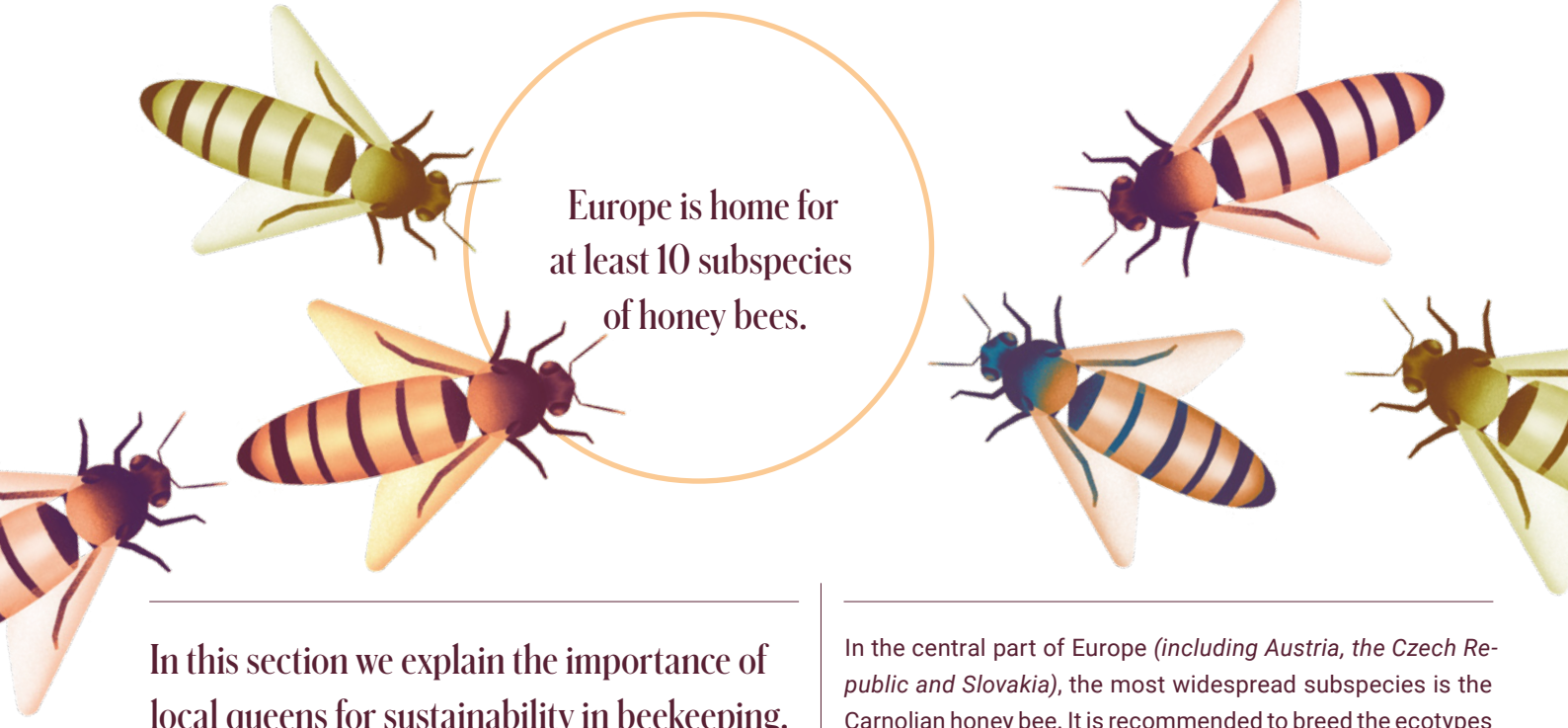
1 · QUEEN BREEDING AND GENETICS

1 · 1

Importance of queen breeding adapted to the local environment



Europe is home for at least 10 subspecies of honey bees.

In this section we explain the importance of local queens for sustainability in beekeeping.

Significant breeding progress aiming to increase honey yields in the recent years has also brought about significant negative aspects:

① A SUBSTANTIAL REDUCTION IN GENETIC DIVERSITY,

② DECLINING VITALITY,

③ AN INCREASE IN DEATHS OF COLONIES DURING WINTER.

