SMARTBEES / FP7-KBBE.2013.1.3-02 / WP6
Sustainable **Ma**nagement of **R**esilien**t** **Bee** Population**s**
www.smartbees-fp7.eu

Performance testing protocol

A guide for European honey bee breeders

Released: April, 2015. Version 1.0

Dr. Aleksandar Uzunov[1], Dr. Ralph Büchler[1], Prof. Dr. Kaspar Bienefeld[2]

[1]Landesbetrieb Landwirtschaft Hessen
Bieneninstitut, Erlenstrasse 9, 35274 Kirchhain, Germany
www.bieneninstitut-kirchhain.de

[2]Länderinstitut für Bienenkunde
Friedrich-Engels-Str. 32, D-16540 Hohen Neuendorf, Germany
www2.hu-berlin.de/bienenkunde

Table of contents

Introduction 3

Program cycle 4

Apiary management 5

Colony management 6

Performance test 8

Program management 10

Frequently Asked Questions 10

Additional information 11

Check list 11

Introduction

Europe is the home of at least 10 different honey bee subspecies, each subdivided in a spectrum of local populations. The high genetic diversity results from long lasting continuous selection under diverse climatic and environmental conditions. Before man started to care for bees and protect them from diseases, reproduction was limited to colonies which successfully coped with all pathogens, pests and environmental challenges. That's why the natural diversity of bees preserves genetic resources for selection on disease resistance and adaptation to future changes in climate and land use.

Although there is clear scientific proof that the performance and survival of honey bees strongly depend on their local adaptation (significant genotype - environment interactions) a limited number of breeding lines, mainly from the two subspecies *Apis mellifera carnica* (Carniolan honey bee) and *Apis mellifera ligustica* (Italian honey bee) are commercially spread throughout Europe and other parts of the world. The import of those bees results in a hybridization of local populations and can end up in a total loss of unique genotypes.

In an effort to:

- preserve the natural honey bee diversity,
- improve the performance and vitality and
- reduce colony losses and the dependence on therapeutic treatments

the SMARTBEES project will support local breeding activities in all European honey bee subspecies with a special focus on so far neglected populations. State of the art techniques for performance testing, identification of resistance traits, data evaluation and program management will be implemented.

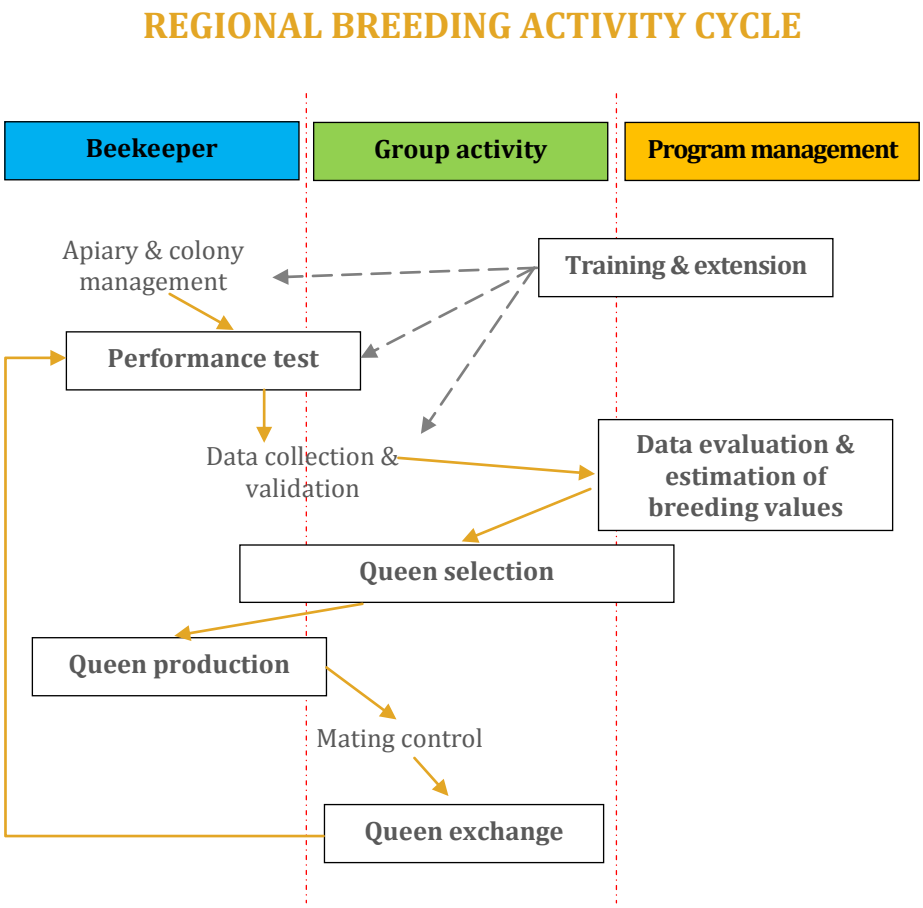
The success of this strategy fully relies on local contribution. Beekeepers, honey bee breeders and scientists need to cooperate to achieve a sufficient population size, to realize an exchange of test queens and to manage data evaluation, controlled mating, queen marketing and further activities.

