Better-B practical recommendations

A protocol for Darwinian Black Box selection for resilience across Europe

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The Better-B project is a four-year Horizon Europe project funded by the European Commission that began in June 2023. The project aims to improve honey bee resilience by restoring balance within the colony and between the colony and its environment. The consortium comprises 16 partners and two associated partners coming from 14 countries. This document is part of a series translating our results into clear recommendations for a diverse target audience. Depending on whether a recommendation is practice-oriented or policy-supporting, it is classified as a "Practical Recommendation" or a "Policy Brief," respectively.

Summary

Varroa destructor remains a major cause of honey bee colony losses in Europe, highlighting the need for more sustainable solutions. Within BETTER-B, we are testing the Darwinian Black Box protocol (Blacquière et al., 2019), which aims to establish locally adapted, Varroa-resilient populations through natural selection. Although the protocol has supported a honey bee population that has survived without Varroa treatment for 17 years in the Netherlands, its application across eight European countries revealed substantial regional differences in colony survival. Our case study shows that the protocol should be adapted to local conditions by reducing other stressors and balancing Varroa selection pressure with the survival of enough colonies to continue selection over successive generations. In this Practical Recommendation, the protocol that emerged from our study is provided.

The problem

Varroa destructor remains one of the main causes of honey bee colony losses in Europe. Regular acaricide treatments help control the mite, but resistance to some products can develop, making control more difficult over time. Breeding bees that can cope better with Varroa could reduce long-term dependence on treatments. However, conventional breeding programs require specialized testing, time and resources and are not easily available to every beekeeper or local breeding group. Natural selection offers another approach by allowing colonies with different resistance and adaptation traits to survive and reproduce under local conditions.

The evidence

The Darwinian Black Box protocol promotes natural selection for Varroa resilience within managed beekeeping. Instead of selecting colonies for one particular resistance trait, it selects colonies according to their overall ability to develop, reproduce and survive without Varroa treatment. In the Netherlands, a population managed using this approach has persisted without treatment for 17 years, showing that the approach can be feasible under suitable conditions. Within BETTER-B, nine partners in eight European countries are testing the protocol under different climatic conditions and with different honey bee populations. During the first selection cycle, survival differed greatly among regions, and some partners lost a high proportion of their colonies. Additional adaptations to the original protocol were therefore introduced to account for local conditions, reduce excessive colony losses and maintain viable selection populations.. Mean winter survival across participating partners increased from 35% in the first cycle to 58% in the second. These preliminary results do not prove that the protocol adaptations caused the improvement, because other factors may have differed between cycles. However, they illustrate the balance required: there must be enough Varroa pressure to favor resilient colonies, but enough colonies must survive and reproduce for selection to continue.

Practical recommendations

The Darwinian Black Box approach provides beekeepers and local breeding groups with a framework for developing locally adapted honey bee populations through natural selection. The original protocol starts with a large and genetically diverse population. Colonies are exposed to natural Varroa pressure without routine treatment, colonies that survive and perform well are propagated, and the process is repeated over successive generations. The approach depends on maintaining a careful balance. Varroa pressure must be sufficient to favor more resilient colonies, but enough colonies must survive and reproduce for selection to continue. BETTER-B results indicate that this balance may differ between regions. The protocol should therefore be adapted to local conditions while preserving its central principle: selecting and propagating colonies that survive and perform well under Varroa pressure.

1. Start with 25–30 genetically diverse colonies

Establish the selection population with 25-30 locally adapted colonies, preferably from several unrelated origins. This provides genetic diversity and reduces the risk that early losses leave too few colonies for selection to continue. In areas where high mortality is expected based on local Varroa pressure or previous experience, consider starting with a larger population.

2. Establish strong mother colonies

Before reproduction, colonies should be healthy, well populated and sufficiently developed. Ideally, each colony should occupy a brood box and an upper box (or 2 brood boxes), with enough adult bees, brood and food to produce viable daughter colonies. Weak colonies should not be forced into the reproduction stage, as this may introduce additional causes of failure unrelated to Varroa.

