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Honey Bee Viruses

by Jane Dunstan

Honey bee colonies continue to suffer harmful effects from mites and viruses which both adversely affect their health, hardiness and longevity. Much has been written about the necessity of management and timely treatment of the varroa mite when numbers exceed the recommended threshold. However, there is less discussion on the impact that the varroa mite has in spreading viral disease in the hive or, for that matter, how viruses are actually transmitted from bee to bee. There is much yet to be discovered concerning the dynamics of virus transmission and the relationship and interaction between the honey bee as the host and the infectious agent. The purpose of this article is to examine what has been learned about viruses and how they are transmitted to our honey bees.

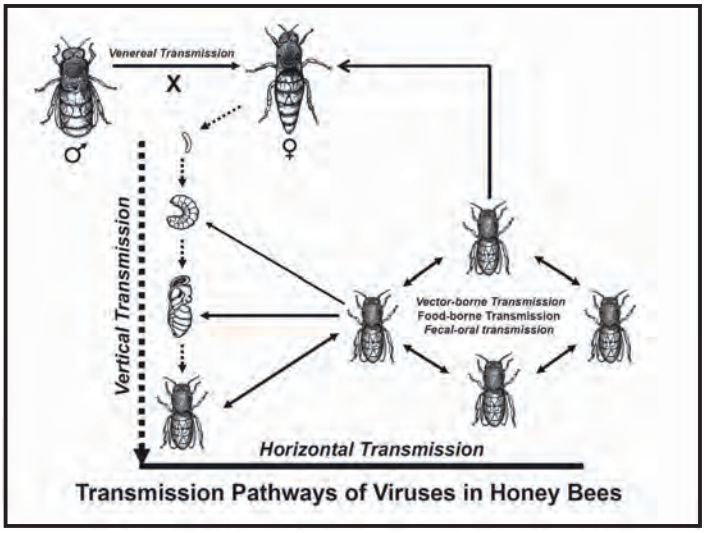
Varroa destructor has the ability to act as "a viral reservoir, incubator, activator and transmitter resulting in levels of certain viruses that affect the survival of the colony" (Tantillo et al., 2015). Varroa mites are ectoparasites (live on the outside of their host) and primary vectors of viruses which affect the honey bee. It has been shown that the occurrence of both high mite infestation and viral infection is most often associated with the death of honey bee colonies (Brutscher et al., 2016).

There are several characteristics of viruses which are important to examine. Viruses are found in all living things. They are parasitic, meaning they cannot reproduce without a host. Viruses do not have their own metabolism and are completely dependent upon the life of their host. Once inside the host, the virus completely overwhelms all of the components of the host cell. The virus inserts its own genetic code or blueprint and takes over the functions of the host. Simply put, they move in lock, stock and barrel, using everything that is already present in the host to reproduce their own offspring called virions. In this process, the host is harmed, resulting in disease or death (Chen et al., 2006).

Honey bee viruses are primarily positive sense single-stranded RNA viruses and reproduce themselves in the cell cytoplasm of the host (Chen et al., 2006). There are 24 viruses that have been identified in the honey bee, mainly from the order Picornavirales. Investigations of colonies which were collapsing from high varroa infestations were found to be overwhelmed with high levels of Picornavirales (Remnant et al., 2017).

Viruses transmit infection to all stages of bee development which includes eggs, larva, capped brood and adult honey bees. Virus infections are often dormant or latent without obvious signs of disease, however can be manifested by physical deformities, paralysis or death of the host. Colonies can have more than one virus in existence at the same time (Chen et al., 2006). Most honey bee viruses have been known to scientists for over 50 years and were relatively common, existing and multiplying within the host without causing obvious symptoms until the problematic arrival of the varroa mite (Moore et al., 2016).

Viruses are transmitted via two primary routes: vertical transmission, horizontal transmission or both. In horizontal transmission, the virus is transmitted among members of the same generation, i.e. worker bee to worker bee and can be further categorized as direct or indirect transmission. Vertical transmission occurs between the queen to her offspring either on the surface of the egg or within the egg itself (Chen et al., 2006).



