A Review: On the Parasitic Mites and Its Impact on the Honey Bee Spp. (Apis mellifera) and Their Colony

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Abstract

Apis mellifera, one of the most significant species of honey bee, provides crop pollination and also provides a wide variety of products. Currently, the parasitic mite has become the most damaging pest of the honeybee, *Apis mellifera,* and also one of the main factors for the colony loss faced by the beekeepers across the world. It mostly parasitizes the honey bee, *Apis mellifera* colony, by sucking the hemolymph of both developing and adult bees, resulting in the transmission of different types of pathogens such as bacteria and viruses, which cause several morphological deformities in developing bee and destroy the large number of honey bee, *Apis mellifera,* colonies. This study may reveal the parasitic impact of mites on honeybee, *Apis mellifera* and their colonies, along with the diseases caused, their prevention, control and the effect of certain environmental factors on them. The studies may also be effective for the taxonomical studies of the parasitic mites and also impart the additional information for further treatment of these parasites.

Key words: honey bee, *Apis mellifera*, pest, parasitic mite, haemolymph and parasite.

1.0. General Introduction

Apis mellifera plays a crucial role by pollinating the crops and maintaining the biodiversity as well as the ecosystem. The honeybee mainly produces a large variety of products, such as honey, bee wax, propolis, etc., having commercial benefits and being essential to the economy of the world. In addition to producing honey, the honey bee also helps in the pollination of a wide variety of blooming plants. They play a major role in the world's food output by contributing to the pollination of nuts, seeds, fruits, and vegetables. Over 90 crops have been identified to be pollinated by honey bees on a worldwide basis (Free, 1993).

Apis mellifera is considered one of the most beneficial honeybee species of the genus *Apis,* which is essential for pollination of crops as well as honey production. It is indigenous to Europe, Africa, and the Middle East, but because of its economic significance and it has been imported to many other regions of the globe. It is one of the most well-known and extensively researched bee species (Seeley, 2011). The *Apis mellifera* is a social insect, which implies that it has a highly structured social organization that includes a division of labor out of distinct

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castes. It is familiar that honey bees have a remarkable ability to communicate via their complicated "waggle dance." They alert other colony members where food supplies are located by performing these dances. Within the hive, effective resource allocation and foraging are made possible by this innovative communication system (Winston, 1987).

Parasitism is a relationship between organisms in which a particular organism, termed the parasite that feeds on another organism, known as the host, frequently harms the host during the course of their interaction (Poulin,2010).Parasites are found in many different organisms *viz.* animals, plants, and even microorganisms. There are several kinds of parasites depending on the mode of interaction such as ectoparasites and endoparasites, which are located on the exterior and interior of their host's bodies respectively (Poulin and Morand, 2000).

Numerous pathogens and parasites, such as bacteria, viruses, fungi, parasitic mites, and microsporidia, attack the large number of honey bee species, becoming a threat to their survival and resulting in a major colony loss (Cox Foster *et al.,* 2007; Genersch *et al.,* 2010; Ratnieks and Carreck, 2010).

Mites are small arthropods that belong under the subclass Acari, the same class as spiders and scorpions, and are closely related to ticks. In addition to soil, water, plants, and animals, mites may be found in a large range of ecosystems. Mites feed in a variety of ways and act as scavengers, consuming decomposing debris, while others are predators, preying on other small organisms such as insects. The parasitic mites are one of them that consume their hosts' body fluids for their nourishment (Walter and Proctor, 2013).

1.1. Systematic Classification, morphological and developmental stages, ecology and behaviours of honey bee (*Apis mellifera)*

Kingdom	: Animalia
Phylum	: Arthropoda
Class	: Insecta
Order	: Hymenoptera
Family	: Apidae
Genus	: *Apis*
Species	: *mellifera*

(Source- https://en.wikipedia.org/wiki/Honey_bee)

