Contributed paper

INDUSTRY CONSULTATION AS THE BASIS OF A BREEDING OBJECTIVE FOR THE NEW ZEALAND BEEKEEPING INDUSTRY

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SUMMARY

Trait prioritisation processes as the basis of the formulation of breeding objectives can be difficult in situations where the economic impact of traits on the production system are poorly understood. Surveys can be a great tool to interact with the industry, gather information and ultimately generate enough context information to allow for the implementation of stringent genetic evaluation systems. We surveyed New Zealand beekeepers to identify traits of importance from a list of 9 preselected honeybee characteristics to be included in a national genetic improvement scheme. Trait preferences were found to vary between groups within the industry (e.g., commercial beekeepers vs. queen breeders), but emphasis on *varroa* mite resistance, honey yield and gentle temperament leading to better workability was put on by all groups.

INTRODUCTION

Despite being an important agricultural species, the Western honeybee, *Apis mellifera*, has received considerably less attention in animal breeding than more traditional livestock species with more accessible life histories. Selection is often performed *ad hoc* and based mainly on beekeeper intuition and experience (Cauia *et al.* 2011), and the adoption of structured breeding programs applying genetic evaluation tools has generally been low among commercial beekeepers. Linguistic discrepancies between beekeepers and other livestock producers around the use of the term “breeding” (which in industry jargon is used almost exclusively to refer to the multiplication of queens, both from selected and unselected dams) and honeybee mating strategies complicate the direct transfer of animal breeding methodologies from other industries.

For the formulation of a clear honeybee breeding objective, an instrumental tool in making beneficial livestock selection decisions (Dickerson 1970), beekeepers from different sectors of the industry (honey- and pollination fee-driven) need to be part of the process, both to improve the understanding of the profitability of commercial beekeeping operations and to disseminate the fundamental concepts of modern animal breeding strategies before making the corresponding tools available to the wider industry.

Industry consultation through surveys has been found to increase adoption rates of genetic evaluation services by aligning the breeding objective with the requirements of breeders and end-users of improved genetics across multiple industries and species such as pasture crops (Smith and Fennessy 2011, 2014), sheep (Byrne *et al.* 2012) and dairy cattle (Martin-Collado *et al.* 2015). Involving beekeepers directly in the formulation of a breeding objective will hopefully result in similar improvements in the adoption both of genetic evaluation services while lifting the understanding of both the promise and the limitations of genetic evaluation and mate selection tools.

MATERIALS AND METHODS

Trait pre-selection. 9 honeybee traits were selected based on literature research and preliminary beekeeper consultation for relevance, measurability, presumed heritability and observed variation in the field (for details on this see Petersen 2019). An overview of the traits included in the survey, their unit (or observation, where units are hard to define) as well as the levels addressed as part of the prioritisation process can be found in Table 1.

Table 1. Honeybee traits included in a survey to determine trait prioritisation in the New Zealand beekeeping industry

Trait	Unit or Observation	Levels
Honey production	kg / hive / season	Unchanged / +1kg / +2kg
Worker brood viability	percentage of viable brood	90% / 100% viable
Workability (Gentleness)	Likelihood of bees stinging	Less likely / unchanged / more likely
Defensive behaviour	Ability of bees to defend the hive	Less able / unchanged / more able
Swarming	Swarming urge	Management needed / not needed
Queen longevity	Queen survival	1 season / 2 seasons
Varroa destructor mite resistance	Ability of bees to control mites	Treatment needed / not needed
Body colour	Colour of drones produced	Drones are the same colour / different
Wintering ability	% surviving bees	Current winter survival / 4% better

Survey design and beekeeper recruitment. The survey was entirely designed and distributed online. It consisted of a demographics part built in SurveyGizmo (Alchemer Inc., Boulder CO, USA) and the core trait prioritisation using multi-criteria decision-making tool 1000minds® (1000minds Ltd, Dunedin, New Zealand). Beekeepers were streamed into 3 distinct sets of demographic and management questions (commercial operator, designated queen breeder and hobbyist) based on their response to the first question and asked questions about their operation (e.g., size in hives, location, staff), hive management strategies, beliefs, and preferences around queen selection. After completing the demographic survey, they were directed to 1000minds®, where they were asked to make a number of trade-off decisions to determine their personal priorities (for details see Hansen and Ombler 2008).

