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Review on Varroa mite: An invasive threat to apiculture industry

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Abstract
Varrora mite is an ecto-parasite which causes more than 50 percent losses to honey bee colonies worldwide. Among all other species of varrora mite, *Varroa destructor* is a major pest of the honey bee which causes serious damage to its host colonies. It is an important pest for honeybee apiaries especially *Aphis mellifera* growing farmers. It mainly feeds on haemolymph of brood and adult bees which cause colony disorder, weakness, decreasing brood and deforming immature and mature bees. Varroa mite infested colonies lead to significant reduction of wing size and weight in worker bee of *A. mellifera*. Russian bees have more efficient grooming behavior which killed Varroa mites as compared to the Thai bees. The botanical green leaf extract mixture (*Artemesia annua* + *Matricaria chamomilla* + *Juglans regia*) @ 150 ml/colony was found highly effective against Varroa mite followed by *M. chamomilla* alone. The bio-pesticide (mycoacaricide) as dusting of *Beauveria bassiana* @ (5 ×10^6conidia/g) was also found effective against Varrora mite. The various chemical methods includes water solution of 0.5% oxalic acid (OA), taufluvalinate (2 strips per colony) and formic acid 85% @ 2 ml per colony were found highly effective against the *V. destructor*.

Keywords: Varroa mite, pest, grooming behavior, apiculture and management

1. Introduction
Honey bees and their usefulness are known to man from ancient time. The modern bee keeping is became possible after the discovery of movable frame hive in 1851 by a well known American bee keeper, L. L. Langstroth. In India, the first attempt was made to keep bees in movable frame hives during 1882 and 1883-84 from Bengal and Punjab area, respectively. The number of honeybee colonies has been grown across the world in last 50 years. The poor bee health has reached alarming levels in some regions of the world. Different species of pests includes bacterial, fungal, viral, protozoan diseases, insect pests, parasitic mites and vertebrate pests which cause damage to honey bees resulting in economic losses. Among all other pests, Varroa mite is an important ecto-parasite threat to commercial beekeeping throughout world. The genus *Varroa* is comprised of four major species namely *Varroa jacobsoni* Oudemans and *Varroa underwoodi* Delfinado-Baker and Aggarwal which was first time described to infest Asian bee (*Apis cerana* Fabricius). The *Varroa rinderi* De-Guzman and Rinderer was found to infest *Apis koschevnikivi* Buttel-Reepen from Borneo. The *Varroa destructor* Anderson and Trueman (Acari: Mesostigmata) was described to parasitize *A. cerana* and *Apis mellifera* Linnaeus which earlier known as *V. jacobsoni* until 2000 (De-Guzman and Rinderer, 1999; Anderson and Trueman, 2000 & Genersch E and Aubert, 2010) [7, 1, 17]. Among the different species of Varrora mite, *V. destructor* was first time described in 1904 from Java (Indonesia) on *A. cerana* as *V. jacobsoni* (Deosi and Chhuneja, 2017a) [10]. The *Varroa* mite is an ecto-parasite with the most prominent economic impact on beekeeping industry. It was also reported as a major pest of the honeybee, spreads very quickly and causes serious damage to its host colonies, where it reproduces inside the capped brood cells so that it protected from most the acaricides (Morse and Nowgrodzki, 1990; Webster and Delaplane, 2001 & Nikaido and Villalobos, 2009) [30, 32, 44]. Varrora mite is parasitizing the European honeybee, *A. mellifera* (Hymenoptera: Apidae) which is responsible for loss of more than 50 percent of *A. mellifera* colonies worldwide (Martin *et al*., 2012) [29]. According to Gulati *et al*. (2009) [21], ninety percent apiaries and fifty percent colonies of Haryana state was affected by this mite only. It feeds on haemolymph of brood and adult bees which cause colony disorder, weakness, decreasing brood and deforming immature and mature bees (Kotwal and Abrol, 2013) [28].

2. Taxonomic tree

Domain	:	Eukaryota
Kingdom	:	Metazoa
Phylum	:	Arthropoda
Subphylum	:	Chelicerata
Class	:	Arachnida
Subclass	:	Acari
Order	:	Parasitiformes
Suborder	:	Mesostigmata
Family	:	Varroidae
Genus	:	Varroa
Species	:	*Varroa destructor*

3. Morphology

Varroa mites are tiny red-brown external parasites of honeybees. It has posse's four pairs of legs in adult stage. The body shape is flattened and having suckers on its legs which enable it to grip the bee's body. There are numerous sensory hairs all over the body which acts as receptors to sense its environment. It having piercing and sucking type of mouth parts which help it pierces the bee's exoskeleton and feeds on its heamolymph. The female mite is consists of 1.1 mm long and 1.6 mm wide with flattened body, brownish in colour and larger than male. However, the male mite stage is 0.7 mm long and 0.9 mm wide with rounded body shape, yellowish white in colour and smaller than female.