This performance testing protocol outlines the basic standards for the beekeepers' participation in the SMARTBEES project. Please contact us for any questions or for practical suggestions. The project will offer a unique chance to sustainably improve the vitality and productivity of honey bees on a European level. The contribution of dedicated beekeepers and their local organizations is highly appreciated!

Program cycle

The SMARTBEES project is focused on identification, breeding and propagation of locally adapted honey bees with high performance and resistance traits to *Varroa destructor*. The implementation of the concept requires coordinated activities between different actors: individual beekeepers (breeders), regional groups and scientists. All actors have their own role, often cross-linked and coordinated with the activities of the remaining partners.

The **beekeeper** is responsible for managing testing apiary, implementing performance tests and producing queens for testing. These activities will be synchronized with other involved beekeepers and experts (**regional group**), who will facilitate the entire process of data collection and validation. Additionally, these groups may be responsible for organization of mating control and for queen distribution among the testing apiaries. The **Program management** is responsible for data evaluation and estimation of breeding values with the aim to support the selection of the breeder queens. The program management is also responsible for development and implementation of the extension program, mainly focused on training of the involved beekeepers and experts.



Apiary management

Location

Testing of colony performance should preferably be implemented under representative local conditions. Constant nectar and pollen availability for the test colonies is the basic requirement for selection of the location. In addition, the location should ensure water accessibility for the colonies, minimum exposure to stress factors (intensive agricultural or industrial operations, high density with colonies etc.) and easy accessibility for the beekeeper. During the testing migratory operations are acceptable, as long as all colonies from a single apiary are moved together.

Test station size

The number of test colonies per test station (apiary) is flexible and depends on the local conditions and the beekeeper's possibilities. The recommended number of test colonies per station ranges from 10 to 20. Due the queens supersedure, swarming and colony losses the recommended number of colonies will ensure sufficient number of survived and assessed colonies throughout a single season. The limitations are based on the required data volume for statistical analysis and optimization of the beekeepers' contribution.

Origin of queens

Comparison of colonies with queens from different origin is the essence of any honey bee breeding model. At least 3 groups of queens from different local genetic origin should be present at each test station (one group of queens should originate from the breeder's population). Each group consists of sister queens, preferably reared in the same series and mated under the same conditions. Each queen should be individually marked by color or plate and registered by its unique breeding number (consisting of codes for the region, breeder, date of birth etc.) which will ensure essential matchless identification and system recognition.

Colonies arrangement

To ensure equal opportunities for objective comparison of the test colonies the queens from the different sister groups have to be randomly distributed within the testing station.
Random orientation of the hives' entrances and their different coloration additionally will improve the objectivity and will reduce drifting (Fig. 1).

Figure 1 An example testing apiary

Hive

Usage of local or commonly known hive types with movable parts and their adequate individual identification is a minimum requirement for implementation of performance testing. Furthermore, it is obligatory that in the single testing station the hives should belong to the same type. For assessment of the natural mite fall screened bottom boards are required.

