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Editorial: Applied bee science and technology transfer

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Editorial on the Research Topic
Applied bee science and technology transfer

Honey bees (*Apis mellifera* L), as the main pollinators in agricultural ecosystems, are essential contributors to food production. However, beekeeping faces many challenges related to a variety of stressors that affect the survivorship of honey bee colonies and compromise their productivity. For example, the parasitism caused by *Varroa destructor* is linked to colony losses and low honey production. The adaptability that varroa mites have demonstrated to different environments out of their original range and their capacity to cause disease and vector-virulent viruses is of extreme concern. Efforts to understand the biology of the parasite, its relationship to viruses, and the discovery of novel methods to control its population growth have been crucial in supporting the beekeeping industry. Applied bee science is instrumental in solving problems of relevance, and effective transfer of technology and knowledge is critical to reaching farmers, helping them implement innovative ways to manage honey bees and reduce the impact of stressors that can compromise the viability of beekeeping operations. Furthermore, applied science can be meaningful for regulators and other professionals to facilitate decision-making processes that can impact the beekeeping industry. This Research Topic provides a compilation of seven studies focused on solving practical problems and facilitating technology transfer into the field of apiculture.

Until recently, Australia remained free of varroosis. The introduction of *Varroa destructor* into Australia became a major concern both for beekeepers in the region and for importing countries that rely on Australia for the supply of bee stock. In this Research Topic of *Applied Bee Science and Technology Transfer* publications, McFarlane et al. from Australia described two methods for the rapid identification of varroa mite species using two Nanopore DNA sequencing methods (PCR amplicon sequencing and Cas9-targeted sequencing). The introduction of invasive pests into new environments due to global trade and rapid climatic changes demands rapid actions to minimize their impact and understand changes in distribution, including the rapid and accurate identification of pest species.

The implementation of an integrated pest management (IPM) strategy is essential to controlling varroa mites, and it requires the use of cultural and biocontrol methods, the incorporation of resistant traits in selected stock for varroa resistance, and the constant monitoring of mite levels. Juri et al. compared different screened bottom boards designed to remove varroa mites from the hive and reported that hives with a sticky board showed 50% fewer mites compared to colonies with control boards. The aim of implementing an IPM approach to control mite levels is to keep their growth below an economic threshold and prevent them from reaching injury levels. Morfin et al. proposed a revision of the economic injury levels to 1% in Western Canada based on varroa levels and colony survival data and found that levels of varroa-vectored viruses, such as deformed wing virus-B and acute bee paralysis virus, were associated with high colony mortality. The always dynamic host-pathogen interactions require constant revisions of economic thresholds and adaptations in management strategies to reduce the impact of pests and diseases on honey bee colonies.

Selective breeding for stock resistant to varroosis is essential to reduce the impact of the mite; however, the selection of traits associated with varroa resistance is not trivial due to the complexity of the reproductive system of the honey bees and the polygenic nature of the behavioral traits associated with varroa resistance. Understanding of the molecular mechanisms behind varroa resistance and the implementation of biomarker-assisted selection could advance breeding programs that can benefit commercial beekeepers. Russo et al. tested 11 candidate genes involved in grooming and hygienic behaviors and found dysregulation of some genes in bee's heads and bodies, advancing the understanding of molecular mechanisms behind varroa resistance and the possible implementation of biomarkers in selective breeding.

Part of an IPM strategy for varroa mite control is the use of organic acaricides, like oxalic acid. Tellarini Prieto et al. addressed one key issue that beekeepers using oxalic acid vapor have: the product's toxicity. Although the authors reported a temporary increase in adult bee mortality, they found no effects on colony or queen health when using 20 g of oxalic acid. The study could have implications for label recommendations and the effective use of oxalic acid vapor for varroa control.

Additionally, Killam et al. explored the role of honey bee gut microbiota in promoting honey bee health. Specifically, they reviewed and hypothesized how supplementation of food with lactic acid bacteria could influence social behaviors, enhancing hive health or performance.

Lastly, laboratory research has led to potential treatments for various diseases that affect honey bees, including varroa mites, but their application at the hive level is challenging for many reasons, such as the effective distribution of therapeutic agents within the colony. Shelley et al. reported the use of the ProtectaBEE® system, aimed at delivering therapeutic agents to treat the colony while reducing hive manipulations. The authors reported effective delivery of the biocontrol agent *Baeuveria bassiana*, an entomopathogenic fungus that has the potential to control varroa mites. It appears that ProtectaBee® could optimize the delivery of this biocontrol agent for varroa control.

As basic science progresses, the need to transfer technology and knowledge to the hands of beekeepers is imperative. Applied bee science and technology transfer on varroa control is a current priority for beekeepers; however, work on other threats, such as nosemosis, American and European foulbrood, the small hive beetle, and *Tropilaelaps* mites, is also important. The use of new technologies and innovative science can greatly increase bee health and improve honey bee productivity, which will benefit agricultural systems. We are grateful to the authors who contributed to this Research Topic, the reviewers, and the editorial team.

Author contributions

NM: Writing – original draft, Writing – review & editing. KA: Writing – review & editing. PA: Writing – review & editing. MG: Writing – review & editing.

Conflict of interest

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