4. Biology

The Varrora mite laid first egg as a male and subsequent eggs are female. After hatching, Varroa mites pass through two larval stages protonymph and deutonymph before developing into an adult. It takes to develop about 5 to 6 and 7 to 8 days for male and female Varroa mites, respectively. The life cycle of the female Varroa mite is subdivided into a phoretic phase and a reproductive phase in which it lives on adult bees and worker or drone brood cells, respectively. The reproductive phase is initiated when the female mite leaves the adult host and enters a brood cell with a 5th instar larva shortly before the cell is capped. This found female passes between the larva and the cell wall to the bottom of the cell and becomes stuck within the larval food. Approximately five hours after cell capping, the bee larva has consumed the rest of the larval food and later it begins feeding on haemolymph of the bee pre-pupa. (Ifantidis, 1988) [24]. At that time, the female mite has already started oogenesis in the terminal oocyte (Steiner *et al*., 1994; Garrido *et al*., 2000) [15,40].

The Varroa mother prepares a feeding site by making a wound in the pre-pupa cuticle which is used by all mite offspring including the male. This feeding site is critical for the survival of all developmental stages, because their mouthparts are not strong enough to pierce the soft cuticle of the bee pupae. The infesting mother mite forms come together at this site with its excreta on the cell wall in which all mobile individuals aggregate on which mating occur (Donze and Guerin, 1994) [12]. Female mites may assault worker or drone brood cells when worker bees bring them in close contact with brood cells. The eye-catching period of drone brood cells is two to three times longer than that of worker brood cells. The factors affecting magnetism of brood cells is related to the distance between the larva, the cell rim and the age of the larva. (Beetsma *et al*., 1999) [4].

The number of reproductive cycles and sex ratio from various bee stage sources, the mite could complete maximum of three reproductive cycles both in worker and drone brood. There were 26.20 and 33.40 percent mites collected from worker brood and adult bees, respectively which could complete the first reproductive cycle. The second and third reproductive cycle was recorded 10.20 & 11 and 2.01 & 3 percent mites, respectively. In case of drone brood 32, 25 and 25 percent mites with their source of drone brood itself, worker brood and adult worker bees, respectively completed first reproductive cycle, 10, 9 and 10 percent for the second cycle and 3.01, 2.01 and 2.01 percent for the third cycle. The male: female ratio was found varied between 1:0.70 to 1:0.84 during various seasons in worker brood, while it ranged between 1:0.83 to 1: 1.23 in spring. However, it varied from 1:2.93 to 1:3.50 in drone brood during spring (Deosi and Chhuneja, 2015) [9]. Deosi and Chhuneja (2017a) [10] recorded that the total developmental time for male and female mite was 141.28±0.24 and 149.06±0.31 hrs in worker brood, respectively. However, it was 140.65±0.24, 152.52±0.49, 153.68±0.19, 152.50±0.28 and 154.22±0.17 hrs, respectively in drone brood for the male and first to fourth female.

5. Seasonal incidence

A survey was carried out in South Gujarat revealed the presence of Varroa mite on honey bees with its peak activities during last week of April (Anonymous, 2016) [1]. Brar (2016) observed higher mite incidence infesting *A. mellifera* colony in stationary condition than migratory condition. Hussain *et al.* (2018) [23] reported that the incidence of Varroa mite was higher in the month of November and April. Maximum number of mites was observed in second fortnight of May (38 and 51 mites/per hive) which was found significantly positively correlated with maximum (r = 0.659) and minimum (r = 0.648) temperature. However, *V. destructor* population was found negatively correlated with relative humidity (-0.416) and sunshine hours (-0.023). Rainfall was found non-significant correlation (0.019) with *V. destructor* population. Data suggested that during summer months, when temperature is high and flower availability is less, mite population increases in *A. mellifera* colonies (Poonia *et al*., 2014) [35].