Colony management

Colony management should be based on traditional and locally used methods which allows development of each colony according to its needs. Still, the number of operations should be reduced and keep as much as possible to the essential ones, such as: adding wax foundations and supers, honey harvesting, ensuring adequate hive microclimate, autumn feeding etc. The colony management can significantly influence test results which imposes standardization of the used methods for all colonies within and between each test station. Recording of the used methods and operations is obligatory.

Establishment of test colonies

The recommended method for establishment of test colonies is the use of package bees (1.2 – 2.0 kg) also known as an artificial swarm. By this method the risk of contamination with different diseases is reduced. Alternatively, the test colonies can be set-up by re-queening the colony or as a nucleus with brood (2 - 3 frames). Anyhow, at the time of establishment (spring/early summer) all test colonies should be simultaneously treated against *Varroa destructor* for ensuring unified and unbiased initial infestation.

Colony manipulation

The colony annual development is significantly influenced by climatic region, food availability and genetic background. However, it is highly recommended that the number of api-technical operations and colony manipulations should be considerably reduced. Therefore, methods used for early spring development, swarming prevention, enhanced honey production, overwintering and disease control should be adapted to the local conditions and traditional manners. This approach will ensure objective assessment and identification of colonies with the preferred performance.

Swarming prevention & control

Sufficient space for colony development, appropriate ventilation etc. will ensure adequate conditions for prevention of swarming and will reduce the chances for subsequent excluding the colony from the testing.

If swarming tendency is evident (presence of numerous queen cells in the colony) the use of traditional and locally adapted prevention methods should be applied for reduction of the negative consequence of losing queen and bees. Part of the colony or the queen can be temporary separated but finally no bees and brood should be taken away in order to maintain the individual colony.

The application of prevention and control methods for swarming should be in accordance with the program management.

Disease monitoring & control

Application of the common principles of biosafety and Good Beekeeping Practices is a general recommendation for the control of honey bee diseases. Here are some of the actions which should be taken into consideration for reduction of the likelihoods of disease appearance in the test colonies:

- restriction of exchange of material between test colonies and stations
- avoid locations with high colony density
- use of disinfected equipment and tool
- prevention of robbery and drifting of the bees between the colonies
- ensure minimum food quantity (5 - 8 kg) in the colonies during the active season
- regular inspection and early recognition of colonies with atypical health condition
- removal of infected/highly infested colonies from the test stations

Application of methods and treatments for any disease control should be in accordance with the program management.

Identification of honey bee populations resistant to *V. destructor* is of particular interest for the SMARTBEES project. Thus, a specific approach should be used for monitoring and control of the mite in at least one full annual cycle. During the summer period the test colonies should be checked for the infestation of bees (Fig. 2) on a monthly basis in order to identify resistant colonies whose infestation levels remain below certain thresholds. Consequently, the identified test colonies will be wintered without therapeutic treatment against *Varroa*. The successfully overwintered colonies, which will reach the next season in healthy condition, will preferably be selected for the further breeding process.

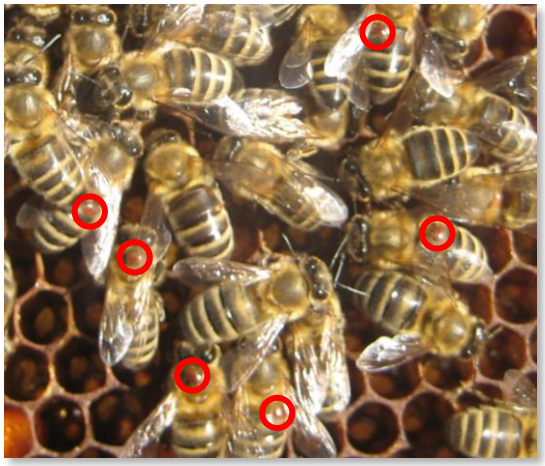


Figure 2 Infested honey bees

Threshold based Varroa control

The *Varroa* infestation within the test station will be controlled by continuous monitoring of the colonies' infestation level and removal and treatment of the highly infested ones. This approach will certainly reduce the risks for mite transmission between colonies ("domino effect") and will favour objective identification of the resistant colonies.

