

Manual of BeeBreed

BeeBreed.eu
Bee institute Hohen Neuendorf

12th December 2018

Disclaimer: this manual is not complete yet.

1 Purpose of BeeBreed

The website <http://BeeBreed.eu> is the user interface of the breeding values estimation carried out by the LIB (Länderinstitut für Bienenkunde, Bee institute, Hohen Neuendorf). It is a instrument for selection for most of systematic breeding in Europe of currently 11 subspecies and 2 hybrids in 24 countries. The method of breeding values estimation, prevailed for most livestock, unifies the basic principles of breeding by selection practised since centuries with findings of modern genetics into a easy applicable system:

- Only the performance and properties of colonies situated at the same apiary in the same season are compared as they largely depend on weather conditions and nectar availability. Only the performance differences are considered, not the performance itself.
- Not all genetic dispositions show immediately in the performance and properties of a colony. Therefore, not only own performance but also of all relatives are taken into account, graduated by the degree of relatedness.
- The genes of a queen are combined of its mothers genes and that of drones. Therefore, controlled mating with appropriate drone colonies is of crucial importance.

1.1 What is a breeding value?

There are distinctive differences between colonies with respect to honey production, behaviour, or Varroa tolerance. These differences are called forth by both the genetic constitution and environmental conditions. Only heritable differences are useful for the selection of breeding colonies, the influence of the environment should be removed. There is a universal solution for this, the concept of breeding values.

Simply put, the breeding value states, for a specific characteristic, how valuable an animal is for breeding purposes. The breeding value of a colony refers to only those differences which can be traced back to the quality of the genes. For breeding value estimation, the effect of environmental influences in the various apiaries and random biologic effects not genetically determined are deducted. The performance tests of all related colonies (daughter, sisters, parents and so on) are taken into account as they have similar genes, to the degree of their relatedness. By the consideration of several traits at once, using estimated genetic correlations, the breeding values can be estimated with higher accuracy as one-time effects are filtered out to a higher degree.

1.2 Standardisation of breeding values

For easy applicability, breeding values are standardised to the whole breeding population - the average of all breeding values of last five years are used as a (sliding) reference base for each characteristic. The average breeding value of all those colonies is 100, the standard deviation is 10. In normalised breeding values, it is much easier to recognise the colonies' genetic superiority or inferiority with respect to the active breeding population. No matter in which scale the characteristics are measured (kg for honey yield, evaluation mark for gentleness, percent for pin test clearance rate), the value of 100 represents the average. Due to the adjustment of the standard deviation, selecting for a breeding value higher than e.g. 105 for honey production has the same selection intensity as selecting for a breeding value higher than 105 for gentleness. For any breeding value, a predetermined percentage of queens is genetically better (or worse resp.).

Breeding values for individual traits can be combined to form a total breeding value, where the multi-trait model is crucial for accuracy. Also the total breeding value is standardised. This also means it deviates from the average of the breeding values for individual traits it consists of.

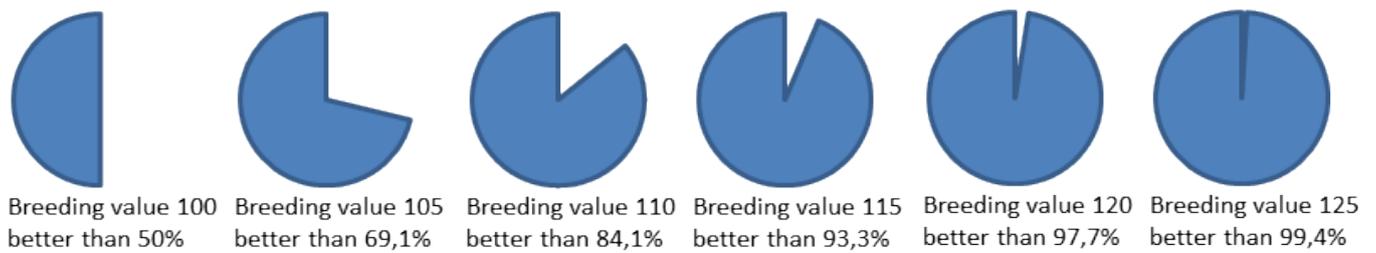


Figure 1: Breeding values are given in the context of the whole breeding population. For any breeding value, it is predetermined how many breeding colonies are better and worse, respectively.