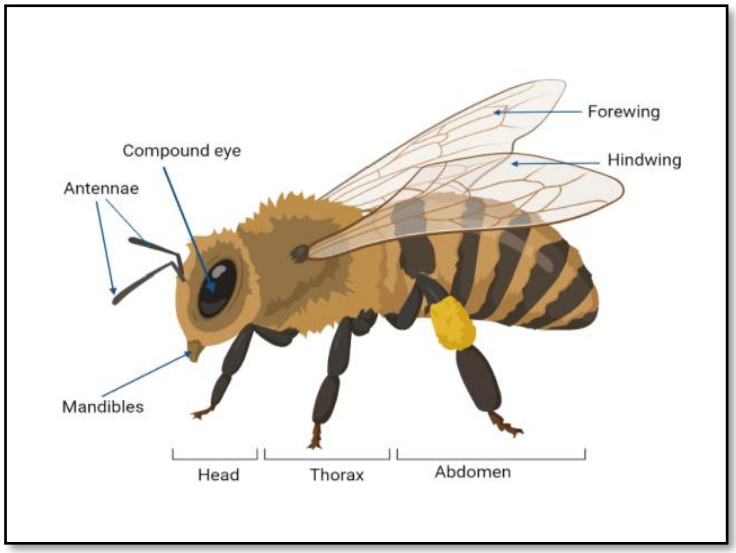


Fig.1.1. General Morphology of *Apis mellifera.*

(Source: Image created with the help of https://app.biorender.com)

Honeybees (*Apis mellifera*) have three distinct body segments, including the head, thorax, and abdomen. The honeybee thorax region having 3 pairs of legs and 2 pairs of wings and additionally, their hind legs contain pollen baskets (Clarke *et al*., 2002; Pinto *et al.,* 2004; Seeley *et al.,* 1982).

The life cycle of a honeybee comprises four stages: egg, larva, pupa, and adult. The queen drones and workers are the three primary castes of a honey bee colony. The female bee has the responsibility of producing eggs and is also known as the queen bee. Male bees, called "drones," are mostly concerned with mating with the queen bee. Non-reproductive females, called "workers," do several kinds of activities, including caring for and foraging the young bees and sustaining the beehive **(**Sammataro, 1998**).**

Worker bees mature and develop into adults in 21 days, whereas drone bees mature into adults in 24 days approximately. The average time for a queen bee to attain maturity is about 16 days (Adjare, 1990; Sammataro and Avitabile**,** 1998). A queen bee of *Apis mellifera* has a life span of about two to three years, while some have been reported to live for five years. The lifespan of a worker bee is usually a few weeks, although it might sometimes be as long as several months if their colony is dormant throughout the winter. Typically, drone bees survive for approximately 4 to 8 weeks only **(**Tarpy and Page Jr, 2001).

Honeybees forage as near to the hive as they can, frequently to a distance of three kilometers apart. They can fly up to 8 to 13 kilometers if required in order to get water and food (Percival, 1947; Sammataro and Avitabile, 1998).

Fragrance and taste are the primary senses used by *Apis mellifera* bees to perceive their surroundings and communicate with each other through chemical signals produced by them. The "dancing" behavior of *Apis mellifera* bees is well recognized as an especially remarkable mode of communication between each other (Breed *et a.,* 1985; Sammataro and Avitabile, 1998).

Apis mellifera obtains its nutrition by gathering pollen and nectar from flowers when they blossom. Additionally, they also consume the honey and secretions formed by other bee members (Adjare, 1990; Gonzalez *et al.,* 1995).

2. Parasitic mites infesting the *Apis mellifera* and their effect on the honey bee colonies

Honeybees are susceptible to pathogens and parasites, including bacteria, virus, protozoan's, and the parasitic mites. Among them, parasitic mite is one of the major problems faced by beekeepers of the honey bee, *Apis mellifera* which is also one of the causes of colony losses in most honey bee apiaries. The parasitic mite while consuming the haemolymph they the transmit viruses that causes to physiological deformities in developing bees (Small body size, shortened abdomens, and wings) and affect the flight duration and potential foraging habits.(Conte *et al*., 2010).

Mites weaken the immunity of the host bees by inhibiting the expression of genes involved in immunity. The honey bee is therefore seriously threatened by mite's infections. The identification of acute bee paralysis (ABVP) virus by RT-PCR techniques in honey bees and *Varroa destructor* was believed to indicate the existence of a common infectious agent present in the majority of apiaries (Hung *et al*., 1996).

2.1. Types of parasitic mite species that affect honey bees *Apis mellifera*

The majority of honey bee research studies reported that *Varroa and Tropiolaelaps* are the two genera of ectoparasites commonly known as parasitic mites, causing calamity to the honey bees and their colonies' survival. They have recently been shown to be major key factors for colony loss around the globe (Genersch *et al*., 2010; Martin *et al*., 2012; Nazzi *et al*., 2012).

