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The greatest challenge facing agriculture over the next five years

The honey bee, *Apis mellifera*, is the most important beneficial insect to the agricultural sector in the United States, contributing approximately $17 billion annually to the U.S. economy, particularly through the pollination of major agricultural crops (Calderone 2012). Due to their importance, the worldwide honey bee population decline continues to cause alarm. This decline not only endangers an essential pollinator, but also puts food security at risk, as one third of the food humans consume is produced through partial or total honey bee pollination. Furthermore, the demand for pollinator-dependent crops continues to increase on a global scale (Aizen et al. 2008). Because so much of the agricultural production is dependent on honey bees, the decline in honey bee populations is one of the greatest challenges facing global agriculture and food security over the next five years in the United States and the world.

The current world population of 7.2 billion humans is expected to rise to approximately 9.6 billion by 2050. One of the most striking challenges associated with this human population explosion is the shocking amount of food that must become available to support it. The well-documented pollinator shortages in the United States and some European countries will directly limit the amount of pollinator-driven food that can be produced (Holden 2006, Aizen et al. 2008, Aizen & Harder 2009). For instance, the shortage managed honey bees in the U.S. has caused almond growers in California to require that approximately 65% of the nation's colonies be transported in early spring, as almonds are fully dependent on honey bee pollination for nut production. The increased demand for almonds worldwide has led to growers importing bees from Australia in recent years to help suffice the minimum number of colonies needed per acre for sufficient pollination of orchards (Holden 2006).

The factors that influence the observed shortage of pollinators, particularly honey bees, are currently under urgent scrutiny. Some of these factors include habitat fragmentation, increased use of agricultural pesticides, disease and pathogens, poor nutrition, and the problems associated with the parasite *Varroa destructor*, a mite that sucks the hemolymph, or bee blood, out of developing and adult bees and simultaneously vectors many honey bee viruses (vanEngelsdorp et al. 2010, Pettis & Delaplane 2010). Farmers of large commercial crop operations understand that pollination is necessary for a successful year, so they offer commercial beekeepers large pollination fees per honey bee colony placed in an agricultural field during a particular plant's blooming period. Beekeepers rush to meet pollination demands all over the country, but particularly for the almond bloom in California. This large scale migration nutritionally stresses the honey bees and makes them susceptible to pathogens, but it also gets the majority of American honey bees in one area, thus creating a reservoir for honey bee pests and pathogens (Ahn et al. 2012). Furthermore, the high levels of chemical use in agricultural settings additionally place these migratory honey bees at risk of death or severe population decline, as foragers bring pesticides back to their home colonies from the field, thus poisoning their colonies.

While commercial honey bee colonies in the U.S. are subject to pollination migrations and the difficulties associated, the most serious honey bee pest is the varroa mite. Varroa mite infestations pose multipronged threats to honey bee colony health, as they are universal American honey bee colonies and physically harm individual bees as well as cause further indirect problems. The varroa mite's lifecycle is very well-matched to the honey bee's lifecycle, so varroa mites mature with honey bee young. During this maturation, the varroa mites feed on the immature honey bees. While the varroa mite can cause physical damage to individual honey bees in the form of detaching forewings and hindwings, making flight difficult to impossible for the bee, varroa mites

also pierce the bee cuticle and suck the hemolymph from the bee, vectoring many potentially deadly viruses in the process. High varroa infestations cause honey bee colony populations to rapidly decrease and die out, so beekeepers take these infestations very seriously. To combat varroa mites, beekeepers commonly use miticides in their colonies. The active ingredients of these miticides stay inside the beeswax due to the wax's lipophilic, or sponge-like, nature. These miticides can build up to sublethal levels within the beeswax and can be particularly harmful to colonies, as bees store their food, rear their young, and live on or in their beeswax combs (Collins et al. 2006, Walsh et al., unpublished data)

In addition to the aforementioned difficulties, honey bees also have to contend with the shortage of accessible high nutrition food and other consequences of habitat fragmentation. Honey bees need ten different and essential amino acids as well as large amounts of high quality nectar which varies depending on the specific geographic environment. As the USDA Honey Bee Forage and Nutrition Summit (HBFNS) in 2014 noted, these dietary needs are getting increasingly difficult for honey bee colonies to obtain without supplemental feeding by beekeepers. Because supplemental feedings of pollen and nectar substitute are not as nutritious as honey bee foraged pollen and nectar, this means that honey bee colonies are becoming more and more at risk as habitat fragmentation and abnormal weather patterns persist. This lack of good nutrition makes colonies more susceptible to pathogens and parasitic infestations, many of which are deadly, as was also noted at HBFNS.

Ultimately, honey bees in the United States face many difficulties which have caused their decline, some of which have been mentioned above. Because there is no single cause of the honey bee decline, there is no single solution. This makes the honey bee decline a complicated problem, and one which we are on a deadline to solve due to the increase in the global human population and pollinator dependent crops planted each year. Although honey bees are not native to the United States, we have built our agricultural sector and economy around them, so it is of paramount importance to apiculture in particular, and our society in general, that we slow or halt the decline of this essential and beneficial insect. If the world population is to grow to almost 8 billion people by 2020, as is predicted by the United Nations, then the next five years plays a critical role in pollinator health and global food security.

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