The recommended method for monitoring of *Varroa* infestation in the colony is the "powdered sugar" (Fig. 3), which can be easily applied in the field.

Figure 3 Powdered sugar method

Performance test

Performance test is a procedure for assessment of queens and colonies regarding certain traits of interest. This procedure includes common test traits such as colony strength, honey yield, expression of defensive and swarming behaviour etc. Beside these "traditional" traits, within the framework of SMARTBEES specific emphasis is given to traits and parameters by which colonies' resistance to *Varroa* can be identified.

Timing & duration

The performance testing starts during the autumn census and should not be earlier than 40 days following the establishment of the test colonies (period needed for replacement of the old bees with that of the new queen). During the next active seasons (spring/summer) the testing continues at each seasonal colony inspection. Data from at least 3 inspections during the entire annual cycle have to be available for estimation of queens' breeding values and subsequent selection. Additionally, the infestation level should be estimated by monitoring of the natural mite mortality in early spring and repeated samplings for bee infestation on a monthly basis during summer. The performance testing ends with data collection from the last honey collection. However, the tested colonies (and their queens) should be maintained until their selection for propagation of daughter queens for the next testing cycle.

Test traits/parameters

Eight test traits and parameters are relevant for assessment of the colony's performance (Tab. 1).

Table 1. Traits/parameters, methods, scoring criteria, values and timing for the testing parameters (modified from Büchler *et al*., 2013).

Trait / parameter	Methodology / Scale	Value unit	Timing/Frequency
Colony development	Nº of frames covered with bees and brood	Nº of frames	autumn, spring and summer census
Defensive behaviour	1= aggressive; 2= manageable 3= gentle; 4= very gentle	Score 1 to 4*	autumn, spring and summer census
Calmness (bees' behaviour on comb)	1= leaving the combs; 2= clustering in the edges of combs; 3= moving on the combs; 4= calm and static	Score 1 to 4*	autumn, spring and summer census
Swarming behaviour	1= strong swarming tendency 2= moderate swarming tendency 3= only slight swarming tendency 4= no swarming tendency	Score 1 to 4	swarming season
Honey productivity	Net weight of extracted honey	kg	whenever honey is extracted
Natural mite mortality	Usage of screened bottom board	Nº fallen mites per day	during 2-3 weeks in spring
Colony mite infestation level	Powdered sugar (50 g of bees)	% of infested bees	monthly from June to autumn
Hygienic behaviour	Pin test or Freeze-killed brood	% of brood removal	at least 2 times per season

* The score can be expressed in intermediate values.

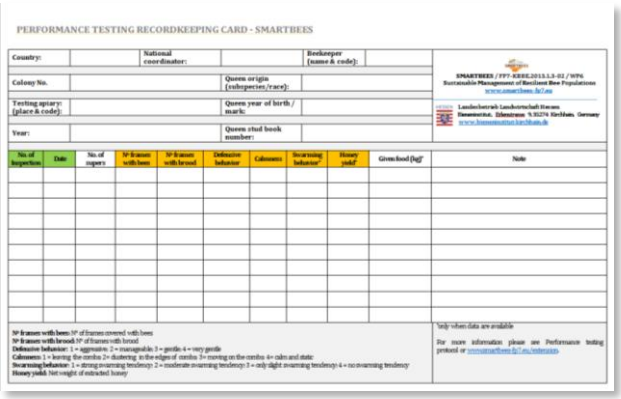
Detailed descriptions of the methods for assessment of the mentioned traits and parameters will be available on www.smartbees-fp7.eu/extension.

It is highly recommended that the performance testing should be assessed under uniform conditions. That is particularly important for traits such as defensive and swarming behaviour, which should be inspected on the same day for all test colonies within the test station and preferably by the same persons (Fig. 4).

