimethalin 5. Triclopyr, butoxyethyl ester 6. Alachlor 7. Simazine 8. Atrazine 9. Picloram, potassium salt 10. Glyphosate, isopropylamine 11. 2,4-D, 2-ethylhexyl ester	1. Dicloran 2. Captan 3. Dodine 4. Propiconazole 5. Ziram 6. Thiram 7. Sufur 8. Mancozeb 9. Trifloxystrobin

Pesticides are also detectable in bee products as a result of their exposure. A global study conducted by Mitchell, et al., in 2017 aimed to identify traces of five pesticides (acetamiprid, clothianidin, imidacloprid, thiacloprid, and thiamethoxam) in 198 samples. The study revealed that 75% of the samples contained at least one of the tested compounds, 45% of the samples had two or more compounds, and 10% of the samples exhibited the presence of four to five of the tested compounds. In a study conducted by Amulen, et al., in Uganda in 2017, traces of pesticides such as imidacloprid, dimethoate, thiacloprid, fenitrothion, chlorpyrifos, and various other compounds were identified in beeswax.

Neonicotinoids

Although nearly all pesticides affect bees, neonicotinoid pesticides have known to have significant detrimental effect on bees. Neonicotinoids, often known as "neonics," are insecticides derived from nicotine. Their mode of action involves binding tightly to nicotinic acetylcholine receptors within the central nervous system of insects. This binding leads to excessive stimulation of nerve cells, resulting in paralysis and eventual death of the insect. Notably, neonicotinoids exhibit high water solubility, persist in the environment for extended periods, and can permeate all parts of treated plants. In less than two decades, neonicotinoids have surged to become the most prevalent class of insecticides worldwide, commanding a staggering global market share of over 25% (Van der Sluijs et al., 2013).

Studies have shown that neonicotinoids, including imidacloprid, clothianidin, dinotefuran, and thiamethoxam, pose significant threats to honey bees. These pesticides have been linked to issues such as impaired flying and navigation, decreased taste sensitivity, and slower learning abilities, all of which adversely affect the bees' foraging capabilities. Additionally, similar research also indicates that bumble bees exposed to neonicotinoids experience reduced food consumption, reproduction rates, worker survival, and foraging activity (Hopwood et al., 2012). Countries like Italy, Germany, Austria and Slovenia have observed that during spring, when corn seeds treated with neonicotinoids are being planted, there is a clear link to a large number of bee deaths. This happens when bees come into contact with the dust cloud around the machines used to plant the seeds. Bees are affected while they are out looking for food in nearby forests or flowering fields (Van der Sluijs et al., 2013).

Parasites and Diseases

Invasive and newly established species, whether they are plants, other free-living animals, or parasites and pathogens, can have a substantial impact on the survival of bee populations in their habitats (Stout & Morales, 2009). Since the 1980s, many Asian honeybee populations have been seriously impacted by the Thai Sac Brood virus, a pathogen that tends to be fatal to colonies as it targets early pupal stages (Olroyd & Nanork, 2009). In a study by Toledo-Hernández et. al., in 2022, infection from microsporidia *Nosema ceranae* affects stingless bees like *Tetragonisca fiebrigi* and *Scaptotrigona jujuyensis*. Apart from that, mites like *Carpoglyphus lactis* affects *Trigona iridipennis, Pyemotes* sp. affects *Tetragonula iridipennis, Tetragonisca angustula* and *Frieseomelitta varia*.

> During the winter of 2006–2007, some beekeepers began reporting unusually high losses, ranging from 30 to 90 percent of their hives.

The sudden increase in honeybees falling prey to parasites and diseases is likely a consequence of pesticide exposure, making them more vulnerable to these attacks. This phenomenon was indeed highlighted in the 2012 study conducted by Pettis et al., which found that imidacloprid exposure promoted *Nosema* spp. infections. *Nosema* parasites reside in the digestive tract of honeybees, reducing the lifespan of individual bees and weakening or even killing entire colonies. The study's findings underscore the complex interplay between pesticide use, parasite infections, and the overall health of honeybee populations.

Climate Change

Almost all synthetic pesticides are derived from fossil, thus contributes to climate change which is also a threat to the bees' colony. For bees, habitat loss isn't solely about the physical space required for their habitation; it also involves the diversity of plant species accessible for their sustenance. Climate change can pose challenges to specific plant species' ability to flourish in particular regions, thereby impacting the available food sources for bees. As per Brown and Paxton's report in 2009, habitat loss, which encompasses habitat degradation and complete destruction, emerges as the primary factor contributing to the decline in bee populations, mirroring the broader trend in biodiversity loss. Habitat fragmentation, which directly results from habitat loss, exerts an influence on the remaining bee populations.

