The COLOSS BEEBOOK, a Manual of Standard Methods for Honey Bee Research

Norman L. Carreck, Vincent Dietemann, James D. Ellis, Jay D. Evans, Peter Neumann & Panuwan Chantawannakul

To cite this article: Norman L. Carreck, Vincent Dietemann, James D. Ellis, Jay D. Evans, Peter Neumann & Panuwan Chantawannakul (2021): The COLOSS BEEBOOK, a Manual of Standard Methods for Honey Bee Research, Bee World, DOI: 10.1080/0005772X.2021.1981677

To link to this article: https://doi.org/10.1080/0005772X.2021.1981677
The COLOSS BEEBOOK, a Manual of Standard Methods for Honey Bee Research

Norman L. Carreck ©, Vincent Dietemann ©, James D. Ellis ©, Jay D. Evans ©, Peter Neumann © and Panuwan Chantawannakul

The Vision
The BEEBOOK project arose from discussions at early COLOSS (Prevention of Honey Bee Colony LOSSES) meetings. The vision was, and still is, to develop a definitive inventory of standard techniques and methods in honey bee research to ensure that studies performed by different laboratories around the world would be directly comparable. The manual, titled the COLOSS BEEBOOK, was inspired by publications with similar purposes for Drosophila fruit fly research (Williams et al., 2012). The previous lack of standards had made, for example, establishing whether honey bee colony losses had indeed increased, or were greater in some countries than in others, exceptionally difficult. The BEEBOOK is not meant to standardize the research itself, but focusses solely on the methods for which standardization is useful to enable reproducibility as a cornerstone of science. The BEEBOOK is a tool for all who want to conduct research on honey bees. It has been written in such a way that those new to honey bee research can use it to begin studies in fields with which they may not be familiar.

Creation
Production of the BEEBOOK began after recruiting international experts to lead the compilation of each research domain. These senior authors (first in the author list) were tasked with recruiting a suitable international team of contributors to select methods to be used as standards and then to report the methods in a user-friendly manner (Williams et al., 2012).

The initial BEEBOOK was divided into three volumes: The COLOSS BEEBOOK, Volume I: Standard methods for Apis mellifera pest and pathogen research; and The COLOSS BEEBOOK, Volume II: Standard methods for Apis mellifera product research (Figure 1). The first two volumes of the COLOSS BEEBOOK were published in 2013 (Figure 2). The final chapters of Volume III were published in 2021 and a hard copy volume will be published shortly.

A Global Enterprise
The BEEBOOK is a truly international collaboration. In Volume I, 167 international scientists from 29 countries collaborated to produce 18 chapters including over a thousand protocols related to studying honey bees and their colonies. For Volume II, 98 international scientists from 22 countries collaborated to produce 12 chapters including over 500 protocols. Volume III represents the work of 133 authors from 26 countries spanning five continents.

One Book, Multiple Forms
Each BEEBOOK chapter has been published as an open access peer-reviewed article in the Journal of Apicultural Research (JAR). The .pdf papers can be downloaded free to view directly from the Taylor & Francis online platform for JAR and through the COLOSS website: https://coloss.org/. They are also available as hard copy books (Dietemann et al., 2013a, 2013b), and can be purchased from the IBRA bookshop: https://ibra.org.uk/shop or from Amazon.

A Standard beyond Others
The reader may wonder about the difference between the BEEBOOK and existing standards provided by the Office International des Epizooties (OIE) and the European Organization for Economic Co-operation and Development (OECD). In the BEEBOOK, we often refer to OIE, OECD, and other standards, since they describe methods to diagnose pests and diseases (OIE) or to perform, for example, routine analyses for toxicity tests (OECD). The BEEBOOK, however, goes well beyond diagnosis and routine analyses by describing the methods to perform research on the honey bee, its colony, hive products, and associated organisms. Where necessary, the BEEBOOK recognizes existing standards such as those provided by the OIE and OECD, and presents a harmonized compendium of research methods, written and reviewed by an international team of scientists.

User Acceptance
With the completion of the original three volumes of the COLOSS BEEBOOK, we now explore whether it has, as hoped, been fully adopted by the bee science community as an aid to collaborative science and the development of our understanding of honey bees. There are several measures of its use. One is the number of citations of the chapters in other scientific papers. The CrossRef database in August 2021 showed a total of 2,300 citations to BEEBOOK chapters. The citations are accumulating at a rate of approximately 50 per month. The rate of citation has increased greatly in the last two years, and the most highly cited chapters are those on Nosema (Fries et al., 2013; 196 citations), Varroa (Dietemann et al., 2013c; 177 citations) and viruses (de Miranda et al., 2013; 156 citations).