3. Allow colonies to enter the reproductive phase

Allow colonies to produce drones and begin preparing to swarm. This helps ensure that colonies entering the next generation have demonstrated adequate development and reproductive capacity.

4. Produce an artificial swarm

Before natural swarming occurs, create an artificial swarm by removing the mother queen together with a portion of the worker bees. This artificial swarm is excluded from the selection programme, while the remaining colony raises daughter queens for the next selection generation.

5. Ideally divide each colony into four nuclei

The original protocol aims to produce four nucleus colonies from each successful mother colony. However, nucleus strength should take priority over producing a fixed number. If four viable nuclei cannot be produced, make fewer, stronger nuclei with sufficient workers, brood and food. Additional sister queens may also be reared, or a second round of splitting may be carried out where colony strength and seasonal conditions allow, to increase the number of daughter colonies and to reduce the risk of losing the selected line.

6. Promote mating within the selection population

Allow virgin queens to mate mainly with drones from selected colonies. Where possible, use an isolated or semi-isolated mating area, ideally with little or no other beekeeping within approximately 3 km. Cooperation with neighboring beekeepers can also increase the presence of selected drones and reduce mating with unselected populations.

7. Confirm that the new colonies are successfully established

Check that each young queen has mated, is laying normally and has produced a regular brood pattern. Confirm that each nucleus has enough bees and food to develop. Record queen loss and mating failure separately, as these are not necessarily related to Varroa resilience.

8. Minimize other causes of colony loss

Varroa should remain the principal selection pressure. Choose apiary locations with sufficient and diverse forage, ensure adequate food reserves, provide supplementary feeding and maintain suitable hive conditions and insulation. Avoid unnecessary disturbance and protect colonies against important local threats, including *Vespa velutina*, where relevant. Reducing these additional stressors makes it easier to distinguish Varroa resilience from losses caused by starvation, poor colony establishment or unsuitable apiary conditions.

9. Allow colonies to develop and overwinter

The daughter colonies should develop sufficiently to produce healthy winter bees and survive until the following spring. Monitor colony strength, food reserves and general health. Where possible, record the likely cause of each loss, distinguishing Varroa-related decline from queen failure, starvation or other causes.

10. Monitor Varroa pressure and prevent colony collapse

Monitor Varroa infestation and colony condition throughout the selection cycle. Colonies should preferably remain untreated, but for ethical reasons, severely declining colonies should be treated and excluded from selection. Colonies with high mite loads that are still performing well may be kept at separate apiaries to reduce the risk of mite and pathogen spread.

If survival is very low, Varroa pressure may be reduced, for example through a single oxalic-acid treatment of newly established nuclei during the broodless period, before the first new brood is capped. Importantly, reducing Varroa pressure and increasing the number of viable colonies can improve the chances of maintaining a surviving selection population without eliminating natural selection, provided sufficient selection pressure remains.

11. Propagate the best survivors

Select colonies that survive under the applied Varroa regime and also show good health, development and reproductive performance. Colonies requiring rescue treatment should not normally be considered selected survivors during that cycle. Use the selected colonies to produce the next generation, while continuing to preserve genetic diversity within the population

12. Repeat the process for at least four years

Repeat the selection cycle annually for at least four years. Natural selection acts over successive generations, so meaningful progress should not be expected after only one cycle. If the surviving population becomes too small, adjust the intensity of selection, increase the number of starting colonies or carefully introduce suitable local genetic material. The central objective is to maintain enough Varroa pressure to favor resilient colonies while ensuring that enough colonies survive and reproduce.

Path to implementation

The DBB approach can be implemented through cooperation between local beekeepers and beekeeping associations. Associations could establish shared mating locations for colonies participating in the DBB program, limiting mating with unselected populations while maintaining genetic diversity. By bringing together colonies from several local beekeepers, sufficiently large selection populations can be established and maintained over successive generations. This could make natural selection for Varroa resilience more feasible at a local or regional scale.

Further reading

Blacquière, T., Boot, W., Calis, J., Moro, A., Neumann, P., & Panziera, D. (2019). Darwinian black box selection for resistance to settled invasive Varroa destructor parasites in honey bees: T. Blacquière et al. Biological invasions, 21(8), 2519-2528.

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