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# The Ecological and Economic Significance of Honey Bees: Challenges and Management in Indian Apiculture

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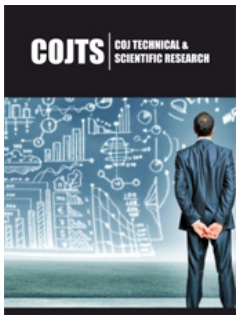


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## Abstract

Honey bees (*Apis spp.*) are essential to ecosystems as pollinators of one-third of the world's crops and producers of valuable products like honey, beeswax, and royal jelly. In India, beekeeping thrives due to diverse agro-climatic conditions, with Uttar Pradesh as a leading producer. Key honeybee species include *Apis dorsata, Apis cerana indica, Apis florea, Apis mellifera*, and stingless *Melipona irridipennis*. Honey bee products hold nutritional, medicinal, and industrial significance, but their populations are threatened by pests, pathogens, and environmental stressors. Common threats include wax moths, ants, mites, and viral, bacterial, and fungal diseases. Effective beekeeping management practices such as pest monitoring, hive hygiene, controlled breeding, and maintaining proper nutrition are essential to sustaining colonies and enabling bees to fulfill their ecological and economic roles. Promoting colony health and resilience is vital for ongoing honey production and agricultural pollination services.

**Keywords:** Pollination; Apiculture; Honey bee products; Pest management; Colony health

## Introduction

Honey bees (*Apis spp.*) are the selfless servants of our ecosystem, playing a vital role in pollinating one third of the world's crops and producing an array of valuable products. Apiary is a place where honey bees are reared and the science of rearing and managing colonies of honey bees for their honey, wax and other valuable products is known as apiculture. India's diverse agro-climatic conditions make it ideal for beekeeping and honey production. As per the recent data, production of honey in India was about 133.20 (000'MT) (2021-2022 2nd advance estimate, NBB). Uttar Pradesh leads in production of honey with 22.5 (000'MT). More than 50% of the honey produced is exported to the major markets of Indian honey- USA, UAE, Saudi Arab, Bangladesh, Canada, etc. The country has exported 107.96 (000'MT) of honey for the worth of Rs. 1470.84 crore during year 2023-24 (APEDA).

### Species of honey bee

***Apis dorsata* (Rock bee):** Rock bees are the largest among all other species of bees. They construct single comb in open area. Rock bees produce maximum honey among all other species (around 36 kg honey/comb/year), but due to their ferocious nature and habit of absconding they are difficult to domesticate.

***Apis cerana indica* (Indian hive bee):** Indian bees are medium in size, less ferocious and can be reared easily as compared to *Apis dorsata*, but they produce less amount of honey (5kg/comb/year). Indian bees are famous for cavity nesting as they make multiple parallel combs on dark cavities. They are also more prone to swarming and absconding.

***Apis florea* (Little bee):** These are the smallest bees and are mainly found in plains and

not in hilly regions (above 450m). *Apis florea* is not considered for rearing as they produce only about half kg honey/ hive/year and are highly prone to absconding.

***Apis mellifera* (European or Italian bee):** Italian bees are the most preferred bee species for rearing as they produce on an average 35kg honey/hive/year as well as they are less prone to swarming and absconding. They are imported from European countries and are now commercially grown in India. Italian bees are larger than Indian bees but smaller than Apis dorsata. They make multiple parallel combs in darkness.

***Melipona irridipennis* (Danner bee):** These are the stingless bee species. Amongst the insect order, honey bees are considered to be the social insects as they live in colonies. A normal colony is composed of 3 different castes i.e. queen, female workers and male drones.

Queen (only functional female in the hive) is the mother of the whole colony producing workers (from fertilized eggs) and drones (from unfertilized eggs). Queen bee is largest in size as compared to workers and drones, but consists of small wings. After 5-10 days of emergence, queen mates with drones in one or more nuptial flights. When her spermatheea is filled with sperms, she will start laying eggs and will not mate anymore. On an average queen may lay 1500-2000 eggs/day. Queen releases pheromone known as queen substance from the mandibular gland which helps in colony organization, brood rearing, hoarding & foraging in a colony, inhibiting ovary development in worker bees and preventing swarming and absconding of colonies. When an old queen is unable to lay sufficient eggs, she will be replaced by supersedure queen. Drones are the male bees produced from the unfertilized eggs. The most important function of drone is to fertilize the queen. They also help in maintenance of hive temperature. Due to absence of stings, drones cannot collect nectar/pollen. Drones can live up to 60 days, although they are killed after the mating. Worker's bees are sterile females produced from the fertilized eggs. They are smaller in size as compared to queen and possess strong wings, large & efficient proboscis and well-developed sting. Hind leg of worker bees has "pollen basket" for collecting pollen. The lifespan of worker bee is around 6 weeks. They perform various duties according to their age such as household duties i.e. cleaning hives, feeding the larvae, etc. (Day 1-14), guard duties (Day 14-20) and foraging (Day 21-35).