2.1.1. *Varroa* mite

According to Anderson and Trueman, the *Varro* mite is native parasite of the Asian honey bee that only present in Asia originally. It is supposed to be one of the most harmful ectoparasites of honeybees (Ritter, 1981; De Jong *et al*., 1982).

The first *Varroa* mites were found among the European honey bee (*Apis cerana*) from Java, Indonesia, over one hundred years ago. They were given the name *Varroa jacobsoni* (Oudemans, 1904). They were subsequently placed in a new family, the Varroidae, and a new genus, *Varroa* (Delfinado-Baker and Baker, 1974). Currently, there are around four distinct species in the genus *Varroaviz.Varroa destructor, Varroa jacobsoni, Varroa rindereri* and *Varroa underwoodi* found across the world. *Varroa* mites are now known to be parasites of brood having a subspecies of the cavity-nesting Asian honey bees that have been interconnected to *Apis cerana*. As honey bees (*Apis* spp.) mature, *Varroa* mites (*Varroa* spp.) proliferate in their cells and they start feeding on adults and developing bees' haemolymph and spread secondary infections that shorten the lifespan of adult bees (Batuev, 1979; Ball and Allen, 1988; Yang and Cox-Foster, 2007; Dainat *et al*., 2011).

The following is an overview of the most recent taxonomy of *Varroa* found in Asian honey bees (Lindquist *et al.,* 2009).

Kingdom	:	Animalia
Phylum	:	Arthropoda
Class	:	Arachnida
Subclass	:	Acari
Superorder	:	Parasitiformes
Order	:	Mesostigmata
Family	:	Varroidae
Genus	:	*Varroa*

2.1.1.1. Morphological appearance and life cycle of *Varroa* mite

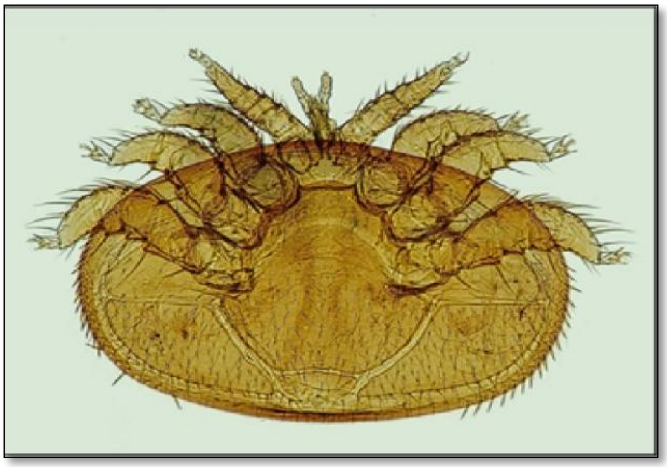


Fig.1.2. Morphological appearance of Varroa mite.

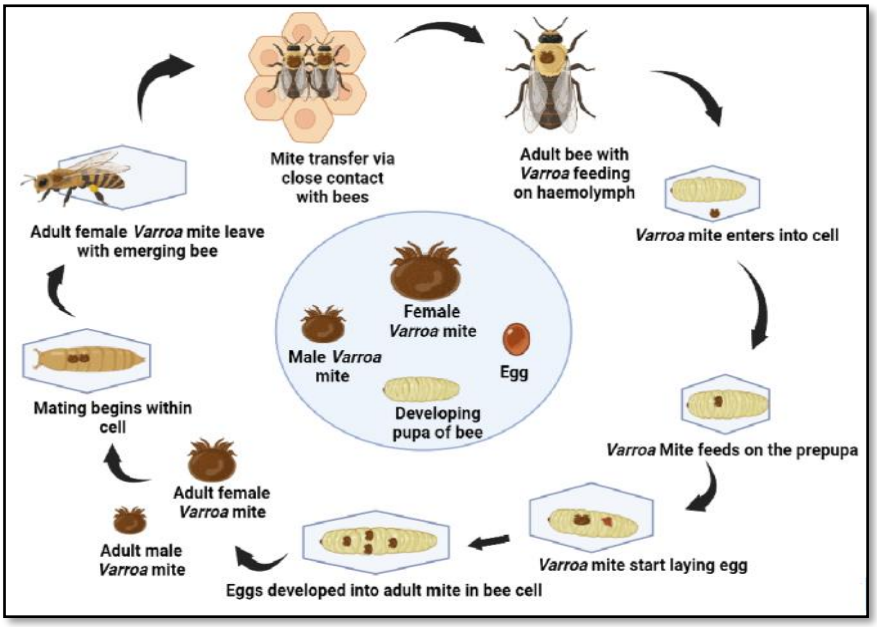
(Source- https://pixabay.com/illustrations/*Varroa*-mite-bee-parasite-1196510/)