6. Honey bee and Varroa mite interaction

The mite does little harm to *A. cerana* and maintains a stable host-parasite relationship largely because the mite reproduces only in drone brood that comprises more than 5% of the colony's brood population (Fuchs, 1990) [14]. When mites will attempt to infesting worker brood cells which resulted into the parasitized pupa. Varrora mites are removed by adult bees exhibiting hygienic behaviour (Peng *et al*., 1987) [34]. Adult bees also remove and kill mites on nestmates which termed as grooming behaviour. Varroa mite was shifted its hosts from *A. cerana* to the European honey bee (*A. mellifera*) in 1950. It parasitizes and reproduces in both worker and drone brood in *A. mellifera*. Adult bees also can be parasitized, but Varroa mites are seldom found on queens.

The defensive behaviour of honey bees against Varroa mites consisting of auto-grooming and allo-grooming leads to the injury and death of mites (Thakur *et al.* 1997) [41]. Stanimirovic *et al*. (2010) [39] found grooming potential in the honey bees by recording the percent damage mites based on the total number of fallen mites in the three consecutive generations of unselected and selected queens which showed that grooming behaviour of honey bees has low heritability character. Kavinseksan (2013) [26] found that Russian bees have more efficient grooming behavior which killed Varroa

mites as compared to the Thai bees. The average injured mite percentage of the Russian honey bee colonies (36.9±1.8 percent) was significantly higher than that of the Thai colonies (27.8±1.9 percent).

7. Damage and symptoms

The mite infested colonies may show the following signs and symptoms (Plate 1). The dark or reddish brown mite is found on brood and adults of honey bees which termed as phoretic mite. There are weak colonies observed with scattered brood pattern. The uncapping of drone and worker brood of honey bee is mainly found in the apiary. The bees will uncap and cannibalize the pupae which can indicate progressed mite damage of Chewed Down Brood (CDB). The adult honey bees are found with malformed or flawed and stunted with deformed wings.

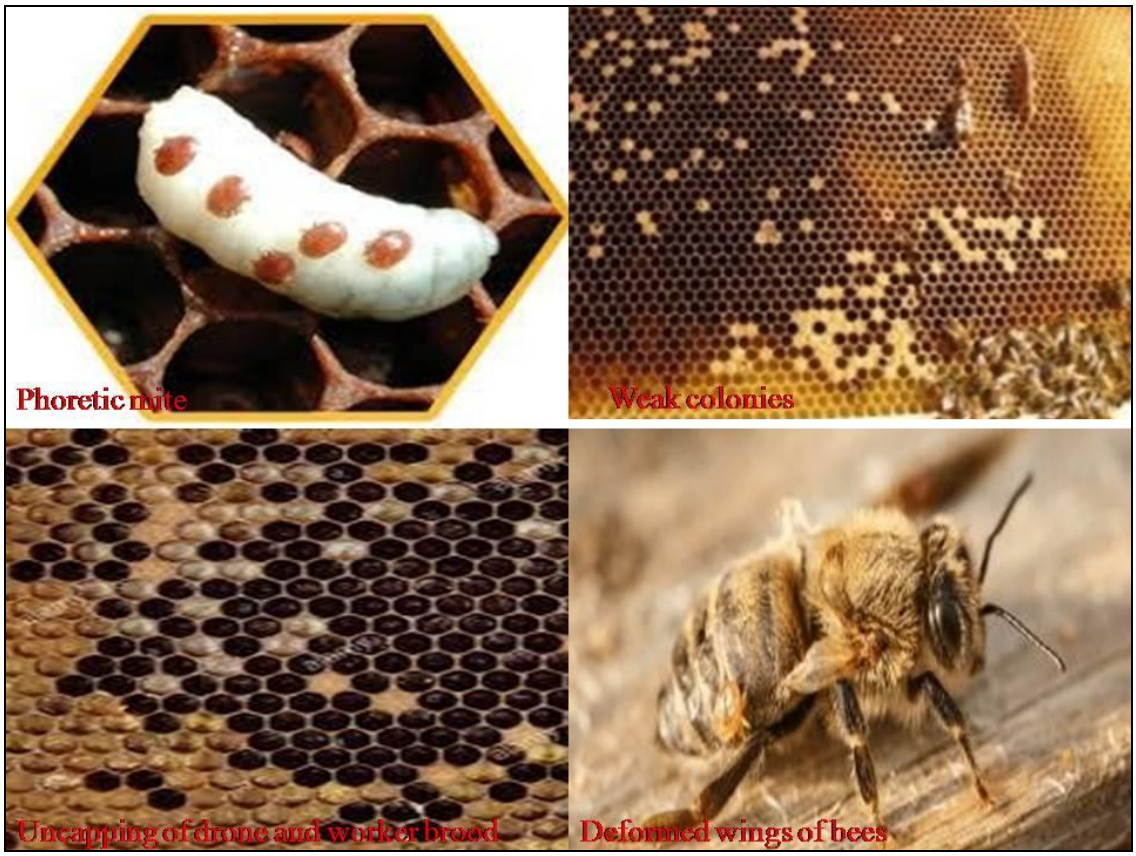

Plate1: Damage symptoms due to Varrora mite infesting on various stages of honey bee