1.3 Performance testing

The accuracy of breeding values critically depends on the correctness of the performance testing. The items relevant for the breeding values are:

- Measuring total honey yield in kg. The honey left in the hive from own foraging in autumn for overwintering is counted in.
- evaluation of gentleness on a scale from 1 (very aggressive) to 4 (very gentle). This criterion is for the aggressive behaviour towards the beekeeper inspecting the hive, not towards intruders such as wasps. The main aspects are the drive to sting and the targeted flight towards the beekeeper. Flying around is covered by the other behavioural parameter - gentleness. The yardstick is defined by the testing beekeeper. It must be constant throughout the apiary and testing year, it may differ from apiary to apiary and year to year. It is crucial to record differences however small they are and negligible for normal beekeeping. It is recommended to evaluate the average of several inspection if possible. In other than very small apiaries it is recommended to do a specific inspection only for gentleness (and calmness) as the weather conditions may change during some hours, and extensively handling frames in the one hive leads to intensified flight activity which may influence the aggressiveness of the remaining colonies.
- Evaluation of gentleness on a scale of 1 (rapidly fleeing from the comb) to 4 (bees keep steady on the comb). The main aspects are running around on the comb, forming bee bulges at frames and on the hive, and flying around. Try to differentiate between the two behavioural traits as much as possible (though they are often closely related). Again, the yardstick is flexible as in gentleness.
- Evaluation of swarming drive on a scale from 1 (strong) to 4 (no drive). A much finer distinction than a two state-criterion swarm/not swarm is needed! Try to differentiate as much as possible by the different aspects of swarming tendency: building queen cells, raising new queens, the behaviour of workers. Take also into account the effort the beekeeper has to undertake to avoid the swarm. Take also into account, that a strong confined colony is much more prone to swarming than a weak colony with much space. Equal conditions here means, the beekeeper follows the procedure to avoid swarms appropriate to the climate, environment and the typical hive management which include giving space and cutting brood at the right moment which will differ between the hives on the testing apiary. In a swarmed colony the whole performance test is mostly devalued.
- Measurement of the hygienic behaviour by the pin test. The duration of the test should be roughly equal for the apiary throughout the year. The duration should be decided such that an average colony reaches 50 percent clearance. Frequent results below 10 percent suggest a longer test duration for the next season, while frequent results above 90 percent should lead to shorter time period, again in next season.
- Evaluation of the starting Varroa infestation in spring by counting the fallen dead mites for about 7 days. The begin of the counting should be at least several days after the first major activities because the hive mites dead for longer time will also be cleaned out. The objective of this test is to count the mites dying in the time frame. In central Europe, flowering goat willow (*Salix caprea*) is the recommended indicator for the appropriate time period but that may differ between countries.
- Evaluation of the infestation in summer by counting the mites on bees on several time points. About 50 grams of bees should be collected and the mites removed with powder sugar or by washing. 3-5 measurements in the time of the greatest increase of mite population which is from June to August in Central Europe.
- Chalkbrood. Although Chalkbrood is associated to bad environmental conditions and weakness of the colony, there is also genetic predisposition.

Further characteristics are currently not subjected to breeding value estimation but still important for the characterisation of a colony:

- Evaluation of colony strength, in consideration of seasonal development
- Evaluation of spring development, characterising how quickly a colony develops in spring.
- Partial honey harvest.
- Diseases: American foulbrood, European foulbrood, Nosema, Sacbrood. Although those colonies are usually isolated, it is important to record the occurrence of the disease to detect higher family incidence.

By the following, the breeder can positively affect quality of breeding values estimation:

- Evaluate all criteria for all colonies, even the bad.
- In the behavioural evaluation, use the full range of marks.
- Also test colonies of other breeders, provide own queens to be tested by other breeders. Prefer to test colonies of different origin.