Due to climate change, as global average temperatures increase, it disrupts fragile ecosystems. In a study conducted in 2023 by Kenna et al., it was observed that bees exhibit a noteworthy decline in their flight performance as temperatures increase. Dr. Richard Gill, the lead researcher of the study quoted that "The frequency to which bees will be exposed to pesticides and extreme temperatures under climate change are predicted to increase". Elevated temperatures can trigger flowers to bloom weeks or months earlier than their typical schedule or result in shorter flowering durations. Bees, which have adapted to precise patterns of pollen and nectar availability, can be significantly affected by even minor alterations in seasonal plant growth. Irregular rainfall patterns can sometimes occur as a consequence of climate change. This irregularity can impede the foraging efforts of bees, ultimately leading to food scarcity and, in turn, the starvation of the colony. Additionally, this disruption can lead to the development of bees that are considerably weaker, rendering them more susceptible to the parasites and diseases mentioned earlier.

Colony Collapse Disorder

Colony Collapse Disorder (CCD) is a phenomenon that occurs when the majority of worker bees in a colony abruptly disappear, leaving behind a queen, an ample food supply, and only a few nurse bees responsible for tending to the remaining immature bees and the queen. During the winter of 2006–2007, some beekeepers began reporting unusually high losses, ranging from 30 to 90 percent of their hives. Alarmingly, up to 50 percent of the affected colonies exhibited symptoms that did not align with any known causes of honey bee mortality (US EPA, 2013). Numerous theories have been put forth regarding the potential causes of CCD, but researchers have yet to arrive at a definitive conclusion.

A World Without Bees

The extinction of all the world's bees would have profound ripple effects throughout ecosystems. Numerous plants, including those that rely exclusively on particular bee species for pollination, like the bee orchids, would face extinction without human intervention. This would disrupt the balance of their habitats and impact the interconnected food webs, potentially leading to further extinctions or declines in dependent organisms (Petruzzello, 2019). Moreover, many fruits and vegetables heavily depend on insect pollination, and their large-scale, cost-effective cultivation would be severely compromised without bees. While hand-pollination is a possibility for most fruit and vegetable crops, it is labour-intensive and expensive, likely resulting in underdeveloped produce.

In the absence of bees, the availability and diversity of fresh produce would substantially diminish, potentially compromising human nutrition and endangering human.

"The extinction of all the world's bees would have profound ripple effects throughout ecosystems."

Call For Action

Photo by Photografiero.

It is evident that action is imperative to halt and reverse the ongoing declines in bee populations and ensure the preservation of their biodiversity for the future. Implementing a ban on the use of highly hazardous pesticides (HHPs) such as neonicotinoids and fipronil is a crucial step in safeguarding bees and their colonies from poisoning. This measure also contributes to mitigating the impacts of climate change. Moreover, banning these HHPs aids in preventing pesticide residues from contaminating honeybee products, which could have adverse effects on both humans and the environment.

According to the United Nations (UN), governments and decision-makers play a pivotal role in safeguarding pollination services and biodiversity by implementing strategic measures aimed at strengthening community participation, particularly that of indigenous peoples who possess invaluable knowledge of ecosystems. This can be achieved through policies that prioritize the inclusion of local communities in decision-making processes, ensuring their insights and perspectives are considered in environmental management initiatives. Additionally, enforcing strategic measures, such as providing monetary incentives for adopting pollinator-friendly practices, can incentivize behavioural change among stakeholders, encouraging the adoption of sustainable agricultural methods that support pollinator populations. Moreover, fostering increased collaboration between national and international organisations, as well as academic and research networks, is essential for effectively monitoring and evaluating pollination services. By working together across sectors and borders, stakeholders can collectively assess the health of pollinator populations, identify emerging threats, and implement evidence-based conservation strategies to protect these vital ecosystems and the services they provide.

Supporting non-governmental organisations (NGOs) that advocate for the cessation of pesticide use, particularly neonicotinoids, is vital for protecting our pollinators. For instance, Pesticide Action Network Europe (PAN Europe) consistently campaigns for the reduction and elimination of pesticides to safeguard bees and farmers. Similarly, PAN North America (PANNA) advocates for the protection of bees from neonicotinoids and operates the Honey Bee Haven website to aid bees and other pollinators affected by commonly used pesticides. Additionally, organisations like Pollinator Partnership Canada, The Bee Girl Organization, The Honeybee Conservancy, Wheen Bee Foundation, World Bee Project and others are actively engaged in campaigns to shield bees from harm, particularly from pesticides. Therefore, it is crucial for us to support these organisations in their efforts to protect our pollinators.