8. Losses

Nearly twenty honey bee viruses have been discovered and the majority of them have an association with Varroa mites which also act as a physical or biological vector (Kevan *et al*., 2006) [27]. Dahle (2010) [6] revealed that the rate of colony losses among beekeepers was significantly lower in regions without *V. destructor* as compared to those where the presence of the mite was verified. Parrey (2011) [33] indicated that benefit cost ratio decreases with increase in the level of Varroa mite infestation. Deosi and Chhuneja (2017b) [11] reported that Varroa mite infested colonies lead to significant reduction of wing size and weight in worker bee, *A. mellifera*. Varroa mite is a serious pest of European honey bees (*A. mellifera*) which found difficult to control in even managed colonies. The study represented that multiple miticide treatment applications, yet mite numbers remained high and colony losses exceeded 55% (Gloria *et al*., 2017) [19]. It also reduces colony ability to pollinate plants (De Jong *et al*., 1982) [8]. The parasite destroys the mechanical protective barriers of the integument and impairs the immune system of the bees (Glinski, 1991) [18]. The Varroa mite has been a threat to world beekeeping industry and now a potential threat to Indian apiculture (Gatoria *et al*., 2005) [16].

9. Changelings

In recent years, Varrora mite control has become a major problem due to its resistance to acaricides. It has found that most widely used synthetic active ingredients increased tolerance against its population. *Varroa destructor* strains have been reported to be resistant to fluvalinate and flumethrin (Baxter *et al*., 1998) [3], coumaphos (Spreafico *et al*., 2001) [38] and amitraz (Elzen *et al*., 2000) [13]. Also, the use of acaricides should be minimized in beekeeping because of their residues and breakdown products in honey and wax (Wallner, 1999) [43]. There is current concern about contamination of bee products with synthetic chemicals used against the Varroa mite (Howis and Nowakowski, 2009) [22]. The problems associated with the use of acaricides proved considerable incentive to develop new treatment strategies and screening for potential acaricides that minimize these problems.

10. Management

Toomemaa *et al*. (2010) [42] reported a water solution of 0.5% oxalic acid (OA) gave effective control of the mite and was not toxic to bees, whereas higher concentration of OA (1.0 and 1.5%) were highly toxic to bees. Sewify *et al*. (2015) [37] observed that *Beauveria bassiana* (Balsamo) as mycoacaricide (5 $\times 10^6$conidia/g) is a potential bioacaricide

against *V. destructor* in honey bee colonies. Natural products having components with various modes of action might provide effective solution to the problem of varroaosis (Imdorf *et al*., 1999) [25]. According to Mutinelli *et al*. (1997) [31], the natural products such as essential oils and their components or organic acids, especially formic acid, oxalic acid and citric acid were used for controlling Varroa mites. Goswami and Khan (2013) [20] indicated that the different essential oil and formic acid applied @ 5ml/ hive for Varroa mite control showed that garlic oil gave significantly superior results in reducing the Varroa mite population up to three weeks with an overall mean value of 75.03 percent followed by formic acid giving 72.94 percent mite mortality. Rasool *et al*. (2017) [36] reported that taufluvalinate (2 strips per colony) was found highly effective against the *V. destructor* followed by formic acid 85% @ 2 ml per colony. However, botanical green leaf extract mixture (*Artemesia annua* + *Matricaria chamomilla* + *Juglans regia*) @ 150 ml/colony was found highly effective against Varroa mite followed by *M. chamomilla*.

11. Conclusion

Varrora mite is a new threat on important honey bee reared species, *A. mellifera*. It remained active round the year with its peak incidence during month of April, June and November. The grooming behaviour of honey bee is helped in removing the mites from its body, but this behaviour mostly found in Russian bee strain only. This mite reduced bee colony strength, produce weakness in brood cell and deforming effects on honey bees immature and adult stages. It can be managed with botanicals, bio-pesticides and chemical disinfectants.

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