Mature female mites of the genera *Varroa* have variations in coloration ranging from a reddish-brown to a slightly dark brown oval in shape. Their length ranges from 1.0 to 1.77 mm, while their width ranges from 1.5 to 1.99 mm (Ellish and Zettel Nalen, 2010).

Their curved bodies have the ability to fit within the abdominal folds of the adult bee, and they remain in that position, aided by their shape and the position of the ventral setae. The chelicerae of male mites are modified for the purpose to help the passage of sperm (Ellish and Zettel Nalen, 2010).

The eggs are white and oval in structure, and male and female protonymphs cannot be distinguished without dissection. The reproductive and phoretic phases are the two stages of the adult female *Varroa* mite's life cycle. When bees are in the phoretic phase, female *Varro* mite feeds on adult bees and spread from colony to colony as the bees approach one another. The female *Varroa* mites are attached to adult bees when they are foraging and are often located

in between the abdomen segments of the bees. Between the segments, *Varroa* pierces the soft tissue, where it then feeds on bee haemolymph (Ellish and Zettel, 2010).



(Source: Created with the help of https://app.biorender.com)

Fig.1.3. Diagrammatic representation of the Life cycle of *Varro* mite in a bee brood cell

2.1.2. *Tropilaelaps* mite

The *Tropilaelaps* mite is an obligatory ectoparasite that nourishes itself on the haemolymph of developing honey bees*, Apis mellifera*.The mite *Tropilaelaps* was first discovered in colonies of *Apis mellifera* in the Philippines, as well as on rats that lived near those colonies (Delfinado and Baker, 1961). The mites have elongated shape setae that resembled small spines on both male and female mites. *Tropilaelaps* have a reddish-brown color, however, males tend to be less sclerotized than females. *Tropilaelaps* are oval-shaped, smaller, and flatter than *Varro* mites.

The developmental process of *Tropilaelaps* has similarities to that of the *Varro* mite, with the exception that *Tropilaelaps* can infect simultaneously worker and drone brood cells (Kapil and Aggarwal, 1987, 1989). Compared to *Varroa*, the *Tropilaelaps* mite significantly raises its population exponentially in a bee colony (Sammataro *et al*., 2000).

A gravid female mite penetrates a brood cell before capping in an established bee colony and feeds on larval haemolymph for two days or less frequently, and then lays her first egg in a bee brood cell. There are generally three to four eggs that may be detected in a brood cell at any one time throughout the reproductive cycle and the first egg will develop into an adult male. It takes around 6-7 days for a fertilized egg to mature into an adult. The female mite and her young ones would emerge from the brood with the adult bee and may then enter other brood cells to mate with the opposite sex in the honeybee colony. When the host queen bee is not laying eggs, adult *Tropilaelaps* will enter a phoretic stage and remain on the bees' sclerites until

there are brood cells to parasitize (Koeniger and Muzaffar, 1988; Rinderer *et al*., 1994; Wilde, 2000).

Tropilaelaps mite species are mostly identified through molecular and morphological methods. *Tropilaelaps* mite infestations may easily be identified visually on bees or by examining hive debris. The presence of *Tropilaelaps* mites can be detected by irregular brood patterns, dead or deformed immatures, crawling bees with deformed wings, and especially by fast-moving, red-brown, elongated mites on the combs (Anderson & Morgan 2007).

Tropilaelaps spp. of mites are classified into the class Arachnida, subclass Acari, superorder Parasitiformes, order Mesostigmata and family Laelapidae (Anderson & Roberts, 2013).

Following a recent revision, the taxonomy of the genus *Tropilaelaps* mite is now as follows: (Lindquist *et al*., 2009; Anderson and Morgan, 2007).