## Communication system in bees

**Round dance:** It is used to indicate food source in short distance (less than 50-100m).

**Wag-tail dance:** It is used to indicate food source in long distance (more than 100m).

## Major comb-derived products

**Honey:** Honey is a wholesome food produced by bees from the nectar of flowers. Foraging bees gather the nectar and process it by digesting and regurgitating it multiple times to create honey. This results in an 80% sugar solution, predominantly made up of fructose and glucose, with smaller amounts of sucrose, maltose, and other complex sugars [1]. The main bioactive components of honey include oligosaccharides, methyl-glyoxal, royal jelly proteins and phenolic compounds. Honey has been shown to be an oxidizing agent with anti-inflammatory, pro-apoptotic, anti-proliferative, anti-metastatic, and immune-modulatory qualities [2]. Honey can be divided into two primary categories based on the source of nectar: floral honey (nectar of flowers) and honeydew honey (secretions of living parts of plants or excretions of plant-sucking insects on plants).

**Beeswax:** Beeswax is a natural wax produced by honeybees, specifically by worker bees, which secrete it from specialized glands located in their abdominal segments. The wax is used by bees to construct their honeycombs, where they store honey and pollen, and where their larvae develop. Beeswax is primarily made up of fatty acid esters, hydrocarbons, free fatty acids, alcohols, vitamins and minerals, pollens and plant resins. Beeswax is predominantly essential for the candle and beekeeping sectors, where it is used to create foundation sheets for honeycombs. Additionally, it plays a vital role in the production of cosmetic products. The pharmaceutical and fragrance industries are also significant consumers of beeswax, incorporating it in items like ointments, pill coatings, and deodorants. Moreover, beeswax is commonly employed in the creation of shoe polish and varnishes.

**Royal jelly:** Royal jelly is a milky white to yellow jelly fluid which is produced by worker bees from their hypo pharynx gland to feed the larvae and the adult queens. It is composed of proteins 15-18%, lipids 2-6%, carbohydrates 9-10% and minerals 0.7-1.2%, and it contains 65-70% moistures.

**Bee pollen:** Bee pollen is collected by bees from plant flower pollen, which they mix with nectar or secretion from their salivary glands. The bees transport it to the hive, attaching it to the pollen basket present in their hind legs. Once inside the hive, flightless bees combine the pollen with their saliva and pack it into honeycombs, which are then coated with a mixture of wax and honey (Figure 1). Bee pollen is marketed as a dietary supplement and is said to possess anti-inflammatory and antibacterial properties [3,4].

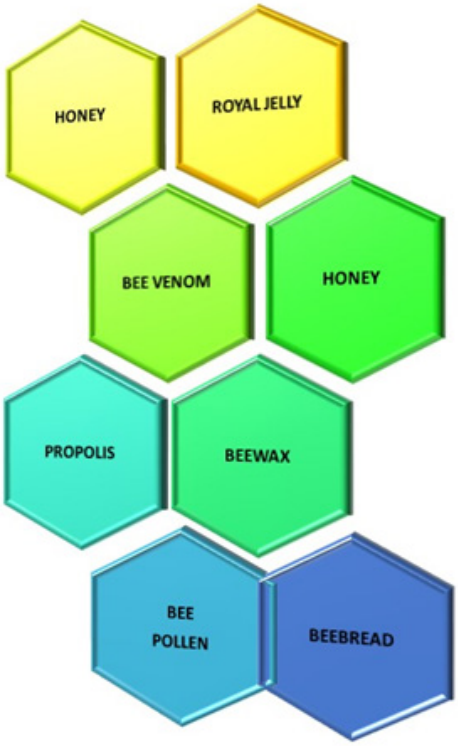


**Figure 1:** Products offered by Honey bee.

**Propolis:** Propolis is a resinous substance made by honeybees from the sap of trees, buds, and other plant materials. The bees combine this sap with their saliva and beeswax to form a sticky resin, which they use to stick frames, seal cracks and crevices. The quality and quantity of propolis collected are determined by plant diversity and availability, the source and duration of collection, beekeeping skills and practices, and environmental health [5,6]. Its antifungal and antibacterial properties help protect the colonies from diseases and infections and restrain the growth of decomposing bacteria. Propolis is used in medicines to cure inflammation and boost immunity [7].