Figure 4 Colony inspection

Recordkeeping

Documentation of the applied management operations and records of the performance testing are essential activities in the breeding process (Fig. 5). Consistency and accuracy of recordkeeping are crucial for establishment of a database for estimation of the queens' breeding values. The currently used international data base www.beebreed.eu is a unique online structure which will allow easy online recording, validation and storage of the information from all test stations around Europe. All data should be sent online with support and validation by the local group manager.



PERFORMANCE TESTING RECORDKEEPING CARD - SMARTBEES

Country:		National coordinator:		Beekeeper (name & code):	
Colony No.		Queen origin (subspecies/race):			
Testing apiary: (place & code):		Queen year of birth / mark:			
Year:		Queen stud book number:			

No. of inspection	Date	No. of supers	N° frames with bees	N° frames with brood	Defensive behavior	Calmness	Swarming behavior	Honey yield	Given food (kg)	Note

N° frames with bees: N° of frames covered with bees
N° frames with brood: N° of frames with brood
Defensive behavior: 1 = aggressive; 2 = manageable; 3 = gentle; 4 = very gentle
Calmness: 1 = leaving the combs; 2= dustering in the edges of combs; 3= running on the combs; 4= calm and static
Swarming behavior: 1 = strong swarming tendency; 2 = moderate swarming tendency; 3 = only slight swarming tendency; 4 = no swarming tendency
Honey yield: Net weight of extracted honey

Only when data are available
For more information please see Performance testing protocol or www.smartbees-fp7.eu/extension

Figure 5 SMARTBEES recordkeeping card

Estimation of breeding values and selection of the queens

The accurate estimation of queen breeding values (genetic value for breeding purposes) can be obtained only from data generated by unbiased and standardized performance testing of different groups of sister queens in various test stations. Additionally, the estimation includes information on the queen pedigree and performance data from the ancestors and genetically related individuals (Fig. 6). The registry and ranking list of the tested queens is transparent and visible for any honey bee breeder and beekeeper.

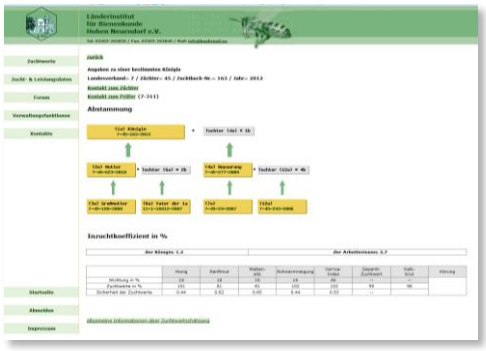


Figure 6 www.beebreed.eu

Mating control

Rapid dissemination of the selection progress can be achieved by use of instrumental insemination of the queens or establishment of a network of mating stations where selected queens are used in the drone colonies. Specific beekeeping management is necessary for maintaining the drone colonies and the mating stations, which should be administrated in accordance with the program management.

Program management

This program is implemented as the main task of the Work Package Nº 6 by the FP7-KBBE.2013.1.3-02 project entitled "Sustainable Management of Resilient Bee Populations" or SMARTBEES.

European beekeepers, breeders, institutions, NGO's and other parties and initiatives interested in taking active participation in the SMARTBEES program should contact:

Prof. Dr. Kaspar Bienefeld
Project coordinator

kaspar.bienefeld@hu-berlin.de

Dr. Ralph Büchler
Work package leader

ralph.buechler@llh.hessen.de

Dr. Aleksandar Uzunov
Program coordinator

aleksandar.uzunov@llh.hessen.de

Frequently Asked Questions

Why does the SMARTBEES breeding concept need my contribution?

High vitality and optimal productivity of bees depend on their local adaptation. They must therefore be tested and selected under local conditions.

Will I be trained for performance testing?

Yes! All engaged beekeepers will be trained to successfully implement performance test under their local conditions. Various extension tactics (manuals, trainings, e-newsletter, website etc.) will be used for keeping all participants informed and updated.

How much time should I dedicate for doing testing and breeding?

The efforts of colony management are comparable to the common beekeeping practice. However, some extra time is needed for Varroa infestation monitoring and control, pin tests and recordkeeping.

How much can this activity help improving my beekeeping business?