Kingdom	:	Animalia
Phylum	:	Arthropoda
Class	:	Arachnida
Subclass	:	Acari
Superorder	:	Parasitiformes
Order	:	Mesostigmata
Family	:	Laelapidae
Genus	:	*Tropilaelaps*

2.1.2.1. Morphological appearance and life cycle*Tropilaelaps* mite

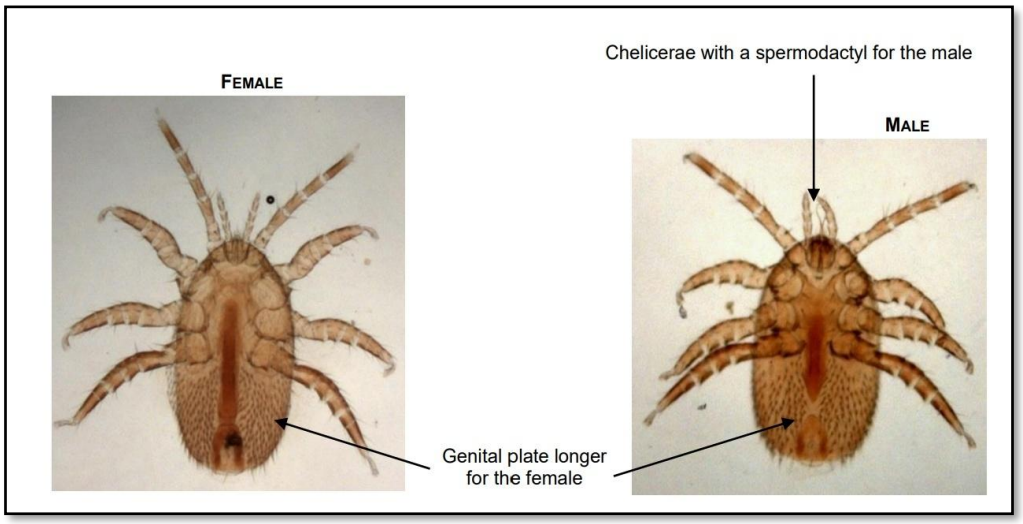


Fig.1.4. The Morphological appearance of *Tropilaelaps clareae, male* and female.

(Ventral view)

(Source: Photos by S. Franco, Anses, Sophia Antipolis laboratory)

The first pair of legs of adult *Tropilaelaps* mites are short (less than 1 mm in length) and remain erect, like antennae. They may be observed quickly traveling across the surface of the combs in colonies that are surrounded by them. Their bodies are shaped quite differently from those of *Varroa* mites and in comparison; their bodies are substantially longer than they are wider. Males and females significantly differ morphologically; males are somewhat smaller than females, and their epigynial thoracic plates are shorter and more sharply pointed to their posterior end (Fig.4).Males are substantially less prevalent than females in honey bee colonies as studied by some workers during the collection of *Tropilaelaps* mites from bee hives (Rath *et al.,* 1991; Anderson and Morgan, 2007).

It is simple to identify males by examining the chela spermatodactyl (sperm transfer organ) using a magnifying lens. *Tropilaelaps* nymph stages are white and are visible to the naked eye. Adult female mites are most often seen within the capped worker bee and drone bee brood cells of infected hives. Whenever mites are present in bee broods they may be simply seen with the naked eye on the outermost layer of the bee brood cell or at the bottom of the cell. Male mites are most likely to be found inside capped cells from which a developing mite is about to emerge, or in random groups of adult mites traveling across the outermost layer of combs (Anderson, &Roberts, 2013).

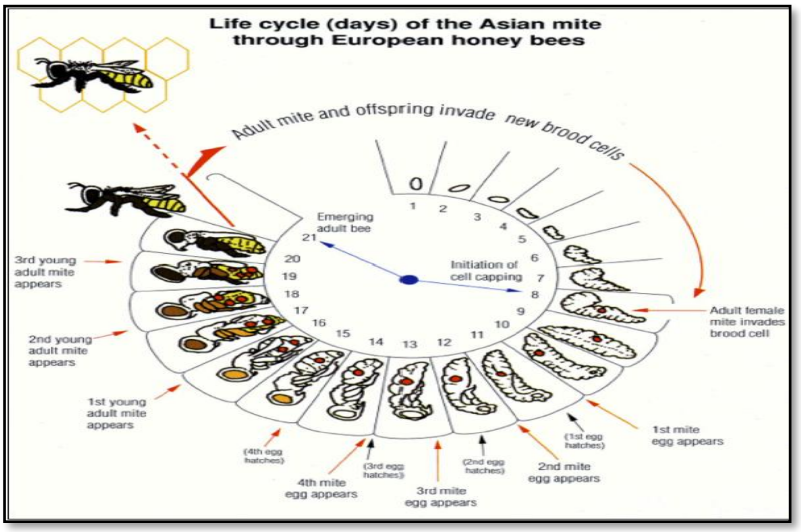


Fig. 1.5. The life cycle of *Tropilaelaps* mite on *Apis mellifera*.