1.4 Nomenclature

Record-keeping requires that each queen has a unique name. The coding scheme of BeeBreed is structured in a way, that the country, the association, the birth year and the breeder can immediately be identified, it is part of the code. The code consists of numbers, separated by dashes, except for the country, which is the ISO 3166 2 letter code. The code is for example DE-4-1-390-2015, for a queen

DE in a German association,

4 in the association Landesverband Brandenburgischer Imker

1 for breeder number 1, Bee Institute Hohen Neuendorf,

390 queen number 390 in that particular year

2015 birth year of the queen.

The breeder's code consists of 3 components: country, association, and breeder number, for instance DE-4-1 for the Bee Institute Hohen Neuendorf.

The full association code consists of 2 components: country and the association number: DE-4 for Landesverband Brandenburgischer Imker. Please note, that the number is not sufficient as there is for instance an association PL-4.

The identification of a seasonal apiary is very similar. It consists of the breeder's code (3 components country, association, breeder number), an additional number, the apiary number, and the year of testing. For example, apiary DE-4-1-1-2016, denotes

DE in a German association,

4 in the association Landesverband Brandenburgischer Imker

1 for breeder number 1, Bee Institute Hohen Neuendorf,

1 apiary number 1

2016 performance test year.

The mating stations follow the system. They are always associated in an association, and an additional mating station number. For instance, mating station DE-6-1 refers to Spiekeroog.

Also inseminators have a nomenclature of three components, for instance DE-4-11. Note that this nomenclature is separate from the nomenclature of mating stations.

2 Work with the web interface Beebreed

Sections of BeeBreed are freely available, to unregistered breeders, beekeepers, interested individuals. In the "Breeding values" section, registered queens can be browsed through and one can get in contact to the breeder. Also texts in the "Info" section are open to the public. In "Contact", breeding administrators and all active breeders can be contacted.

The sections "Breeding Data" and "Administrative functions" are password-protected and only available to the registered breeders, where the data input is organised.

2.1 Overview over the breeding population organised in Beebreed

After calling the website <http://beebreed.eu> in an internet browser, the honeybee races are shown with some information on the race and the populations. The majority of queens belong to the main populations of Carnica, Mellifera and Ligustica, decentralised breeding programs in several countries. A population can be selected here, which leads to the submenu "Breeding values". An overview over all associations is in

Info → Association numbers¹

In the menu option

Contact

all associations, their administrators, and finally all active breeders (who agreed) can be found. In the first column contains an abbreviation of the bee race, the second column the country code, and the association code. Furthermore, the name and telephone number of the administrator is shown. The letter symbol leads to a contact form (e-mail addresses are normally not shown). The symbol to the far right (pictogram with 2 torsos) leads to the list of active breeders, those who submitted breeding data in the last 3 years. For each of the breeders, there is also a contact form in case, an e-mail address is supplied by the association.

2.2 Finding registered queens

With the exception of some public testing stations all performance data including behaviour and disease information is private. It is only displayed to the testing breeder itself and the administrator of the association. However, the pedigree of all honeybees, the breeding values with their associated reliabilities, the license class information is public. It is available in "Breeding values" section. Before you start you have to select a bee population, see below, because breeding values are only comparable within a population. The easiest access is at

Breeding values → Breeding value results for selected queens.

In the filter mask you may restrict the queens by choosing country, association, year, license, minimal breeding values. The complete Carnica main population contains nearly 180000 queens, and cannot be displayed - the limit is 40000. A field left blank means no restriction here. Additionally, the sort criteria can be chosen, either by the queen or the total breeding value. The composition of the total breeding value can be freely chosen. The number should add up to 100 but if their are not, the software adjusts them. The click on "Next" shows the requested table of queens unless there are errors. The table consists of the queen identification, the apiary code, inbreeding coefficients, the breeding values, and the license information. The queen code is clickable, leading to the pedigree browser, and the apiary is clickable leading to a list of other queens of the apiary.