The survey was made available to the public via a link on the website of a national honeybee genetic improvement research project, and beekeepers were encouraged to participate throughout the 2019 Apiculture NZ conference. When participation continued to be low throughout the beekeeping season 2019/20, a priority set of around 50 beekeepers was identified and contacted directly, with the survey being conducted interview style.

Data analysis. Data analysis was carried out on the combined dataset of the demographic survey as well as 1000minds® in R. The Kruskal-Wallis test was used to determine the difference in traits preference ranks for different beekeeper demographics. Principal component analysis (PCA) was employed to reduce the dimensionality of the data and to investigate patterns of preferences in trait rankings. PCA was followed by Correspondence Analysis (CA) of the principal components. Hierarchical clustering was performed using Ward's criterion on the selected principal components. K-means clustering was used to improve the initial partition obtained from hierarchical clustering and to determine the final number of clusters.

RESULTS AND DISCUSSION

A total of 61 responses were recorded. Survey responses were excluded from the sample if they did not complete the 1000minds® survey. The final sample used in the analysis was 41 responses made up of 24 commercial operators, 11 queen breeders and 6 hobbyists.

Results from the combined dataset of all 3 beekeepers demographics showed a strong preference for *varroa* mite resistance and workability, two traits primarily associated with operational costs (e.g. mite treatments, labour), as well as honey yield, which was stated to be the source of at least 50% of income for all beekeepers. Defensive behaviour against wasps and other intruders, and body colour were found to be the least preferred traits (Figure 1, left).

While the general trend seen in the whole dataset was also found in the preferences of commercial beekeepers only (Figure 1, right), the ranking of honey yield was significantly higher among commercial beekeepers, while body colour was considered irrelevant.

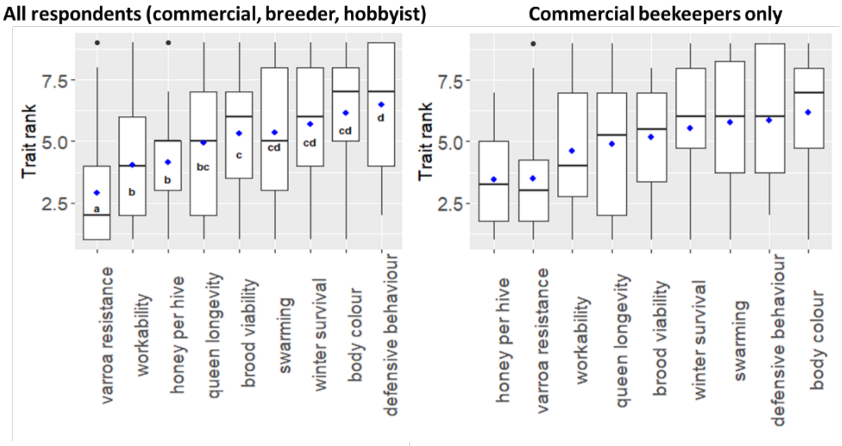

Figure 1. Ranking of trait preferences for all respondents compared to commercial beekeepers
Boxplots represent mean (blue), median (solid lines), first and third quartiles (contained in the boxes), and outliers (open points) of the distribution of the ranks of each trait improvement. Order of preferences for trait improvements is from most preferred (left) to least preferred (right). Different letters indicate significant (P-value<0.05) differences between the traits.

PCA revealed underlying patterns in the trait preferences, the most surprising of which was that although *varroa* mite resistance ranked highly in the results overall, the preference for mite resistance showed a high level of variation within the principal component (Figure 2, left). Honey yield in contrast was found to have almost no variation, due to having been given high emphasis by all respondents. Further analysis of the trait preferences showed the existence of heterogeneity even among players in the same value chain i.e. commercial operator, where 3 clusters spearheaded by queen longevity, *varroa* mite resistance and winter survival respectively could be identified (data not shown).