(**Source:** The diagram was constructed from data reported (Anderson, & Roberts, 2013) by Saleu, 1994, Photo: Denis).

2.0. Discussion and Conclusion

Varroa was initially discovered in India on *Apis mellifera* in Himachal Pradesh (Kumar *et al.,* 1988). In addition, the lethal haplotype of *Varroa destructor* that severely harmed colonies was discovered in Punjab (Gatoria *et. al.,* 2004). The queen bees from affected regions were introduced, and infected colonies of bees were moved to pollinate themselves; which accelerated the mite's fast spread (Denmark *et al*., 1991).

As reported by Kotwal *et al. (*2013) the infestation was caused by the ectoparasitic mite *Varroa destructor* throughout the summer month and the mite invasion was maximum in the month of February and March reaching its peak in June and August.

Studies on the impact of environmental conditions on the *Varroa destructor* population reported that the maximum number of mites found in May which showed a strong positive relationship with both the highest and lowest temperatures. Although there was no statistically significant association between rainfall and the *Varroa destructor* population, there was a negative correlation between the population of the organism and relative humidity and sunlight. It was concluded by the workers that the mite population rises in *Apis mellifera* colonies in the summer, during seasons of high temperatures and limited flower supply (Poonia *et al.,* 2014).

The infestations of *Tropilaleaps clareae*, which occur between February and May as well as September and November in Ludhiana, Punjab, coincide with the height of brood-rearing activities (Chahal *et al.,* 1986).The months of October and November have been shown to have the highest prevalence of *Tropilaleaps clareae* (Gatoria *et al.,* 1995).

In variations population sizes are reported to be caused by variations in seasons of *Tropilaleaps clareae* in the Shivalik hills of Himachal Pradesh. According to their findings, the *Tropilaleaps clareae* mite population increased in the colonies of *Apis mellifera* between September and October. Taking into consideration the fact that their characteristics were positively associated with temperature and relative humidity, it was inferred by the workers that possibly the large population of *Tropilaleaps clareae* on *Apis mellifera* during the autumn season was due to the optimal conditions of temperature and humidity (Sharma *et al.,* 2011; Asha *et al.*, 2013; Deosi and Chhuneja, 2012;Chahal *et al.,*1986.).

The studies for the detection of mites are crucial for obtaining information as well as for identifying their pathogenicity in the honey bees and their colonies. The infestation of mites spread rapidly and emerged as a major threat to honey bees. By transmitting several viruses and immunosuppressant's to the developing honey bee, the parasitic mite nourishes the haemolymph of developing broods and adult bees, particularly drone broods, which weakens and shortens the life span of the bee.

Finally, phylogenetic analyses and environmental factors reveal some positive and negative correlation among the parasite and their host. Incidence of diseases caused due to parasitic mite has significant relation with relative humidity and temperature showing that these factors can play important role in outbreak of several diseases and impact on honey bee health. The mites from the genus *Varroa* and *Tropilaelaps* infestation was observed by large number of beekeepers from March-July. The period of mite appearance differed in other areas being March-April , March –June and April-June .

The major loss of honey bee colonies were seriously affected the beekeeping globally. Although the exact causes are currently unknown but it is considered that parasitic mites, together with associated viruses, are frequently mentioned as potential culprits. Honey bees provide critical pollination services to agriculture and natural landscapes, and the honey, bee wax and also some bee product produced by honey bees plays an important role on the economy across the world. The above sources suggest that the parasites and pathogens have recently

invaded honey bee populations and indicate that these parasites and pathogens cause irreversible effect on honey bee health.

The main aim of this study on the parasitic mite of honey bees (*Apis mellifera*) is to analyze the influence of mite on honey bee health and the problem faced by the beekeepers across the world. The parasitic mite alters the physiology and behavioral responses of honey bees. In addition to this, they are playing vital role in transmitting pathogens and microbes such as bacteria and viruses into healthy bees.

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