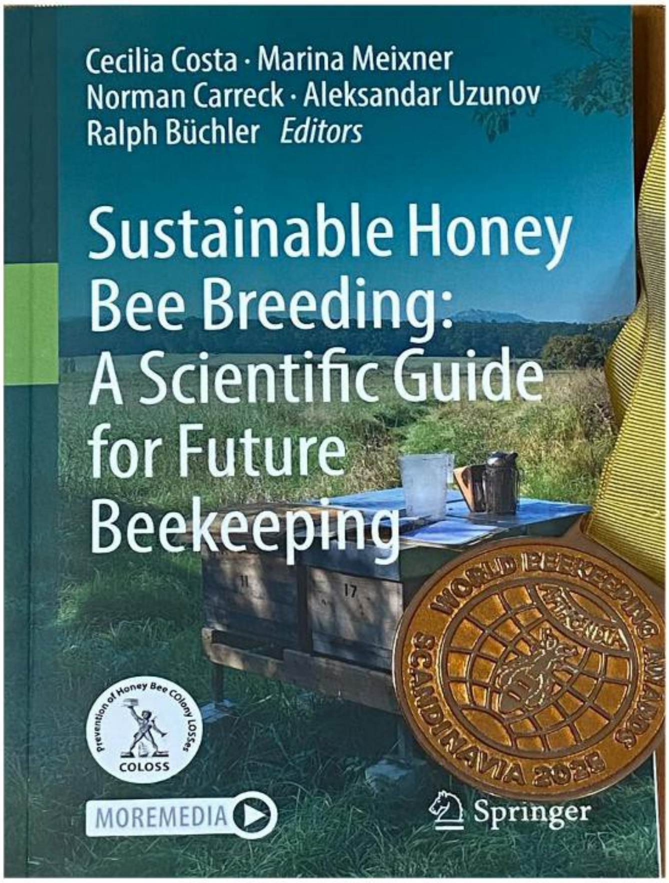
Which Breeding for Future Beekeeping?

Beekeeping is facing many new challenges, including climate change, emerging diseases and parasites, habitat loss, instability in the bee products market, and many others.
Honey bee breeding is one of the tools we can use to address these challenges. But which kind of breeding? And aimed at improving what?



The book's cover

We interviewed the Editors of the book "Sustainable Honey Bee Breeding: A Scientific Guide for Future Beekeeping". The book won the bronze medal at the latest edition of the World Beekeeping Awards, presented during the 49th Apimondia Congress in Copenhagen.

Dr. Costa, why this book?

- Over the past 20 years it has become clear that breeding should consider aspects related to vitality and adaptation. This is true for all agricultural crops and farm animals, and bees are not an exception: the difficulties in controlling the parasitic mite *Varroa destructor* and the additional challenges posed by climate change, have altered the perspective of the aims that bee breeding should follow. At the same time, beekeeping remains an agricultural activity in which productive and behavioural traits linked to management and profitability are still important. In this book, we put together the results and experience of many years of collaborative activities performed within the framework of the COLOSS association's Task Force "Research Network for Sustainable Bee Breeding", with the aim of providing bee breeders, extensionists and beekeepers, with some theoretical background on why sustainable bee breeding makes sense, and practical tools and recommendations on how to achieve it.

What types of genetic improvement did you take into consideration?

– The title itself gives the answer! With "Sustainable breeding" we mean that traits connected to resilience to stressors and to adaptation to local environments should be considered, as well as traits which measure traditional apicultural aspects such as honey production and low aggressive behaviour. In the book we provide some examples stemming from our research on how this has shown to be possible; also we provide evidence on how local adaptation and selection of varroa resistance traits can provide a productive advantage for the beekeeper.
We describe how to set up a breeding program, even at a small scale, how to set up a performance testing apiary and how to measure yield and behaviours linked to varroa resistance. We provide practical information and many details on how to achieve controlled mating, which is an essential component of genetic selection. The methods we describe may be employed on different levels, from a simple breeding program based only on phenotypic values (mass selection) to the recommended genetic selection using pedigree values, extended performance testing across different environments and calculation of Breeding Values using the BLUP-Animal Model, which will ensure the highest progress in selection.

