Honey Bee Colony Losses

Subjects: Entomology
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Various factors have been considered to be contributing to honey bee losses, and recent investigations have established some of the most important ones, in particular, pests and diseases, bee management, including bee keeping practices and breeding, the change in climatic conditions, agricultural practices, and the use of pesticides. The global picture highlights the ectoparasitic mite Varroa destructor as a major factor in colony loss. Last but not least, microsporidian parasites, mainly Nosema ceranae, also contribute to the problem. Thus, it is obvious that there are many factors affecting honey bee colony losses globally. Increased monitoring and scientific research should throw new light on the factors involved in recent honey bee colony losses.

Keywords: honey bee losses ; colony collapse disorder ; Varroa destructor ; viral diseases ; nosematosis ; negative pressures

1. Introduction

Managed honey bees are the most important pollinators for many crops and wild flowering species. Many countries worldwide, particularly in the Northern hemisphere, rely on the Western honey bee, Apis mellifera, for commercial pollination of certain crops, but over the recent years there has been an increase in losses in managed honey bee colonies in some regions of the world. Colony collapse disorder (CCD) has been reported for the first time in 2006 in the USA [1]. Although some bee losses have also been reported in China and Japan, published data from various investigations have shown that honey bee colony numbers have been stable for the past ten years in these regions [2][3]. The global picture has shown that there are no significant honey bee colony losses reported in Africa, Australia and South America. In the Middle East, the high temperatures and droughts in the summer are the main factor leading to colony losses because many plants, which are important sources for bee forage, suffer from heat stress [4]. Another factor aggravating the problem is the lack of comprehensive laws and legislations concerning the importation of bee colonies [5].

Indeed, bee colony losses are not a new phenomenon, and historical records show that extensive losses were not unusual in the past. Whilst recent problems may give the impression that there has been a massive decline, global research on honey bee colonies has shown that numbers actually increased between 1961 and 2007, mostly in Asia (426%), Africa (130%), South America (86%), and Oceania (39%) [6]. The most significant honey bee colony losses take place during overwintering, as shown by comparisons of colonies going into wintering and surviving the winter. The latter is a symptom of CCD, which has appeared in Europe, causing losses of up to 30% in some countries [7][8][9]. It has been difficult to determine a common pattern for the colony losses, but different investigations confirm that it is a phenomenon characteristic of the Western honey bee, while the Asiatic honey bee, present in southern, southeastern, and eastern Asia, appears to be more resistant to various pests and diseases [10].

2. Role of Pests as Drivers Leading to Honey Bee Colony Losses

To understand the causes underlying the current decrease in honey bee colonies worldwide, it is important to shed light on the key pests and diseases that negatively affect bee health. Honey bees can be affected by various pests and diseases, including mites, different viruses, microsporidia, bacterial infections, and fungi (Ascosphaera apis) (Table 1). Due to the burden of infectious diseases and their agents, honey bee colonies may manifest significant weakness or even death. Only recently have scientists come to understand better the impact of the development and interactions of these pests and diseases.

Table 1. Some honey bee pests and diseases correlated with colony losses.

Type of Pathogen	Kind of Relationship	References
Varroa destructor	**Ectoparasitic mite**	**[11][12]**

Type of Pathogen	Kind of Relationship	References
Acarapis woodi	**Tracheal mite**	[13]
Varroa jacobsoni	**Ectoparasitic mite**	[14]
Tropilaelaps clareae	**Ectoparasitic mite**	[15]
Deformed wing virus A	**Viral pathogen**	[16][17][18][19][20]
Deformed wing virus B (VDV1)		
Acute bee paralysis virus		
Kashmir bee virus		
Israeli acute paralysis virus		
Chronic bee paralysis		
Sacbrood virus		
Black queen cell virus		
Nosema ceranae	**Intestinal parasites**	[21][22]
Nosema apis		
Nosema neumanni		
Ascosphaera apis	**Fungal pathogen**	[23]
***Aspergillus* spp.**		
Aethina tumida	**Beekeeping pest**	[24][25][26][27][28][29][30]

2.1. Parasitic Mites

Honey bee hives can be a suitable habitat for various mites (Acari), including nonparasitic, omnivorous, pollen-feeding species, and parasites. Out of the different mite species associated with honey bees, *Varroa destructor*, *Acarapis woodi*, *Varroa jacobsoni* and *Tropilaelaps clareae* are economically significant pests of honey bees, and their infestation may lead to the destruction of the beekeeping industry in many cases [31][32]. *Varroa destructor* is the most serious pest of honey bee colonies around the world, as it is an obligate parasite which is able to attack different developmental stages and castes of *A. mellifera* [33]. It is interesting to note that Varroa mites have been established in New Zealand since 2000, but as of yet, Australia is still Varroa-free [34]. Additionally, in Africa, African honey bees seem to survive despite the presence of *Varoa destructor*, as do the Africanized honey bees in South America [35]. It is well known that the ectoparasitic mite *Varroa destructor* switched hosts from Eastern honey bees (*Apis cerana*) to Western honey bees (*Apis mellifera*) [36]. Thus, the Western honey bee has shown more susceptibility than *Apis cerana*. This increased resistance of the Africanized honey bees against *V. destructor* may be explained with their more aggressive behavior than the Western honey bee [37][38]. The association of *V. destructor* with the Western honey bee has led to a significant reduction of honey bee colonies.