Transmission of viruses in honey bees. Solid lines represent horizontal transmission and dotted lines represent vertical transmission. Reprinted with permission from the author from "Horizontal and vertical transmission of viruses in the honey bee, Apis mellifera". Yanping Chen, Jay Evans, Mark Feldlaufer, March 12, 2006

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In looking at the direct pathway for horizontal transmission of viruses, this avenue would include air-borne infection as well as food-borne transmission of infection where bees eat and share food contaminated by virus and then pass the virus in their feces (Chen et al., 2006). In a honey bee colony, horizontal transmission of disease occurs when nurse bees feed royal jelly to developing larva, when worker bees receive and process pollen and nectar from foragers, as well as during the interaction between the queen and her retinue. Studies have documented the detection of several viruses in both pollen and honey which were then transferred to an uninfected queen by her attendants and later detected in the eggs and larva (Brutscher et al., 2016). As a result of the densely populated conditions in a colony structure and frequent contact between members of the colony while sharing food or by chemical communication, the opportunity for transmission of disease is great (Chen et al., 2006).

With vertical transmission, studies by Chen et al. (2006) found that queens can be infected with not only one virus, but multiple viruses and confirmed that eggs can also have viruses from the infected queen. Further research found that when queens were tested and found to be positive for certain viruses, those same viruses were found in all developmental stages of the bee, despite lack of overt symptomology (Chen et al,. 2006).

There is also indirect transmission of viruses by the varroa mite and nymph while using their mouth parts to pierce the body wall of bees in different stages of development. Their movement between brood and adult bees perpetrates the occurrence of vector-born viruses. Bowen-Walker et al. (1999) conducted experiments looking at the varroa mite as a vector which "demonstrated that Varroa mites obtained DWV from infected bees and acted as a vector to transmit the virus to uninfected bees, which developed morphological deformities or died after mites fed on them for certain periods of time" (Chen et al., 2006 p.156). The symptoms of DWV, such as deformed wings, stunted abdomens, pale coloration, abnormalities in behavior and a reduced life span are the most common symptoms. Virus is present in all body parts of the honey bee with greater accumulation in the digestive tract. In drones, higher accumulation of the virus is found in the testes and seminal vesicles while greater viral load is found in the ovaries of the queen. Research also indicated that despite colonies appearing to be without overt symptoms, those same colones were associated with higher winter mortality (Amiri et al., 2018).

Research has also suggested that the strength and severity of the pathogen can be determined by the manner in which it was transmitted. For instance, horizontal transmission prefers obvious manifestation and expression of the disease and increases the pervasiveness of the infection

when there are favorable conditions such as high host population and increased pathogen duplication rate. In direct contrast, vertical transmission is a mechanism for long term virus persistence and favors development of less serious infections (Chen et al., 2006).

It was surmised that when colonies are living in healthy conditions without competition for food, space, etc., viruses are present in a dormant state without obvious signs of infection when vertically transmitted. However, in stressful conditions such as when colonies are heavily infested with Varroa mites, have poor food supplies and are plagued by other disease states, there is a reduction in the growth rate and health of the host. This causes the virus to no longer remain latent, but become more infectious and overt in its' symptomology, often leading to the death of the bee hosts and possibly the colony as a whole when transmitted by the horizontal route (Chen et al., 2006). An article by Dolezal and Toth (2018) examined declines in bee health related to multiple stressors in their environment, most importantly forage/nutrition deficits, parasites, other diseases and pathogens and the feedback loop between poor nutrition exacerbating virus manifestations at the same time that disease and pathogens are adversely affecting honey bee nutrition.

Further cutting edge research continues in honey bee virology as the decline in honey bee health continues. Investigations proceed to determine the role of viruses in bee health which continues to be a global threat. The knowledge which we currently have underscores the importance of regulation of varroa mite populations in our colonies.

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Answers to quiz questions:
1) d
2) a
3) a
4) d
5) d
6) d
7) b
8) c
9) d
10) True

Photo courtesy of Judith Stanton