A Submission to the Senate inquiry into the future of the beekeeping and pollination service industries in Australia

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Summary

The future of Australia's beekeeping and pollination service industries is directly linked to the future of food security and agriculture; however, these industries are facing a number of serious threats that are already causing major concern for beekeeping and pollination industries in Europe and North America, as well as other countries around the world. Pollination is an essential ecosystem service in agricultural and natural systems, and the management decisions made in these systems directly impact the ability of bees and other pollinator insects to provide this essential service.

In this submission, I present a summary of evidence from scientific research into honey bees and crop pollination services in agricultural landscapes, including from my own PhD research. This information is mostly relevant to points (b) and (f) from the terms of reference for this inquiry, and aims to summarise the threats facing the beekeeping and pollination service industries and the key points to consider in addressing these threats. In addition, the evidence presented here from international studies demonstrates the need to expand research and management programs that enhance our understanding of managed and unmanaged pollination services, as well as ecosystem services in general, in Australian agricultural landscapes.

In section 1, I respond to point (b) from the terms of reference and present evidence for the threats facing managed honey bee colonies around the world, particularly those used to provide crop pollination services. I also suggest some options for addressing these threats. In section 2, I respond to point (f) and present evidence showing how wild pollinators contribute to crop production, and discuss how acknowledging and understanding the contribution of wild pollinators is imperative to the future of the pollination service industry and food security in general. A list of the literature cited in this submission is provided on page 6.

1. TOR (b) Current challenges facing the beekeeping industry domestically and internationally, and its future sustainability.

Globally, managed honey bee colonies are under increasing stress from intensive management practices, both within the beekeeping industry itself and agricultural industries generally. Commercial honey bee colonies are managed under an intensive 'nomadic' lifestyle, which is in contrast to their natural behaviour of forming perennial colonies in a

single location. Managed colonies are constantly travelling between locations to follow flowering seasons, often across huge ranges of climate or altitude. This practice means the bees need to cope with sudden and repeated changes in temperature, available resources and local environmental conditions over short periods of time, which has serious consequences for the health and survival of the hive. In addition to the stressors associated with the operational structure of the pollination service/beekeeping industries, the intensification of agricultural landscapes in many parts of the world, including Australia, has created inhospitable environments for managed honey bees and other pollinator insects.

In particular, the abundance, species richness and individual health of pollinators in agricultural environments are being severely impacted by:
(**i**) climate change;
(**ii**) the intensification of agricultural landscapes through increasing areas of land under intensive crop monoculture cultivation, and the loss of unmanaged vegetation in the form of flowering weeds, wildflower meadows and native woodlands/forests (Kennedy et al. 2013; Woodcock et al. 2013); and
(**iii**) the use of pesticides and other agricultural chemicals, including those used to treat in-hive pests (Johnson et al. 2009; Brittain & Potts 2011; Goulson 2013).

As a result of continuous exposure to multiple stressors, managed honey bee colonies are under increased threat from a variety of pests and pathogens, including the *Varroa destructor* mite, *Nosema* parasite, hive beetle, and the diseases or viruses that are spread through colonies via these organisms.

Following is a summary of some relevant scientific studies conducted overseas, which provide evidence for the increased stress that managed honey bees are exposed to through common beekeeping and agricultural management practices. There are many similar studies published in the peer-reviewed literature, but only a few are presented here as examples:

<u>Diet diversity</u>

- Alaux et al. (2010) found that honey bees fed a monofloral pollen diet similar to that found in a monoculture crop field had lower levels of immunocompetence, which affects the bee's ability to fight infection, than honey bees fed with high pollen diversity from multiple different floral resources.
- DeGrandi-Hoffman et al. (2010) found that honey bees fed protein supplements and sugar syrup (a common practice for managed honey bee colonies) had lower protein concentration, and smaller hypopharyngeal glands, and were also more susceptible to infection by deformed wing virus. Protein intake (i.e. nutrition from a diet of diverse floral resources) and the size and function of a bee's hypopharyngeal gland have a direct impact on the bee's health and immune responses, and therefore the survival of the colony as a whole.

- Di Pasquale et al. (2013) found that honey bees parasitised by the microsporidian parasite *Nosema ceranae* died sooner if fed with a monofloral diet than parasitised bees fed with a polyfloral pollen diet.

Pesticides and environmental toxins

- Köhler et al. (2012) found that honey bees simultaneously exposed to an immune challenge (*E. coli* bacteria) and a dietary toxin (alkaloid nicotine, as found in neonicotinoid pesticides) died sooner than honey bees exposed to only one of the stressors alone.
- Wu et al. (2012) found that adult honey bees reared in brood combs containing high levels of pesticides had increased rates of infection by *Nosema* parasites and became infected at a younger age, compared to honey bees reared in the presence of little or no pesticide residues.
- Pettis et al. (2013) found that honey bees had a higher risk of infection by the *Nosema* parasite when they consumed pollen containing high levels of fungicide, a type of chemical that has previously been considered safe to use where pollinators are active.

These results, along with results from other similar studies, show that the future of the beekeeping and pollination service industries is at most risk from current management practices. The breadth of scientific evidence available shows that honey bee colonies are enduring repeated exposure to multiple, consistent stressors in the form of agricultural pesticides and other chemicals, lack of floral diversity available in broadacre monoculture crop fields, and the overall high-stress 'lifestyle' associated with the pollination service industry.

This repeated stress means honey bees are more susceptible to infection by pests and diseases, just as a human who is already frail or run-down will be more likely to develop a serious flu infection than a healthy person exposed to the same virus. Consequently, an increased number of honey bees with stressed or compromised immune systems will mean increased economic and biological losses for the beekeeping and pollination service industries.

