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Viral Infection Triggers Honey Bee Queen Supersedure Via Methyl Oleate Pheromone Disruption

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Abstract

This study reviews a new way that viral infections might cause a supersedure, or colony-wide coup, in *Apis mellifera* honey bees. Researchers found that queens infected with viruses like deformed wing virus B (DWV-B) have impaired reproductive health, as seen by fewer eggs laid and crucially lower levels of the queen pheromone component methyl oleate. Methyl oleate serves as a vital chemical signal to the colony, indicating the queen's fitness and reproductive viability. Worker bees interpret the sharp decline in this pheromone as a signal that the queen is no longer fit to rule, subsequently initiating the process of rearing a new queen from a larva. Methyl oleate acts as a **"honest signal"** to the worker bees, communicating the queen's reproductive health and overall vigor. High levels of Methyl oleate is a chemical assurance to the colony that the queen is healthy, highly fertile, and laying eggs prolifically.This finding establishes a direct link between viral pathogenesis, specific pheromone chemistry, and the complex social behaviour of supersedure, illustrating how pathogen-induced physiological changes can manipulate key colony functions.

Keywords: *Apis mellifera*, Deformed Wing Virus B, Queen Supersedure, Methyl Oleate, Pheromone, Social behaviour.

Introduction

The honey bee queen produces pheromones that function in both releaser and primer roles such as attracting a retinue of workers around her, attracting drones on mating flights, preventing workers from reproducing at the individual (worker egg-laying) and colony (swarming) level, and regulating several other aspects of colony functioning. The queen mandibular pheromone (QMP), consisting of five synergistic components, is the only pheromone chemically identified in the honey bee (*Apis mellifera*) queen, but this pheromone does not fully duplicate the pheromonal activity of a full queen extract. To identify the remaining unknown compounds for retinue attraction, honey bee colonies were selectively bred to have low response to synthetic QMP and high response to a queen extract in a laboratory retinue bioassay. Methyl oleate (MO) is a significant component of the Queen Retinue Pheromone (QRP) complex in honey bees (*Apis mellifera*), and research papers detail its role as an honest signal to worker bees regarding the queen's health and reproductive quality.

Component of the Queen Retinue Pheromone (QRP) Discovery and Synergy: Methyl oleate (methyl (Z)-octadec-9-enoate) was identified in the early 2000s (Keeling et al., 2003) as one of the new components of the QRP, expanding the blend beyond the initial five components of the Queen Mandibular Pheromone (QMP).

Releaser Effect (Retinue Attraction): MO, along with other new compounds like coniferyl alcohol, was found to synergistically enhance the attractiveness of the core QMP blend, eliciting the full retinue behavior in worker bees.

Source:https://www.mdpi.com/vetsci/vetsci-09-00221/article_deploy/html/images/vetsci-09-00221-g001.png

This retinue involves workers feeding, grooming, and antennating the queen, which is crucial for distributing the pheromone message throughout the colony.

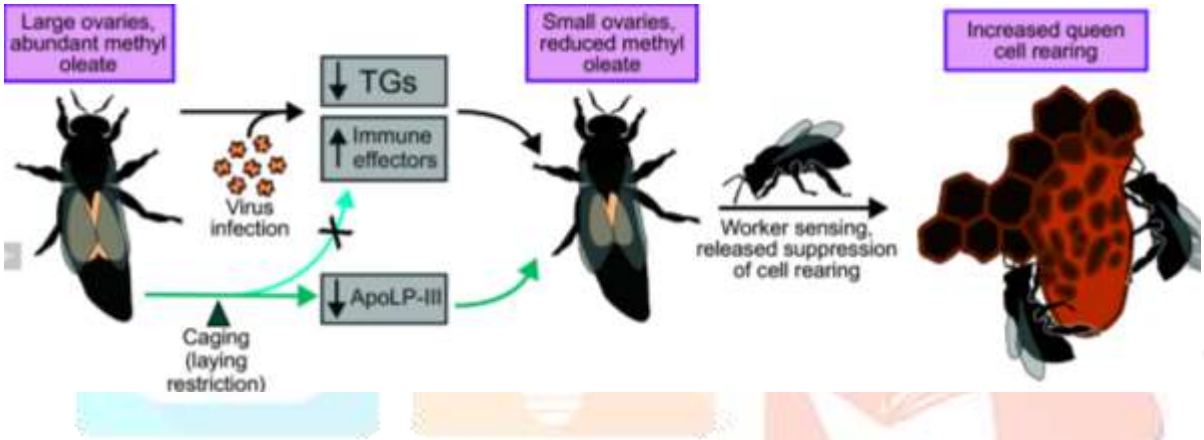
Indication of Queen Reproductive Fitness and Health

Recent research highlights MO's crucial role as a honest indicator of the queen's physiological state linked to ovarian mass and fecundity. Studies have found a positive association between the amount of methyl oleate a queen produces, and her ovary mass (a proxy for high egg-laying capacity or fecundity). Queens with larger, more developed ovaries produce more MO. Signal of viral health indicating elevated infection levels of common honey bee viruses, such as Deformed Wing Virus B (DWV-B) and Black Queen Cell Virus (BQCV), have been shown to cause a significant reduction in methyl oleate production.