**Bee bread:** Bee bread is a highly nutritious, fermented product created by honeybees, serving as an essential food for the hive and offering potential health benefits when consumed by humans. Bee bread is stored in the honeycomb cells and is often sealed with a layer of honey or wax to preserve it. Bee bread is a highly nutritious food source. Its primary components include protein, vitamins like B1, B2 and B12, magnesium, potassium, lipids, enzymes and antioxidants. Because of its biochemical richness, this natural product might be utilized to improve immunity, regulate digestive system function, and have antibacterial, anti-aging, and anti-anemia properties [8].

**Bee venom:** Bee venom is a complex, biologically active substance produced by honeybees primarily as a defense mechanism to protect the hive from predators or threats. This transparent, acidic substance is expelled through the bee's stinger. It consists of a combination of enzymes, sugars, amino acids, minerals, and compounds with both inflammatory and anti-inflammatory properties. Bee venom is used in treating conditions like arthritis, multiple sclerosis, and potentially even cancer.

## Major threats to honey production

Honey bees, native to Asia and Europe, play a crucial role in both environmental and economic contexts. These insects are essential for pollinating wild flowering plants as well as key agricultural crops, making them highly valuable [9]. Bees, however, are exposed to various harmful pathogens, such as viruses, both internal and external parasites, bacterial infections, excessive exposure to environmental pesticides, and a lack of access to nutritious food sources [10]. Some of the major threats to bee population and honey production are listed below:

**Insects/ pests:**

**a) Greater wax moth:** In tropical and sub-tropical Asia, the greater wax moth (*Galleria mellonella*) is commonly known to damage both honey bee colonies and bee products. It tends to cause the most harm between July and October, as well as from November to December. When left improperly stored or unattended, items like empty combs, rendered wax, comb foundation, and bee-gathered pollen are highly susceptible to infestation and damage by the wax moth.

**b) Lesser wax moth (*Achroia grisella*):** Weak honey bee colonies are usually the ones affected by lesser wax moth infestations. The larvae are attracted to dark combs, especially those with pollen or brood. They are commonly found on the bottom board, surrounded by wax fragments. Preferring to create small passageways beneath the brood cells, the larvae raise the brood. Meanwhile, the bees continue constructing new cells in an upward direction, resulting in the familiar scratched appearance of the comb. Management practices of greater and lesser wax moth include protection of weak colonies by uniting 2 or 3 colonies, holes or cracks should be sealed properly as they can serve as entrance for wax moth and other bee predators, regular cleaning of bottom board, display of infested combs to sunlight for 15-20min. Stored combs can be protected by keeping them at low temperature (0-10°C) for 5 hours or permanently. Another way to protect stored combs without degrading its quality is by using water soluble concentrate of spores of *Bacillus thuringiensis* Serotype 7.

*c) Ants:* Ants are the most common predators of honey bees. They may invade honey bee hives, especially when the bees are not as vigilant, such as during poor weather or when a colony is weakened. Ants can target the hive's entrance, attempting to steal honey, pollen, or even brood (larvae and pupae) from the bees. Ant infestation can be prevented by maintaining hive hygiene, using traps, placing the hive on stand or platform to restrict ants' entry and using ant repellents.

*d) Wasps and hornets:* Wasps are natural predators of honey bees and can pose a significant threat to their colonies. Some common wasps that attack honeybees are:

**i. *Vespa spp.* (Hornets):** *Vespa spp.* is well equipped for the hunting of bees, they have a larger body size compared to their prey, a heavy chitinous armor to resist bee attacks and their strong mandibles and venomous sting make them a deadly nemesis for honey bees of different species [11].

**ii. *Vespula spp.* (Yellow jackets):** Yellow jackets are aggressive social wasps that prey on honey bees. Attracted to sugary substances like honey and nectar, they can invade bee colonies to kill worker bees and steal honey supplies [12].

**iii. *Dolichovespula maculate* (Bald faced hornets):** Bald-faced hornets are opportunistic predators and often target honeybee colonies to feed on the worker bees. Worker bees are particularly vulnerable when they are out foraging or when they are weakened due to stress or disease.

Management practices involved regular monitoring of bee colonies, setting up hornet traps, removal of hornet nests located near apiary, strengthening defense mechanism of bees to protect their hives and in serious infestation of wasp, insecticide is applied.

**e) Honey bee mites:** Small parasitic arachnids, such as *Varroa destructor* and *Acarapis woodi,* pose significant threats to honeybees. These mites damage individual bees and entire colonies, weakening them and spreading diseases. If left unmanaged, they can ultimately cause the collapse of the entire colony.

**i. Varroa mite (*Varroa destructor*):** *Varroa destructor* and *Varroa jacobsoni* are external parasites of honeybee. These are small red mites which not only attack on the adult honey bee but they also multiply on larvae and pupae of developing brood and spread viral diseases [13].