A lot. By your direct and active participation you will have a free access to the improved local honey bee stocks which certainly will improve your production capacity and overall beekeeping business performance.

What will happen when the SMARTBEES project will end?

With the involvement of perspective and broad-minded beekeepers and breeders the SMARTBEES concept afterwards should continue as a sustainable European network for breeding of resistant and productive local honey bee populations.

Additional information

This booklet is written based on a long-time professional experience as well as relevant articles, manuals, websites and scientific papers (listed below) which can be additionally used for more detailed information:

- **Virtual testing apiary** - (www.smartbees-fp7.eu/extension)
- **SMARTBEES** web site (www.smartbees-fp7.eu)
- **BEEBREED** web site (www.beebreed.eu).
- **Standard methods for rearing and selection of *Apis mellifera* queens**. Büchler *et al*., (2013), *Journal of Apicultural Research,* 52(1*)* (www.ibra.org.uk).
- **Methodenhandbuch** (2013). Arbeitsgemeinschaft Toleranzzucht - AGT (www.toleranzzucht.de).
- **Breeding for resistance to Varroa destructor in Europe.** Büchler *et al*., (2010) *Apidologie* 41: 393-408 (www.link.springer.com). Apidologie 41: 393-408.
- **Managing *Varroa*** (2013). The Food & Environment Research Agency (www.defra.gov.uk/fera).
- **Research Network for Sustainable Bee Breeding** (www.beebreeding.net).

Check list

By this list you can quickly self-check your motivation and eligibility for taking participation in the SMARTBEES activities.

Question	Yes	No
Are you enthusiastic regarding the conservation of locally adapted honey bee populations?	☐	☐
Can you devote some time and effort for testing honey bee colonies from different origin?	☐	☐
Can you organize (establish) a test station with 10 to 20 colonies in the test?	☐	☐
Can you follow the recommendations given in this protocol?	☐	☐
Are you willing to participate in different training and informative workshops?	☐	☐
Will you be ready to share your experience and knowledge with other beekeepers from the region and Europe?	☐	☐

Photos: D. Schuller, R. M. Francis, R. Büchler, A. Uzunov

Acknowledgment: We are grateful for the support provided by Bjørn Dahle, Magnus Ljung, Per Kryger, Cecilia Costa and Jakob Wegener.

Who we are

The SMARTBEES (Sustainable Management of Resilient Bee Populations) consortium is a multidisciplinary team of European institutions and experts, coordinated by the Länderinstitut für Bienenkunde Hohen Neuendorf e.V from Germany, which aims to provide a solid framework for improvement of honey bees performance and vitality and ensure sustainable conservation of honey bee diversity in Europe. The consortium is responsible for implementation of a 4 year project, which specifically addresses the topic "Sustainable apiculture and conservation of honey bee genetic diversity" within the 7th Framework Programme for Research and Technological Development.

What is our mission?

The Work Package Nº 6 is responsible for the Field testing and selection of local bee populations which includes performance testing of various honey bee populations under different environmental conditions and their selection and breeding based on breeding values. Our mission is to integrate beekeepers into stock improvement and to initiate selective breeding in all European honey bee subspecies in order to conserve their diversity and to propagate resistant and productive locally adapted bees which enable sustainable apicultural production and preserve the pollinator role of bees in agriculture and the nature.

Contact us

The European beekeepers, breeders, institutions, NGO's and other parties and initiatives interested in taking active participation should contact:

Dr. Aleksandar Uzunov
aleksandar.uzunov@llh.hessen.de

Dr. Ralph Büchler
ralph.buechler@llh.hessen.de

HESSEN
Landesbetrieb Landwirtschaft Hessen
Bieneninstitut, Erlenstrasse 9, 35274 Kirchhain, Germany
Tel.: ++49 6422 9406 11, Fax: ++49 6422 9406 33
www.bieneninstitut-kirchhain.de

SMARTBEES

SMARTBEES / FP7-KBBE.2013.1.3-02 / WP6
Sustainable **Ma**nagement of **R**esilien**t Bee** Population**s**

"This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 613960".