PANAP and its partners work to protect bees and other pollinators through advocating for the phase out of HHPs and promoting agroecology as an alternative to chemical-dependent corporate agriculture. Additionally, the 2024 Protect Our Children from toxic pesticides (POC) campaign aims to empower young people to advocate for their right to a clean and toxic-free environment under the theme "Pollinators Matter! A pesticide-free future for children and the environment." Please support PANAP's work by sharing resources on media and social media, as well as donating to PANAP to continue its work in ensuring food security, protecting farming communities, and fighting against the decline of biodiversity.

Beekeepers and farmers can contribute significantly to the protection of pollinators and biodiversity by implementing practical measures within their operations. One crucial step is to reduce or stop the usage of pesticides and opting for safer alternatives or applying them judiciously to minimize harm to pollinators. Diversifying crops within agricultural landscapes is another effective approach, as it provides a variety of food sources for pollinators throughout the growing season. Planting attractive crops that offer abundant nectar and pollen can help sustain bee populations and enhance their foraging opportunities. Additionally, creating hedgerows and other natural habitats within or around fields provides essential shelter, nesting sites, and foraging areas for bees and other wildlife, promoting biodiversity and ecosystem resilience.

Each of us can contribute to the preservation of bee populations and biodiversity in our own way. Individually, we can start by planting a diverse array of native plants in our gardens or outdoor spaces, ensuring that they flower at different times of the year to provide continuous food sources for bees. Supporting local farmers by purchasing raw honey and products from sustainable agricultural practices helps to sustain beekeeping operations and promote environmentally friendly farming methods. In our own gardens, avoiding the use of pesticides, fungicides, or herbicides is crucial to safeguarding bee health and preserving their habitats. Whenever possible, protecting wild bee colonies and sponsoring a hive can make a tangible difference in supporting bee populations. Setting up a bee water fountain by leaving a shallow water bowl outside provides bees with access to clean water, essential for their hydration needs. Contributing to the conservation of forest ecosystems also indirectly supports bee habitats and biodiversity. Additionally, raising awareness within our communities and networks about the importance of bees and the threats they face can inspire collective action towards their conservation.

World Bee Day is marked each year on May 20th. An FAO guide on pollinator-friendly agricultural production released on World Bee Day in 2023 provides additional insights into how individuals and communities can contribute to bee conservation.

At the international level, progress must be made on key global initiatives crucial to safeguarding bees and establishing a conducive environment for their prosperity. The Convention on Biological Diversity (CBD) and its Kunming-Montreal Global Biodiversity Framework (KMGBF) play a pivotal

> "Bees play a pivotal role in maintaining the ecological balance and ensuring the availability of diverse and nutritious food. Their conservation is not just about safeguarding their future but also securing our own."

role in addressing the various challenges that bees face. Target 7, focused on reducing pollution risks, and Target 9, centred on sustainable wild species management, highlight critical aspects of protecting biodiversity. Pesticide Action Network UK (PAN UK) underscores that to meet the mandate of the KMGBF on pesticides, governments need to:

- reduce the overall use and toxicity of pesticides (pesticide load / toxic load) by at least half by 2030, with the most effective single action being the phase out of the use of Highly Hazardous Pesticides (HHPs);
- dramatically increase investment in and implementation of agroecological farming practices;
- eliminate subsidies and other incentives that support pesticide use, and redirect incentives to implement agroecology and non-chemical alternatives to pesticides; and
- ensure companies monitor, assess and publicly disclose the biodiversity impacts of their pesticides-related activities.

Moreover, the Global Framework on Chemicals includes a target for governments, the private sector, and other stakeholders to phase-out HHPs by 2035, as well institute measures to promote non-chemical alternatives. Concrete efforts must be made to ensure these commitments are delivered, and a Global Alliance mandated to steer the work towards the phase out of HHPs is operationalised.

Most crucially, safeguarding bees and other pollinators rests upon upending profit-oriented, corporate-controlled global food systems that drive increasing habitat loss, use and toxicity of pesticides, and climate change impacts. Measures to protect and conserve these remarkable, nature's tiny powerhouses will be most meaningful if undertaken within the framework of transforming food systems with people's food sovereignty – a central principle of the agroecological transition – at its core.

The future of bees and their invaluable contributions to ecosystems and agriculture depend on our collective efforts to mitigate the major threats posed by pesticides, habitat loss, and climate change. Whether it's advocating for stricter pesticide regulation, planting bee-friendly flowers, or engaging with communities towards more transformational change, each action, no matter how small, contributes to the preservation of these essential pollinators. Bees play a pivotal role in maintaining the ecological balance and ensuring the availability of diverse and nutritious food. Their conservation is not just about safeguarding their future but also securing our own.

> "The conservation of bees is not just about safeguarding their future but also securing our own."

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