**ii. *Acarapis* mite (*Acarapis woodi*):** This mite, attack the tracheal system of the adult bees, therefore known as endoparasitic mite. These mites are less visible than Varroa mites but can still cause significant damage, particularly in colder climates. Bees infected by *Acarapis* mite may appear weak and disoriented.

Management practices involve regular monitoring of hives for mite infestation, application of chemicals such as oxalic acid and formic acid, breeding mite-resistant bees and hive maintenance.

**f) Birds:** There are many predatory bird species that feed on honey bees such as *Merops apiaster, Pernis apivorus, P. ptilorhynchus* etc. Even though they are less harmful than pests such as mites, these birds can still negatively impact colonies by feeding on adult bees, brood, or stored honey. To minimize the impact of birds on honeybee colonies, some of the management practices which can be adopted are use of bird nets, regular monitoring for bird activity and placing hives in naturally covered areas.

**Diseases:**

**a) Fungal diseases**

**i. Nosema diseases:** *Nosema apis* and *Nosema ceranae*, two species of spore-forming fungi (microsporidians), are the main parasites responsible for causing Nosema disease [14]. Common indicators of nosema infection are bees failing to fly, excreta on the combs or entrance boards, and dead or weak bees found on the ground near the hive. Nosema diseases can be controlled by maintaining hygiene as well as providing adequate ventilation in the colonies. In case of severe infestation of diseases application of antibiotic such as fumagillin is done to inhibit the growth of the nosema spores within the bee's digestive system. Some beekeepers are breeding honeybee strains that show increased resistance to *Nosema infection*, particularly Nosema ceranae. These bees may be better able to withstand the infection without suffering as much damage.

**ii. Chalk brood diseases:** The fungus responsible for chalkbrood disease is *Ascosphaera apis*. As nurse bees feed larvae, the larvae unknowingly consume the spores, which then grow in their digestive tract, causing them to starve and die [15]. At first, the deceased larvae expand to fill the cell and are coated in the fungus's white mycelium. Over time, they mummify, become firm, shrink, and take on a chalky, dry appearance. To manage chalk brood disease in honeybees, infected larvae and mummies should be removed and discarded,

and contaminated frames should be replaced to reduce the fungal spore load. Regular monitoring, especially during spring and fall, will help detect early signs of the disease, allowing for timely intervention. Breeding for naturally resistant bees may also help reduce disease occurrence over time.

**b) Bacterial diseases**

**i. American foul brood diseases:** American foulbrood, caused by the bacterium *Paenibacillus larvae*, is a disease that targets bee larvae. Larvae of workers, drones, and queens all become infected when they ingest spores in their food. Initially, the disease may only cause a few older larvae or pupae to die, but if no corrective action is taken, it can rapidly spread to other colonies. Infected larvae turn brown and eventually become a dark, sticky mass [16]. Early detection of diseases is beneficial to avoid spread of AFB. Affected colonies and instruments should be isolated and destroyed. Antibiotics such as oxytetracycline can be used to treat AFB.

**ii. European foul brood diseases:** Another bacterial infection that affects honeybee larvae is European Foulbrood (EFB), which is caused by the bacterium *Melissococcus pluton*. The infection spreads through contaminated food, such as pollen or nectar that the nurse bees feed to the larvae. The larva affected by EFB are younger than the larva affected by AFB, they are commonly 3-5 days old. Infected larvae appear discolored (often yellowish or brown) and diseased larvae may look deformed, exhibiting a twisted or curved shape. Management practices followed under EFB are similar to that of AFB.

**c) Viral diseases**

**i. Sac-brood diseases:** Sac brood, a viral disease impacting the brood of *Apis mellifera*, causes the larvae to appear in a sac-like shape. It is perhaps the most common viral affliction found in honey bee colonies. In Asia, including India, two primary strains have been recorded: one that affects *Apis mellifera* and another called Thai sac brood that targets *Apis cerana*. Infected larvae do not undergo pupation after four days and the head and thorax of the affected larvae may darken and become rubber [17]. When removed from the cells, the larvae have a tough skin and a watery interior. Although there is no complete cure for this disease, effective management practices can help mitigate its effects and prevent its spread within a colony. Some of the key management practices followed to prevent sac-brood diseases are regular hive inspection, reduce overcrowding, maintain proper ventilation, removal of infected bees and broods, reduce exposure to other diseases and maintain hive hygiene [18].

## Conclusion

Honey bee products like honey, beeswax, and pollen are valuable to both humans and the environment. However, honey bees face many challenges from pests, diseases, and environmental stress. Effective management practices, such as proper hive care, pest control, and good nutrition, are crucial to protect bee colonies. By taking these steps, beekeepers can help ensure the health of bees, allowing them to continue their important role in pollination and the production of honey bee products.

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