The breeding work thus obviously contributes to the genetic exhaustion and reduced vitality of the managed bee colonies. Europe is home of at least 10 subspecies of honey bees, each of which creates a wide range of locally adapted populations and ecotypes.

In the central part of Europe *(including Austria, the Czech Republic and Slovakia)*, the most widespread subspecies is the Carnolian honey bee. It is recommended to breed the ecotypes best adapted to the given altitude and landscape type. It is not recommended to import queens from more distant regions of Europe belonging to other subspecies. Imported queens from remote regions and non-native subspecies have a problem with adaptation, leading to increased mortality and unsustainability of this hybridization, either in the short or long term.

The beekeepers can use bee populations which are best adapted to the local environmental conditions and can make selections to improve beekeeping characteristics within the locally adapted lines. Such sustainable selection supports the conservation of the genetic diversity. To achieve this goal, the method of sustainable selection of colonies can be used to prevent the extinction of the endangered subspecies and ecotypes of bee colonies in Europe prepared in the framework of the “Smartbees” project *(www.smartbees.fp7.eu)*.

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Selection of queens for their resistance to diseases

In this section, we highlight the importance of favouring local queens rearing with increased hygiene behaviour.

At present, almost all bee colonies in Europe are kept by beekeepers, and their breeding systems include, among other things, regular chemical treatments against mites or other diseases that contribute to the spread of colonies unable to survive without human interventions. One of the major solutions is the preference of beekeeping with increased hygiene behaviour.

In most queen breeding programs, characteristics such as honey production and colony strength have priority, alongside with other desirable characteristics for commercially managed bee colony breeds *(such as stingless and low swarming tendency)*. On the other hand, disease resistance, viability and adaptation to the local conditions were considered to be less important, as the deficiencies in these features could be compensated by treatments, artificial feeding or other zoo-technical methods.

SELECTION

A pre-selection from a larger population of bee colonies.

Testing the viability of selected breeding colonies.

A selection of drones.

A practical solution for ordinary beekeepers is to keep bee colonies with increased hygienic behaviour. Hygiene behaviour means that the kept bees have the ability to recognize capped brood cells with a dead or infected brood and subsequently remove such damaged brood. The principle of the most common testing of hygiene behaviour of the bee colonies consists in killing *(piercing or freezing)* a certain number of pupae, usually 50 to 100 per colony. Subsequently, the removal rate of the killed pupae is monitored over a period of time *(12 hours and 24 hours)*, and the higher the removal rate of the dead brood, the more obvious is the hygiene behaviour of the bee colony. The breeding of the bee colonies that survive without treatment is still functional only in areas where the flying from other colonies *(usually on isolated islands)* is prevented.

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Importance of the selection of queens and the therapeutic colony treatment

In this section, we explain the importance of queen selection and the evaluation criteria needed for the selection of queens.

In the period from spring to late autumn, it is necessary to monitor the population of mites in the tested bee colonies at regular monthly intervals in order to identify and breed colonies where the mite population remains below the critical level.

In particular, the natural daily mite fall, the level of the total mite population and hygienic behaviour can help to reduce dependence on treatments and biological methods to control the mites in colonies.

A comprehensive bee-testing performance protocol — a guide for European bee breeders — was created by members of the SMARTBEES project consortium and is available in several languages at www.smartbees-fp7.eu/extension/performance/. The protocol focuses on identifying, breeding and locally spreading of adapted colonies with high utility and resistance to the mites. The protocol describes the establishment of a test apiary *(its location, size, origin of queens, hives layout)*, work with colonies *(establishment of test colonies, interventions in the bee colonies, prevention of swarming, disease prevention and treatment, evaluation of natural mite fall)*, as well as details of testing characteristics.