This reduction is often linked to systemic lipid deficiency and reduced ovary mass caused by the viral stress. The drop in MO is theorized to be the mechanistic pathway by which pathogens can destabilize colony social structure serving as the mediator of supersedure. When a queen's MO level drops due to viral infection and resulting reproductive decline, worker bees detect this "weakness" in her pheromonal signal.

A reduced MO signal prompts workers to initiate supersedure, the process of rearing a replacement queen. Field trials using synthetic pheromones confirmed this. Blends containing methyl oleate significantly suppressed queen cell rearing, while blends lacking it resulted in an intermediate or higher rate of replacement queen rearing.

In summary, methyl oleate serves two key functions for worker bees: Function Mechanism Indication to Workers Retinue Attraction (Releaser) synergistically enhances the QMP blend with immediate presence of a queen who requires attention/care. Honest Signal (Primer) Production level correlates with ovarian mass and health indicating Queen's reproductive fitness and overall viability and its drop signals she is failing and needs replacement.



Source:https://pubmed.ncbi.nlm.nih.gov/41086214/#&gid=article-figures&pid=fig-5-uid-4

Review of Literature

Three groups of mites and one insect species are economically relevant arthropods infesting honeybees. The most notorious threat to hives is represented by the *Varroa* genus, with the worldwide distributed *V. destructor* and the Asia-confined *V. jacobsoni*. (Traynor *et al.*,2020) Additional mite genera affecting bee health are the tracheal colonizer *Acarapis woodi* and the ectoparasites *Tropilaelaps mercedesae* and *T. clareae*. In general, mites feed on bees, weakening their immunity and lowering their performance, thus ultimately compromising the stability of the hive (Chantawannakul*et al.*,2018). Finally, the opportunistic parasitic insect, *Aethina tumida*, better known as the small hive beetle (SHB), is from a global perspective considered a minor pest that feeds on larvae and bee products and uses the hive as a nest. However, as an invasive species, this insect has generated great losses in some geographic regions and its further distribution is of considerable concern (Pasho*et al.*,2021). Arthropods also act as vectors of highly pathogenic viruses, such as DWV, facilitating and promoting their distribution. With the exception of *A. woodi*, arthropod pathogens are easily recognized with the naked eye.

Discussion

Viruses are a large class of honey bee pathogens that negatively affect colony health, yet their prevalence and transmission dynamics in commercial queen production operations remains poorly understood. To address this gap, we conducted a series of controlled queen monitoring experiments and surveys to understand the prevalence and viral loads of seven viruses across developmental stages of queens, drones, royal jelly, and workers from associated colonies (Aurel *et al.*,2021). All viruses except SBV were detected, with BQCV, DWV-B, and LSVs showing consistently high prevalence. Eggs were frequently infected with LSVs, DWV-B, and CBPV, suggesting vertical virus transmission, and highlighting the importance of selecting healthy breeder queens. BQCV, on the other hand, dominated in queen larvae, pupae, and adult stages (McAfee *et al.*,2025). Mated queens, particularly those maintained in bank colonies, exhibited higher prevalence and viral loads than virgin queens, with DWV-B and BQCV being most abundant. Worker bees from bank colonies also showed slightly higher viral loads compared to other colonies, indicating potential risks associated with queen banking. Drone samples revealed high BQCV and DWV-B prevalence, indicative of their potential role in venereal transmission. The results from hierarchical clustering and correlation analyses provided evidence that viral profiles of queens did not necessarily match those of their resident colonies, highlighting complex viral transmission dynamics. Collectively, these findings provide novel insights into virus transmission dynamics during queen production and emphasize the need to improve queen health.

This alteration in the queen's chemical signal is interpreted by the worker bees as evidence that the queen is compromised or failing. The pheromonal shift serves as the precise signal that triggers the workers to begin rearing new queen cells, thereby initiating supersedure (Bruckner *et al.*,2023). This research provides a robust working mechanism for queen replacement, illustrating how a sub-lethal virus–host interaction within a single individual can drive a critical, adaptive change in the collective, pheromone-coordinated behavior of the entire eusocial colony. This process confirms that worker bees are actively policing the functional status of their queen based on an acute, measurable chemical signal derived from her physiological state. This dynamic suggests that supersedure, often viewed as a normal outcome of aging, is frequently an accelerated, pathologically induced response to viral stress, leading to high queen turnover rates and increased economic costs for apicultural operations (CAPA., 2023-2024). Consequently, MO levels could serve as a non-invasive biomarker for assessing queen quality and predicting future supersedure risk.

Conclusion

It is now conclusively known that common viral infections, particularly high titers of Black Queen Cell Virus (BQCV) and Deformed Wing Virus (DWV), prevent honey bee queens from producing eggs, which ultimately results in premature supersedure. This effect stems from serious, systemic physiological harm and is not only behavioral. Increased viral loads cause noticeable ovarian shrinkage, a characteristic "small-ovary phenotype" that severely impairs the queen's ability to procreate. A significant systemic lipid shortage, characterized by the depletion of triacylglycerides—essential energy reserves—accompanies this physiological decline. The discovery suggests that rather than merely impacting specialized tissues, viral infections are interfering with basic metabolic and energy allocation networks.

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