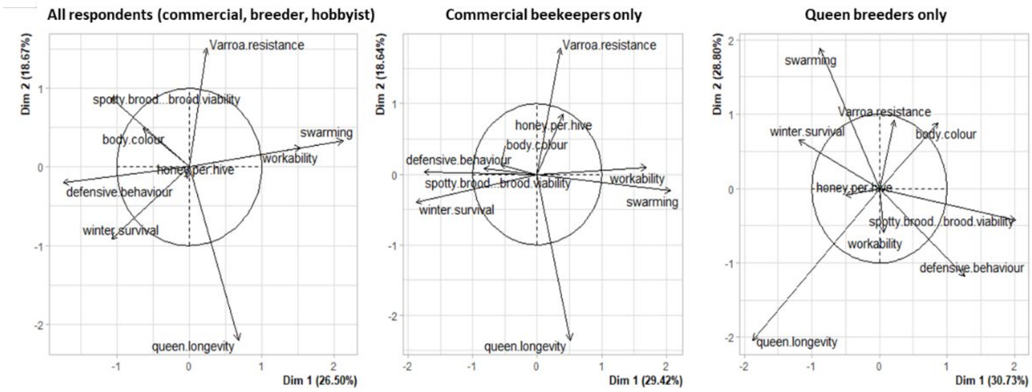

Figure 2. Patterns of trait preferences in varying respondent groups

One of the questions central to both commercial beekeepers who purchase queens from breeders and queen breeders themselves is whether queen breeder selection goals match the perceived needs in the industry. Comparing the patterns of preferences for all respondents with commercial beekeepers and queen breeders (Figure 2) reveals that this might not always be the case, since queen breeders more consistently put emphasis on mite resistance and traits that are low priority for commercial beekeepers, such as body colour, while showing variation in their emphasis on honey yield. Honey yield only placed fifth overall out of the 9 traits in the preferences of queen breeders (data not shown), indicating that they are either not able to observe honey production due to the constant "interference" with hives that is required during the queen rearing process, or that they do not consider honey yield a trait that can primarily be manipulated by selection.

An obvious limitation of this study is the number of responses from beekeepers, which limits its ability to identify e.g. clusters of preferences that could form the basis of different selection indices. However, representation of certain industry groups is strong; New Zealand currently has around a dozen specialised queen breeders out of which 11 responded to the survey or were interviewed. Within the group of 24 commercial operators, 10 fell into the range of >3,000 hives or "mega commercial" operators, representing 20.5% of these businesses which currently manage around 50% of the country's honeybee population (New Zealand Ministry for Primary Industries 2020).

Based on these rates of representation, our results can be considered meaningful despite their small sample size.

CONCLUSIONS

The presented study showed that there is considerable heterogeneity in the trait preferences of different groups within the beekeeping industry, but that surveys present a valuable tool in ranking traits with no direct monetary value attached to them (such as bee behaviour traits) to allow scaling them to production traits (e.g. honey yield) with a set value or to potentially verify a calculated value based on a set of vague assumptions against their perceived value based on ranking.

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REFERENCES

Byrne T. J., Amer, P. R., Fennessy P. F., Hansen P., and Wickham B. W. (2012) *Animal.* **6**: 778.

Cauia E., Siceanu A., Patruica S., Bura M., Sapcaliu A., Magdici M. (2011) *Econ. Manag. Financ. Mark.* **6**: 1146.

Dickerson G. (1970) *Journal of Animal Science* **30**: 849.

Hansen P. and Ombler F. (2008). *J. Multi-Crit Decis Anal* 2008; **15**: 87.

Martin-Collado D., Byrne T.J., Amer P.R., Santos B.F.S., Axford M., and Pryce J.E. (2015) *J. Dairy Sci.* **98**: 4148.

Nielsen H.M., Amer P.R.. (2007) *Animal*. **1**:1254.

New Zealand Ministry for Primary Industries (2020) Farm Monitoring Report NZ - Apiculture Report 2019, NZ MPI.

Petersen G.E.L. (2019) PhD Thesis, University of Otago.

Smith K.F. and Fennessy P.F. (2011). *Crop and Pasture Science*. **62**: 355.