Another measure of adoption by the scientific community is the number of times that individual chapters are downloaded. The chapters from Volumes I and II had 2,986 downloads from the IBRA website between January 2013 and September 2014, before JAR was transferred to the Taylor & Francis Online platform in April 2015. Since that time, there have been nearly 180,000 downloads...
Beyond *Apis mellifera*

The field of bee science has much to gain from the development of research on the Eastern honey bee, *Apis cerana*. Correspondingly, experts on this species from the COLOSS network have collaborated to share technical experiences on specific techniques for *A. cerana* research in Volume IV, “Standard methods for *Apis cerana* research”, which is currently being prepared. This will provide standard methods for general research on *A. cerana* and research on its pests, pathogens, and hive products. More information on Eastern honey bees will provide greater insight into the evolution and host-parasite relationships of *Apis* species.

**Not Only for Scientists!**

The unique BEEBOOK project has been fully embraced by the honey bee research community, and the numbers of citations that the papers receive are encouraging. Although many COLOSS members are research scientists, and the first volumes of the BEEBOOK concentrated mainly on scientific techniques, many other members work in agricultural extension services and have the task of disseminating scientific knowledge to beekeepers. Therefore BEEBOOK Volume V, “Standard methods for sustainable beekeeping”, is in the planning stages and will follow the format of earlier volumes. Global principles will be summarized by international contributors who will detail regional variations in beekeeping techniques due to local conditions.

**An Evolving Tool**

The BEEBOOK was, from the outset, intended as an evolving tool, keeping pace with the development of new methods and the improvement of existing ones. The field of molecular methods for honey bee research has experienced a rapid evolution since the first publication of Evans et al. (2013), especially with the development of “omics methods” namely: genomics, the study of the structure, function, evolution and mapping of genomes (the genetic makeup of an organism); proteomics, the study of genes coding for proteins and their function; and metabolomics, the study of the genetic basis of an organism’s metabolism (the chemical processes within an organism that sustain life). Since it is the COLOSS BEEBOOK’s purpose to compile the most up to date methods, we are currently including a chapter focused on “Standard methods for *Apis* ‘omics research” in Volume IV. This chapter will cover the immense changes in sequencing and analytics related to full-genome analyses of honey bees and functional insights into bee health, development, reproduction, and behavior. It will also cover new work comparing the genomes and biology of multiple *Apis* species, including *A. cerana*, and the emergent field of metabolomics, which can use protein and biochemical insights to describe the multitude of important chemical processes that occur inside bees. This chapter will provide methods, resources, and a roadmap to online genomic and genetic databases that will be useful for researchers.

It was recognized at the start of the BEEBOOK project that new threats to bees and new areas of interest would emerge and would need to be added. For example, the yellow legged Asian hornet *Vespa velutina* was at the BEEBOOK’s inception not considered of significance to western honey bees. However, in the last few years, this view has changed as many parts of Europe now experience its harmful effects. Correspondingly, a new chapter on *V. velutina* is being written. This provides an example of how the BEEBOOK can evolve to include new areas of research not previously considered relevant to honey bees.
Inevitably, as new techniques are developed, some of the BEEBOOK chapters will become outdated. Thus, several of the original chapters are now being updated. Following contact with the initial author teams, we can report that interest has been expressed updating several of the original chapters. In some cases, the original lead author will be coordinating the revision, but in many cases, newer and younger authors have now joined the teams. In this way, the BEEBOOK project will continue to develop and evolve for the foreseeable future.

In conclusion, the BEEBOOK is one of COLOSS’s most successful, impactful, and enduring outputs to date. We believe it will continue to impact honey bee research globally for decades to come. We also believe it is a fitting testimony to the accomplishments made when scientists work together with common purpose.

Acknowledgements
The editors would like to thank the many international authors and numerous reviewers who wrote and refereed the BEEBOOK. We would also like to thank the International Bee Research Association and the Journal of Apicultural Research editorial team, Taylor & Francis Ltd, and Northern Bee Books for making its publication possible. The COLOSS network is supported by the Ricola Foundation – Nature & Culture, Vetpharma and the Eva Crane Trust as well as numerous local sponsors. P.C. acknowledges the Ricola foundation Nature & Culture and Chiang Mai University for supporting Eastern honey bee research.

Disclosure statement
No potential conflict of interest was reported by the authors.

References
Bankova, V., Bertelt, D., Borba, R., Conti, B. J., da Silva Cunha, I. B., Danert, C., Eberlin, M. N., Falcao, S. I., Isla, M. I., Moreno, M. I., Papotti, G., Poppova, P., Santiago, K. B., Salas, A., Saxena, A. C., H. F., Schwabl, N. V., Sifontes, J. M., Simone-Finstrom, M., Spivak, M., … Zampini, C. (2019). Standard methods for Apis mellifera propolis research. In V. Dietemann, P. Neumann, N. L. Carreck, & J. D. Ellis (Eds), The COLOSS BEEBOOK, Volume III: standard methods for Apis mellifera hive product research. Journal of Apicultural Research, 58(2). https://doi.org/10.1080/00218839.2016.1222661

de Miranda, J. R., Bailey, L., Ball, B. V., Blanchard, P., Budge, G., Chepurnovskiy, N., Chen, Y., P. Gauthier, E., Genersch, E., De Graaf, D., Ribère, M., Ryabov, E., De Smet, L., & van der Steen, J. J. M. (2013). Standard methods for virus research in Apis mellifera. In V. Dietemann, J. D. Ellis, & P. Neumann (Eds), The COLOSS BEEBOOK, Volume II: standard methods for Apis mellifera pest and pathogen research. Journal of Apicultural Research, 52(4). https://doi.org/10.3896/IBRA.1.52.4.22

Dietemann, V., Ellis, J. D. & Neumann, P. (Eds). (2013a). The COLOSS BEEBOOK, Volume I: standard methods for Apis mellifera research (pp. 636). International Bee Research Association.