2.2.1 Pedigree browser

The pedigree browser shows comprehensive information of a colony and many links to related colonies and other information pages. Right on top there is a box with concise information on the breeder and its association, the tester if different from the breeder, and the license. Below are a selection of links:

- contact links to the breeder (and tester if different) leading to detailed personal information (if supplied) and a contact form allowing to address the breeder
- If you are the breeder of the colony, there is a direct link to see and edit the performance data.
- Breeding values of queens tested on the same apiary
- Breeding values for maternal half siblings, i.e. queens which have the same mother colony

- Breeding values for paternal half siblings, i.e. queens which have the same drone ancestry
- Breeding values for full siblings
- Direct links to breed planning functions which are described below

Then the pedigree is shown in the typical layout of bee pedigrees. The yellow boxes refer to individual registered queens. The grey boxes refer to the facilities of drone production which could be a mating station or the drone colonies of an inseminator, and in some cases an individual drone colony. Each of the boxes is preceded by the traditional identifiers which are in use for over half century in German and Austrian bee breeding. As they are often mentioned in beebreed.eu and external text, they are briefly described here:

1a The reference queen

1b The mating partner, the facility which mated the 1a

2a Mother queen of the 1a

4a Mother queen of the drone colonies which 1b is stocked with, it is also called drone ancestry queen

The identifiers below are used less often and only explained for completeness:

2b The mating partner of the 2a

3a Mother queen of the 2a

6a Mother queen of the drone colonies which 2b is stocked with

4b The mating partner of the 4a

7a Mother queen of the 4a

12a Mother queen of the drone colonies which 4b is stocked with

This system assumes that there is only a single mother queen of the drone colonies. If this is not the case, the drone ancestry is so unpredictable that it is not recorded at all. The system is suited to the situation where the drone colonies are not registered individually - they are subsumed under 1b. But in case where a single drone colony was used this colony is displayed in the place of the 1b. There are special mating places with several mothers of drone colonies - in this case the mating station itself is displayed but no 4a is given.

In the ancestry map, the queens and mating stations can be clicked. A click on a queen leads to the pedigree browser page of this queen while the click on a mating station leads to a special mating station details page.

The next item are the coefficients of inbreeding, with the distinction of queen and workers. The inbreeding coefficient refers to the queen itself disregarding the stored drone semen. The inbreeding coefficient of the workers is influenced by the relationship of the queen and the drones. This is the more relevant figure as the adverse effects of high inbreeding may occur when the inbreeding of the workers is high. Note that this inbreeding coefficient is also valid for daughter queens raised in this colony.

The next item are the breeding values for each trait and the total breeding value. The values are ordered on the composition of the total breeding value - first the traits belonging to the total breeding value, then the total breeding value, then the traits not belonging to the total breeding values. A breeding value in brackets indicates that there is no own performance for this trait.

Beside, the reliability of the breeding value is given. This figure represents how good the breeding values could be estimated on the basis of the performance data supplied. High reliabilities are the combination of own performance data, other tested colonies on the same apiary, and tested relatives: siblings, mother, drone ancestry, daughters and so on.

It is important to note that the calculation of reliabilities assumes the performance data as true. A high reliability figure does not necessarily mean that the breeding value represents the "truth". The main message is the "comprehensiveness of data" to calculate breeding values is good.

The reliabilities depend on the specific properties of the trait. For honey yields, a value of 0.35 can be considered good enough, while for aggressiveness and calmness higher values can be found.

A very low reliability value can be result of missing own data, missing relatives or relatives with missing data.

Finally, a list of descendents is given - on the left side descendents as a mother colony, on the right side the descendents where the colony acts as drone ancestry.

2.2.2 Mating place information

The mating place information page is displayed whenever an appropriate mating station link is clicked - in the pedigree browser, in the list of mating stations, and the breeding planning for mating stations.

It starts with a box of information supplied by the head of the mating place and the administrator of the association, which often included extensive notes.

Below are lists of colonies:

- Daughter colonies of the 4a (drone ancestry colony). As noted above, drone colonies are often not registered. However, if they are, they can be found in this list. If they received a D-license, they are most likely situated at the mating station. This lists also consist of colonies which are normal breeding colonies and not used as drone colonies. These colonies also give an indication on the genetic quality of the mating station.
- Colonies mated at the mating station. These colonies give an indication on the use frequency of the mating station. For mating stations of previous years, the breeding values of the descendants give an indication if the genetic quality of the mating stations was indeed as good as originally planned.
- Daughter colonies from colonies mated at the station are given for the same purpose.