SMARTBEES PROJECT

Scan the QR code with your smartphone or enter the address in your browser.

http://www.smartbees-fp7.eu/

PERFORMANCE TESTS

① COLONY DEVELOPMENT

② TENDENCY TO STINGING

③ DIVERGENCE *("SITTING" ON HONEY COMB)*

④ TENDENCY TO SWARMING

⑤ HONEY PRODUCTION

⑥ NATURAL MITE FALL

⑦ LEVEL OF MITE INFESTATION

⑧ HYGIENIC BEHAVIOUR

In particular, the last three characteristics can help to reduce dependence on treatment interventions in colonies. In summer, it is necessary to monitor the occurrence of mite in the tested colonies at regular monthly intervals in order to identify colonies in which mite infestation remains **below a specified threshold** *(below 1000 mites)*. Subsequently, the selected colonies will be winterized without treatment against the mite. Those colonies which successfully survived the winter are preferred for further breeding work. The level of mite infestation at the testing apiary is continuously monitored and the most infested colonies are unwanted and treated against the mites. This approach will reduce the risk of transmission of mite among colonies *("domino effect")* and will support an objective identification of resistant colonies. The recommended way to monitor the level of mite occurrence in a bee colony is monitoring with powdered sugar, which is easy to carry out under practical conditions.

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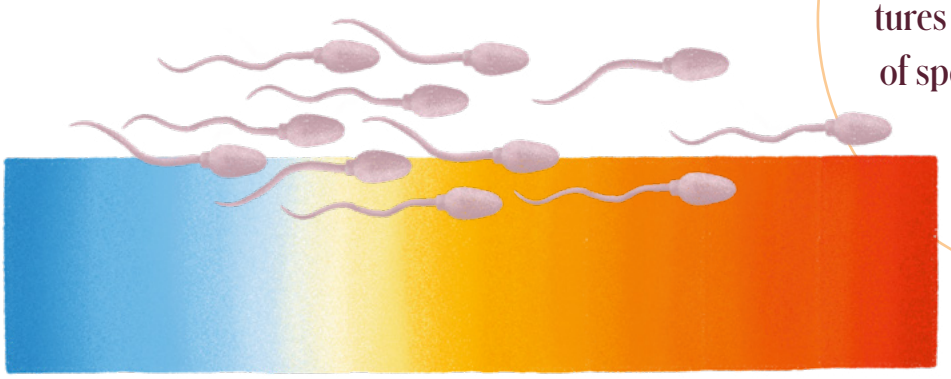
Measures to prevent queens failing and replacing them because of poor sperm quality of drones



Even the short-term exposure to high temperatures can kill more than 50 % of sperm in the spermatheca of the queen.

In this section, we will explain the reasons of the queen failure and the need to take actions against this phenomenon.

The number of drones needed for fertilization of the queen is increasing, on average, the queen mates with 12 to 17 drones during 1 to 5 mating flights. In commercial beekeeping operations in USA, up to 50 % of queens are replaced within half a year. The causes may vary, such as e. g. insufficient fertilization, low sperm viability, queens' infections, including semen-born viral infections, possibly nosemosis, temperature stress or impact of pesticides. The origin of low sperm viability may be due to the impact of drones or the effect of high temperatures to which queens have been exposed during transportation. When sending queens, the queens are often exposed to temperature extremes *(<8 and >40 °C)*, and even the short-term exposure to such temperatures can kill more than 50 % of sperm in the spermatheca of the queen.

The breeders of drones produce and distribute a large number of offspring only from the selected queens — line founders that reduce genetic variability in the bee population. Sufficient genetic variability in the population and high levels of maternal polyandry is important for disease resistance, homeostasis, thermoregulation, and of the physical condition of colonies. High polyandria also increases the frequency of communication signals among worker bees, resulting in better use of food resources. In inbreeding *(close family breeding)*, the proportion of diploid drones laid by the queen increases, which triggers cannibalism in the worker bees, thus eliminating and eating such genetically anomalous male animals, which in turn results in so called "shot brood" *(other names used are aslo: "pepperpot brood", or "pepperbox brood")*.

Exchanges of queens by beekeepers are considered to be one of the main factors influencing the successful overwintering. The beekeepers who do not regularly change queens have a much higher risk of winter deaths compared to beekeepers who change their queens every year at least in half of their hives. Young queens increase the likelihood of successful overwintering.