Dietemann, V., Ellis, J. D. & Neumann, P. (Eds). (2013b). The COLOSS BEEBOOK, Volume II: standard methods for Apis mellifera pest and pathogen research (pp. 636). International Bee Research Association.

Dietemann, V., Nazzi, F., Martin, S. J., Anderson, D., Locke, B., Delaplane, K. S., Wauquier, Q., Tannahill, C., Frey, E., Ziegelmann, B., Rosenkrantz, P. & Ellis, J. D. (2013c). Standard methods for varroa research. In V. Dietemann, J. D. Ellis & P. Neumann (Eds), The COLOSS BEEBOOK, Volume II: standard methods for Apis mellifera pest and pathogen research. Journal of Apicultural Research, 52(4), 1–4. https://doi.org/10.3896/IBRA.1.52.1.09

Evans, J. D., Schwartz, R. S., Chen, Y., F., Budge, G., Conran, R. S., De La Rua, P., De Miranda, J. R., Forest, S., Foster, L., Gauthier, L., Genersch, E., Gisder, S., Jarosch, A., Kucharski, R., Lopez, D., Lun, C. M., Mortiz, R. F. A., Maleszka, R., Muñoz, I., & Pinto, M. A. (2013). Standard methodologies for molecular research in Apis mellifera. In V. Dietemann, J. D. Ellis & P. Neumann (Eds), The COLOSS BEEBOOK, Volume I: standard methods for Apis mellifera research. Journal of Apicultural Research, 52(4). https://doi.org/10.3896/IBRA.1.52.4.11

Fries, I., Chauvat, M.-F., Chen, Y.-P., Doublet, V., Genersch, E., Gisder, S., Higès, M., Mcmahon, D. P., Martin-Hernández, R., Natsopoulou, M., Paxton, R. J., Tanner, G., Webster, T., C., & Williams, G. R. (2013). Standard methods for nosema research. In V. Dietemann, J. D. Ellis & P. Neumann (Eds), The COLOSS BEEBOOK, Volume II: standard methods for Apis mellifera pest and pathogen research. Journal of Apicultural Research, 52(4). https://doi.org/10.3896/IBRA.1.52.1.14

Williams, G. R., Dietemann, V., Ellis, J. D., & Neumann, P. (2012). An update on the COLOSS network and the ‘BEEBOOK’ standard methodologies for Apis mellifera research, Journal of Apicultural Research, 51(2), 151–153. https://doi.org/10.3896/IBRA.1.51.2.01

Norman L. Carreck
Carreck Consultancy Ltd., Woodside Cottage, Dragons Lane, Shipley, West Sussex, RH13 8GD, UK

University of Sussex, Falmer, East Sussex
BN1 9QG, UK

Email: norman.carreck@btinternet.com

Norman L. Carreck https://orcid.org/0000-0001-7779-9736

Vincent Dietemann
Swiss Bee Research Center, Agroscope, Bern, Switzerland

Department of Ecology and Evolution, University of Lausanne, Lausanne, Switzerland

Vincent Dietemann https://orcid.org/0000-0002-0791-9939

James D. Ellis
Entomology and Nematology Department, University of Florida, Gainesville, FL, USA

James D. Ellis https://orcid.org/0000-0003-0318-8646

Jay D. Evans
USDA ARS, Bee Research Laboratory, BARC East, Bldg 306, Beltsville, MD 20705 USA

Jay D. Evans https://orcid.org/0000-0002-0636-4651

Peter Neumann
Institute of Bee Health, Vetsuisse Faculty, University of Bern
Swiss Bee Research Center, Agroscope, Bern, Switzerland

Peter Neumann https://orcid.org/0000-0001-5163-5215

Panuwat Chantawannakul
Environmental Science Research Center and Bee Protection Laboratory, Department of Biology, Faculty of Science, Chiang Mai University, 50200 Thailand

https://doi.org/10.3896/IBRA.1.51.2.01

Note on Disclosure Statement
Disclosure statement
No potential conflict of interest was reported by the authors.

Acknowledgements
The editors would like to thank the many international authors and numerous reviewers who wrote and refereed the BEEBOOK. We would also like to thank the International Bee Research Association and the Journal of Apicultural Research editorial team, Taylor & Francis Ltd, and Northern Bee Books for making its publication possible. The COLOSS network is supported by the Ricola Foundation – Nature & Culture, Vetpharma and the Eva Crane Trust as well as numerous local sponsors. P.C. acknowledges the Ricola foundation Nature & Culture and Chiang Mai University for supporting Eastern honey bee research.