For logged in users there is an extensive summary on phenomenological analysis reports on race characteristics on the colonies above. Currently, this system is only active for the Carnica main population. These reports are a critical evaluation tool that

- the breeding queens are still belonging to the Carnica subspecies
- the pedigree of drone ancestry colony (4a) is indeed as recorded
- the drone colonies are indeed daughters of the 4a
- the mating station is free from in-flight of foreign drones.

2.2.3 Breeding planning

BeeBreed allows the breeders to pre-calculate the breeding values and the inbreeding coefficients of a prospective queen of the next generation.

While the prospective breeding value is straightforward (it is simply the average of the parents' breeding values), the calculation of inbreeding is sophisticated and of big interest in planning the next generation.

If you have selected a queen as mother colony (2a) and a drone ancestry colony (4a) you enter their codes of in "Individual breed planning", click "Next" and see the results: the prospective breeding values and the inbreeding coefficient of the workers of the new colony.

Note that it is not necessary to display the inbreeding of the queen of the new colony as it is identical to the worker's inbreeding of the mother colony.

This individual breed planning is only necessary if you want to inseminate and organise the drone colonies yourself. If you want to use a mating station, you can use "Breeding planning for mating stations" and see this information in tabular format. The inbreeding coefficient is on the final column. The allocation of the mating stations refer to the current year.

Often, inseminators provide drone colonies and record them in beebreed. For these colonies, there is a "Breeding planning for inseminators" giving a similar table as for mating stations.

In the tables, the inbreeding coefficient leads to the individual breeding planning function. Clicking "to selection form" allows to modify the request.

2.3 Entering performance data

You are registered as a breeder with an association and have tested colonies. Then, your beebreed area is the password-protected "Breeding Data".

2.3.1 Breeder accounts

You can not register yourself, you have to ask the administrator of the association to do this for you. He/She will do this only if (s)he considers that you are a trusted breeder. This is very important as the system of breeding value estimation requires that each breeder puts the best effort to truthfully test the colonies and reports the data. The system only works with mutual trust, and big harm can be done to the correctness of the breeding values if breeders report wrong or fake data.

There is no user name, each breeder logs in with the country, the association number and the breeder number which is organised by the administrator. Often, this is also the internal breeder number within the association. For each association, race and bee population is fixed, there is no need to enter that.

2.3.2 Enter data sets

At any time, the ancestry, the performance and properties, and additional information of a colony can be recorded. It doesn't have to be recorded in one go at the end of the year, the recommended way to do this is in several steps:

- When the breeding queens are mated and are established in their colony, enter the ancestry and some information (hatch date)
- When the testing station is established, review the data, and enter the apiary number. If a colony is transferred to another breeder, use the transfer of the dataset function.
- If you received a queen for testing which is already registered with the breeder, confirm the transfer and review the data.
- At the end of testing season, record all performance and properties data, check the box: "Performance test complete".
- If the colony is sold, transferred, deceased, record this in "Remaining" section

The dataset is a complete account on the performance test. Its elements are:

Queen (1a) The code of the queen tested, consisting of country, association, breeder, studbook number and year of birth. If you have tested another breeder's queen, you have to enter the code provided by this breeder, not yours.

line You may enter an identifier of the breed line here. It is for reference only.

generation you may enter the number of the generation in a specific breeding line

Mother (2a) the code of the mother queen

Mating (4a/1b) the code of the drone ancestry. If you have used a mating station, you should rather enter the mating station identification below and leave the fields blank - it will be filled automatically. In case of a AGT mating station with several 4a the fields must be left blank and remain blank - the necessary information is stored in the mating station's accounts. For artificial inseminations the breeder has the responsibility to enter the correct ancestry. In most cases, drone colonies of a single 4a are used, which is entered here. In case of an insemination with a registered single drone colony you enter the code here, please be sure to tick 1b-mating below. If the drones for the artificial insemination are derived from several registered drone colonies, they are entered as "several queens".

hatch date day the queen was actually born. This is for reference

sign a sign on the queens plate, may be up to 3 characters

type of mating 1 - artificial insemination, 2 - island mating station, 3 - line mating station, 4 - race mating station, 5 - apiary mating, 6 - tolerance mating station with several 4a. See a specific section below for more details