2.2. Honey Bee-Associated Viruses

About 24 honey bee-associated viruses have been identified in the Western honey bee (*Apis mellifera*) [39]. Some of them generally persist in the bee’s body, without causing a disease or manifestation of any clinical signs. In general, virus infestations were not considered to be a significant problem to honey bee health. On the other hand, some viruses are more virulent and infective, and thus may cause a significant loss in honey bee colonies as well as a decline in honey bees’ health and production [40]. Some viruses show pathogenicity only under certain favorable environmental conditions.

Varroa mites *V. destructor* are considered to be the main transmitter of many honey bee viruses: deformed wing virus (DWV); acute bee paralysis virus (ABPV), Kashmir bee virus (KBV), and Israeli acute paralysis virus (IAPV) [41][42]. Furthermore, three viruses in the transmission of which Varroa seems to play no significant role, namely, chronic bee paralysis virus (CBPV), sacbrood virus (SBV), and black queen cell virus (BQCV) are also frequently surveyed [43][44]. This fact allows to us think that Varroa mites alone are not the (only) cause of honey bee losses. The negative influence of *V.*

destructor results from its role as a viral reservoir and a transmitter of some honey bee-associated viruses [33]; the mite promotes replication of honey bee viruses like DWV [45]. Due to its feeding behavior, the Varroa mite injects directly viruses in the hemolymph, which has been associated with oral or sexual transmission of these viruses [46].

2.3. Microsporidia

Microsporidia are fungal, obligate intracellular parasites, infectious to honey bees. Microsporidia are possibly the smallest single-cell organisms which have a true nucleus. The genus *Nosema* is a parasitic fungus infecting insects such as honey bees, bumble bees and silkworms. Until now, only two species of microsporidia, namely, *Nosema ceranae* and *Nosema apis*, have been reported to parasitize on adult honey bees [47]. In 2017, a new species of Nosema, named *Nosema neumanni*, in honey bees from Uganda was reported [22]. It has been established that *N. apis* is specific for the Western honey bee, *Apis mellifera* L., whilst the Asiatic bee, *Apis cerana,* harbors *N. ceranae* [48]. For a long time, it was believed that *N. ceranae* and *N. apis* were species-specific. Since the beginning of this millennium (mainly post 2003), many investigations have revealed that *N. ceranae* has switched hosts and has become the dominant species in many countries [49][50][51][52][53]. Thus, it has been suggested that *N. ceranae* is possibly more virulent than *N. apis*.

3. Anthropogenic Direct Drivers Associated with Honey Bee Colony Decline

In addition to different pest and diseases as direct natural drivers, there are many other drivers named anthropogenic, that lead to colony losses [54][55]. In many cases it is the interaction of these factors that leads to morbidity and mortality, and colony losses (Table 2).

Table 2. Environmental factors associated with honey bee colony losses.

Anthropogenic Direct Drivers that Cause Honey Bee Decline	Impact on Honey Bee	References
Pesticides	**High rate of mortality, alteration of different biological processes**	[56][57][58][59]
Climate change	**Alteration of honey bee behavior, physiology and distribution, induced changes in flora for honey bees vitality**	[60]
Introduction of alien species	**Competition for food resources, decline of indigenous species, alteration of the new habitat**	[61][62][63][64]
Genetically Modified Organisms (GMOs) crop	**Alteration bees foraging behavior**	[65]
Land use and management	**Habitat and forage loss, honey bee and wild bee competition**	[55][66]
Bee management	**Hybridity of honey bees, migratory pollination**	[67][68][69][70]
Environmental pollution	**Imbalance in homeostasis, weakening of the immune system**	[71]
Interactions between drivers	**In many cases poorly studied**	[72][73][74][75][76][77][78][79][80][81]

4. Conclusions

Recent investigations have reported an increase in colony losses in some regions and have stimulated investment in more coordinated monitoring of bees and research on the impact of pests and diseases, bee diversity, bee-keeping practices and bee foraging environments on bee vitality. Factors such as land management and environmental conditions further affect the availability and quality of food sources as well as the conditions in the hive. Effective management of bee colonies under changing situations also depends on beekeeping practices and bee selection. All these diverse factors can affect bees' vitality and ability to overcome pests and diseases.

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