Dr. Bűchler, how far along is the research on resistance to varroa?

– Research on resistance started in the 1980s in central Europe with scientific comparisons of mite susceptibility in different *A. mellifera* stocks and first studies on resistance traits of bees. The search for relevant resistance characters in European *A. mellifera* was stimulated by parallel investigations on the behaviour of the original mite host *A. cerana* in Asia. In the following decades, more and more resistant *A. mellifera* populations were detected and further investigated in Africa, South-, North-America and Europe. After the arrival of varroa in North America, researchers from the United States Department of Agriculture (USDA) successfully established selective breeding programs for SMR (Suppression of Mite Reproduction) and VSH (Varroa Sensitive Hygiene) expression which resulted in breeding lines with increased mite resistance. Meanwhile, quite a number of selection programs for mite resistance are running around the globe, and a large-scale study mandated by the European Union commission (the EurBeST project) recently proved the success of selective breeding on mite resistance and its economical value for the beekeeping sector.

The book's authors. From the left, Cecilia Costa, Aleksandar Uzunov, Ralph Büchler Marina Meixer, Normann Carreck

Dr. Carreck, what about selection for other diseases and parasites?

– Although most recent efforts have been concentrated on varroa, research into breeding for disease resistance actually goes back to the 1930s, when US scientist Walter Rothenbuler visited a commercial beekeeping operation where the owner had, for many years, collected second-hand equipment from colonies which had died out from American foulbrood (AFB). Rothenbuler made the observation that live colonies robbing honey from this equipment, which would have been heavily contaminated with bacterial spores, did not die and remained healthy. He realised that these colonies were capable of detecting infected brood cells and removing them from the colony. He demonstrated that this ability, which he named “hygienic behaviour” had a genetic basis and could be selected for. It was later shown that as well as AFB, this behaviour conferred protection from the fungal brood disease chalkbrood, and also from varroa. The “freeze-killed brood” test, and later in Europe, the “pin test” were developed to identify hygienic colonies. This led to much further refinement to examine the genetic basis which confer the SMR and VSH traits. With the threat of the *Tropilaelaps* mite on the edge of Europe, there is currently much interest in whether resistance traits for varroa may also protect against *Tropilaelaps*.

Dr. Meixner, what can breeding do to face climate change?

Due to warmer winters and generally more unpredictable weather, climate change is a challenge for honey bee colonies that often do not cease rearing brood when there is no frost, and thus deplete their winter stores too quickly. In addition, under such conditions, brood parasites have a chance to propagate continuously throughout winter. By documentation of brood rearing during winter and by measuring the consumption of winter stores, colonies can be identified that consistently rear less or no brood in winter. Selective propagation of such genetic stock can lead to increased resilience and better survivability. Climate change, with overall rising temperatures, also increases the chance of invasive new parasites and pathogens, such as the *Tropilaelaps* mite, expanding their range. Like in breeding efforts for varroa resistance and other diseases, investigation of relevant behavioural traits that limit reproductive success of these parasites, combined with selection of lines with increased resistance, will also contribute to improved resilience against climate change and its consequences.

Prof. Uzunov, what is the relationship between breeding and conservation of honey bee biodiversity?

– The relationship between breeding and conservation of honey bee biodiversity lies in the strategic and systematic use of genetic resources, whereby sustainable breeding programs combine populations' natural capacities with targeted improvement. In this way, by prioritizing local genetic resources over foreign ones, and enhancing their attractiveness to beekeepers, these programs strengthen resilience of local biodiversity and ecological balance. "Conservation via utilization" is preserving biodiversity by integrating it into selective breeding for productive beekeeping; this is the most effective long-term approach for bees and for beekeepers. Modern breeding programs embed these principles, combining genetic improvement with biodiversity conservation to secure productivity and ecological sustainability. It is important to keep in mind that native and local resources remain a vital source of genetic potential for future challenges.