4a-mating/1b-mating The normal mating system for honeybees is the 4a-mating: from a single colony (called 4a) queens are raised to form drone colonies which provide the drones for mating. In special situations in artificial inseminations (like one-drone insemination), drones are directly taken from registered colonies, in which case 1b-mating must be selected.

to mating place date the queen was mated, for reference

mating station/inseminator code consisting of country, association number, and the unique number of the mating station/inseminator

drones number of drones in insemination, must be blank for mating stations and may normally also be left blank for artificial insemination unless the number was explicitly controlled (as in one drone insemination)

drone colonies number of drone colonies in artificial 4a-insemination. For mating stations this should be left blank, the information is recorded with the mating station's account.

laying eggs since for reference and plausibility check on the record

No. of the colony normally the internal number of the hive. Please us this as a double check that the correct queen is tested. The number will also appear in the breeding license.

Performance test year Normally, the next year after queens birth, the field is pre-filled. In special situations this can be changed, e.g. in Mediterranean countries where the queen is born in the beginning of the year and tested the same year. When setting this field keep in mind: all colonies entered by you as a tester with the same year and apiary are assumed to be tested against each other!

apiary Number of testing apiary.

hive records Normally, one final evaluation for each trait suffices for beebreed. The final evaluations are normally based on hand-written hive records/stockcards. You can also keep the hive records online. See separate section below for this.

hive records/SmartBees An extended version of hive records related to the SmartBees Performance protocol.

1st/2nd/3rd honey yield The total honey yield is divided in four parts - the first three parts are harvested in specific time ranges while the amount of honey left for winter stores is estimated. Breeding values are calculated for the total yield. However, for a finer distinction on the qualities of a queen it is useful to record also the partial yields.

Total yield (kg) If the field is left open, the partial yields are summed up if performance test complete is ticked. If the partial and total yields are filled it is checked, if the sum is correct.

Robustness in winter This property should be rated on a scale from 1 (weak) to 4 (strong) where two aspects should be considered: Is the colony strong after overwintering? What is the ratio of bees before and after overwintering. The value 0 is reserved for colonies deceased in winter.

Defensive behaviour From 1 (aggressive) to 4 (not aggressive). Property which focuses on attacks on the bee-keeper.

Calmness Form 1 (agile) to 4 (calm, steady on the comb). This property has some overlap with defensive behaviour but should be distinguished as much as possible. Calm bees stay on the comb and simplify inspection. Non-steady bees may run on the comb, to corners of the hive box, or hanging from the comb. Fleeing by flying belongs to the Calmness trait, while targeted flying towards the beekeeper is defensive behaviour.

Swarming drive From 1 (high) to 4 (low swarming tendency). Please, make a finer distinction than 1 for swarmed and 4 for not swarmed! Possible indications are the number of false and true warm cells and behaviour. Take conditions (strength, space, weather) into account.

Development in Spring More generally, how much is the colony able to increase the number of worker bees in prospect of nectar flow - in some countries this may not actually be spring.

Colony strength Overall strength evaluation throughout the year.

Vitality test Tick only if colony is not treated against Varroa.

Varroa mite drop:week/date Please enter calendar week of date of the inspection.

Number of mites Number of fallen mites.

Days days of inspection

infestation measurement If you plan to enter several measurements, go directly to "Additional measurements" and leave the fields in the main window open.

hygienic behaviour Record the percentage of completely cleared cells

diseases Either click "none" or all diseases that have been observed.

Workers typical for the race? Y/N For countries with established race characteristics reports, it is not needed as it is automatically filled. If there is an external investigation service, the number can be entered below. Otherwise, select Yes if you have observed the bees.

breeding license If you select a breeding class here, you applied for a license. It is only issued if the administrator of the association confirms this.

remaining (passing/loss) You can select the time and reason, what happened to the colony after testing season. This is very useful to follow up.

notes You can pass any notes in this field. This field is only intended for short notes. Notes for individual inspections should be inserted in the respective notes sections in "hive records".

performance test complete Check this if you finished editing the dataset. The dataset will then be shown to the administrator in a special list to check the plausibility and release it. After the administrator released the dataset, the breeder can not edit most of the fields.