Conclusions

Australian honey bee hives are already exposed to a number of exotic pests and diseases, including *Nosema* parasites, and *Varroa destructor* will arrive in the near future. Scientific experts are in agreement that there is not one single factor that causes poor health and stress in honey bee colonies; rather, honey bee losses occur from exposure to multiple stressors, both within the hive and in their foraging environment. Therefore, the future of the beekeeping and pollination service industries in Australia depends on:
(**i**) limiting management practices that impact honey bee health, in these and other agricultural industries; and
(**ii**) promoting practices that enhance diet diversity and immunocompetence of managed honey bees.

Options to address these risks include:
(**i**) assessing the current regulations on, and availability of, pesticides and agricultural chemicals, particularly those that have been proven to have detrimental effects on pollinator insects, and developing initiatives that will encourage conventional crop growers to limit chemical use;
(**ii**) encouraging growers of pollinator-dependent crops to establish permanent on-site honey bee colonies as part of the crop management operations, rather than maintaining the unsustainable cycle of renting and importing temporary hives for the duration of the brief flowering season. This has the added benefit of removing the additional pressure of crop pollination services from managed honey bee colonies that are needed for native honey or beeswax production; and
(**iii**) encouraging growers to provide alternative floral resources within and adjacent to crop fields to give managed honey bees access to diet diversity, which can increase the general health and immunocompetence of bee individuals and colonies.

2. TOR (f) Any related matters.

The information presented here is specifically relevant to the pollination service industry. Wild pollinator insects (e.g. native bees, butterflies, wasps, flies) are essential pollinators in natural ecosystems and loss of these insects has severe knock-on effects for native plant reproduction and other wildlife populations. Unmanaged wild pollinators also visit and pollinate many crop flowers cultivated in Australia, but their contribution to crop production has largely been overlooked. Some native Australian bee species can be successfully managed as crop pollinators for some tropical and subtropical crops (Heard 1994; Heard 1999; Bell et al. 2006; Hogendoorn et al. 2006) and research into this field is continuing.

However, there is very limited understanding of how to maintain suitable habitat for unmanaged wild pollinators in crop fields in the Australian context. Overseas, there has been more than a decade of scientific research conducted in agricultural landscapes of Europe and North America that shows how important unmanaged wild pollinator insects are to crop production. For example:

- Greenleaf & Kremen (2006) found that the presence of wild bees in hybrid sunflower fields indirectly enhanced sunflower seed production. Honey bee foragers specialise on either pollen (male flowers) or nectar (female flowers), so most of these individuals will not make the necessary switch between male and female flowers to effect pollination. However, when wild bees were present, honey bees were three times more likely to move from a male to a female flower after encountering a wild bee competing for pollen on the male flower, compared to when they encountered another honey bee.
- Winfree et al. (2008) measured bee visits to vegetable crops on 29 farms in eastern United States over 2 years and found that wild bees were the most common visitor to

crop flowers – 4592 visits by wild bees were recorded compared to 2842 by honey bees.

- Breeze et al. (2011) found that the UK land area under cultivation of insect-pollinated crops has increased over the last 20 years, despite the significant decline in the number of managed honey bee colonies available for pollination. This suggests that wild pollinators are making a much greater contribution to crop pollination than was previously assumed.
- Brittain et al. (2013) found that Californian almond orchards with wild non-honey bee pollinator insects present had a greater proportion of fruit set compared to orchards where only honey bees were present.

Wild pollinators are at risk from the same stressors that threaten the future of managed honey bee colonies and research conducted in agricultural systems around the world has shown there are a number of ways to maintain diverse local pollinator communities, including:
(**i**) maintaining floral diversity in and around crop fields through polycultures of crops or weedy/wildflower vegetation (Carreck & Williams 2002; Baños-Picón et al. 2013);
(**ii**) retaining mosaics of native vegetation throughout agricultural landscapes (Ricketts et al. 2008; Garibaldi et al. 2011); and
(**iii**) limiting agricultural chemical application (Brittain et al. 2010; Brittain & Potts 2011; Whitehorn et al. 2012).

Unfortunately, there is very little evidence available on how growers can benefit from the services wild pollinators provide in Australian agricultural systems, although a few studies have highlighted the importance of retaining native vegetation near crop fields (Blanche et al. 2006; Lentini et al. 2012; Cunningham et al. 2013).

Over the last 4 years I have been completing my PhD research into wild pollinator insects around flowering almond plantations in the Sunraysia district of northwest Victoria, Australia. Almonds are completely dependent on pollinators to set fruit, and the industry currently relies on renting managed honey bee colonies at a significant cost to growers. As part of my research, we found that wild pollinators, including native bees, were more abundant and more species rich in small almond orchards where weedy ground cover was maintained across the orchard floor, compared to broadacre monoculture plantations where all weedy vegetation was actively removed throughout the plantation (Saunders et al. 2013).

Conclusions

Wild pollinators are essential contributors to fruit and seed set of many plants, including a number of economically-important crop species. The future of the pollination service industry in Australia depends on acknowledging the role that wild or unmanaged pollinators play in crop production, as well as managing agricultural systems to provide suitable habitats and environments for the establishment of diverse wild pollinator communities.

There is a need for more research into wild pollinators and ecosystem service provision in Australian agricultural landscapes. Maintaining habitat for wild pollinators in agricultural

systems can reduce the amount of stress on managed honey bee colonies and in some cases may actually enhance crop yields, however very little research has been conducted in Australia on how wild pollinators contribute to crop pollination and how they are influenced by agricultural management practices. Hence, there is an opportunity for Australian research to contribute new information to the global discourse on wild pollinators and ecosystem services in agricultural systems, while enhancing the future of our beekeeping and pollination service industries.

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