Final report summary

Progressing implementation of genetic selection in Australian honey bees

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Abstract

This project demonstrated capacity to produce estimated breeding values (EBVs) for a range of honey bee traits using pedigree and performance data, and capacity to obtain DNA data on honey bees. EBVs can be used to understand relatedness among queens. Together, they provide the foundation of an industry system for genetic evaluation of queens and widescale genetic progress for honey production, health, temperament and, potentially, pollination traits. This system has been modelled under realistic assumptions and shown to be cost-effective and indeed profitable for industry.

Queen breeders and beekeepers can participate in and help build this industry system by collecting systematic records of hive performance and keeping pedigree (either by controlled mating and/or DNA methods).

Industry should actively engage with the development of the system, including consulting with government to obtain co-investment that would ensure continuity and stability, to deliver genetic progress vital to the viability of Australia’s honey and pollination-dependent industries.

Background

This project addressed the challenge of progressing genetic improvement in the Australian honey bee industry. It focused on:

1. Ensuring that tools are available to enable delivery of EBVs for key traits. EBVs are simply descriptors of the value of the genes of individual queens. With EBVs, queen breeders and beekeepers can confidently identify queens with superior genes, and by selecting the queens with the best genes they can breed genetically better daughters and sons, and hence make genetic progress.

Delivering EBVs requires appropriate software to analyse data; such software is available through the Animal Genetics and Breeding Unit (AGBU). Delivery also requires performance data relating to honey production, temperament and health, and pedigree records. Pedigree can be maintained by controlled mating (and by identifying queen mothers and, where possible, drone mothers) or by using DNA tools.

2. Investigating the potential to use information derived from DNA technologies, often referred to as genomics. DNA information provides scope to identify pedigree relationships and improve knowledge of relationships among queens – both of which are crucial to accelerating genetic progress.

3. Identifying how industry could implement widescale recording and genetic analysis, enabling all or many queen breeders and beekeepers to obtain EBVs for traits of interest. Such a model should use DNA technologies. A model for industry implementation would be a roadmap for industry to progress the adoption of modern genetic improvement.

Successful implementation of genetic selection has the potential to radically improve the long-term viability of the Australian honey bee industry, and thus honey production and pollination services. Doing so will also help the industry prepare for risks such as incursion of Varroa.

Research approach

Delivery of EBVs from industry data

Performance data and trait scores, along with queen pedigree for queens in their dataset, were provided by the Horner family from Mudgee NSW. A small dataset of rapid hygiene scores was also available from a subset of one line maintained by the family.

The data analyses were conducted on laptops, reflecting the small size of the datasets. Data analysis was conducted using software developed by the AGBU for more general use.

Identification of DNA service providers and DNA analysis of industry samples

After considering a number of providers, DNA analysis was undertaken by the Australian Genome Research Facility (AGRF), an Australian genomics provider.

Analysis of the results delivered by AGRF was conducted using software developed by the AGBU for use across a range of species. Analysis included undertaking quality assurance procedures for genotypes (the DNA “read”) and identifying genomic relationships between queens and sources of queens.

Modelling industry implementation of performance recording, genetic analysis and genomic analysis

An industry implementation model was built in Excel, to account for factors including the size of the core breeding population and the commercial population; the costs of trait recording and genotyping; and the rate of genetic improvement when selecting based on standard pedigree data or genomic pedigrees and relationships. The model was only applied for honey production, but can be extended to selecting for other traits.

Project outcomes and implications

The key findings of the project were:

- EBVs for a range of production, health and temperament traits were produced from industry data.
- The EBV ranges (from best to worst) indicate that there is substantial scope for rapid genetic progress in these traits in the Australian honey bee population.
- A suitable DNA service provider was identified, and sampled hives from industry populations have been “read” – meaning that DNA analysis on a suitable scale is available to the Australian industry.
- Results from the pilot DNA analysis showed relatedness between a number of sources of queens in Western Australia and New South Wales, providing proof-of-concept that DNA tools can be used routinely for genetic analysis of queens in the Australian population.
- A model to implement genetic evaluation and genomic selection in Australian honey bees was developed, and was used to explore potential benefit-cost. The results suggest that implementation can be profitable at an industry level and, depending on the specific model used and the pricing principles applied, profitable for individual queen breeders and beekeepers as well.
Together, these results point to substantial opportunity for the Australian honey bee industry. In parallel with this project, project partners have contributed to the design and development of the Plan Bee collaborative R&D project – which represents a substantial step towards full industry implementation of the results of this project. Industry engagement with and support for implementation is strongly recommended.

The project had an additional objective, to genotype imported semen to allow inclusion of the new genetic sources to be properly evaluated in the future through inclusion of source pedigree information. This objective could not be achieved because there was no importation of semen during the project term. However, the genotyping protocols and service identified mean that this activity could be completed in the future should importation become possible.

Recommendations

The model for industry-scale recording and selection should be progressed. This will involve the following elements:

• Standardised trait definitions and recording protocols.
• Database capable of receiving and storing pedigree, performance and genotype data.
• Analysis tools (in place).
• A nucleus or core of recorded and genotyped queens.
• A strong communications program aimed at encouraging four main activities:
  • Recording of key traits in colonies maintaining at least five hives.
  • Submitting of hive samples for genomic testing, to establish relationship with the national genomic reference population and the genetic merit of the hive (and hence queen) sampled.
  • Selection within the genomic reference to generate rapid genetic progress for important traits.
  • Widespread use of AI from elite genetic material to disseminate the genetic progress being made.
• Development of an industry governance model, including a mechanism for sustained funding, and a business model for participation.

Industry should use the Plan Bee project as the focus for:

• Developing co-investment to sustain the model beyond the current R&D project.
• Encouraging participation by queen breeders and honey producers, who can contribute vital trait data and pedigree and/or DNA data.

These recommendations are relevant to all stakeholders of genetic improvement of the Australian honey bee industry.

Related research

The project builds on and extends a previous RIRDC project, Genetic Evaluation of Australian Honey Bees using BLUP procedures.

The project has contributed to the design and development of the Plan Bee collaborative R&D project coordinated by AgriFutures Australia.

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