Why does Africa need to rear queen honeybees?

Much of the world's food production depends on honeybees for pollination. With the global population expected to grow by another two billion people by 2050 – and the majority of that growth in Africa – managed pollination services will be key to safeguarding food supplies and increasing food production. Over 70 percent of what people eat every day is pollinated by honeybees: without them, the current system of food production would suffer major declines.

Healthy queen bees help to reproduce colonies that carry desirable traits such as resistance to pests and diseases, high levels of honey productivity and effective pollination capabilities. Queen bee rearing replaces queens that are failing or have died, increases colony numbers, and re-queens hives that have become aggressive, so that future bee progeny are more docile for beekeepers to manage.

What is queen rearing?

Queen rearing is a process of raising honeybee queen cells that uses an existing queenless or a queenright (with a queen) colony. It encourages the reproduction of queens with characteristics that help bees to thrive in specific climatic and geographic conditions. So far, *icipe* has been working a good deal with *Apis mellifera scutellata* and *Apis mellifera bandasii*, two honeybee subspecies that are excellent honey producers in the plains and highlands across East Africa.

The first step, grafting, involves transferring female bee larvae into artificial cell cups made of beeswax within l2–24 hours of hatching. Nurse bees then feed the larvae with royal jelly, the food that ensures that they mature into sexually developed adults rather than worker bees that cannot reproduce. The new virgin queen emerges after 12 or 13 days.

What are the benefits?

- Beekeepers can multiply colony numbers and make more money
- Honey productivity improves through reduced swarming, which maintains the strength of the apiary for the next flowering season. When a hive swarms, the old queen leaves with bees from the hive to create a new colony, depleting hive numbers
- An unproductive, failing queen is replaced with a mated queen bee, which can reproduce 'on demand' according to the colony's requirements
- The risk of introducing pests and diseases into the apiary is reduced, and quality is controlled
- Bee colonies can be raised that have desired characteristics – such as less aggressive bees, high productivity of honey and royal jelly, and robust pollination services.

The new virgin queen emerges

What are queen bees and how are they replaced naturally?

A queen is larger than a worker bee, having a pea-sized thorax and a long, tapered abdomen. Unlike worker bees, her reproductive organs are fully functional. Six to ten days after emerging from her cell, she mates in flight with 10–15 drones. A mature queen may lay up to 2000 eggs per day, but usually averages 700–1000. Although she can live for up to five years, under commercial conditions, a queen is usually replaced every one or two seasons to ensure vigour, which translates into colony health.

A wild or domesticated colony of bees will raise queen bees in three circumstances: to replace a queen that has died (emergency) or an old or failing queen (supersedure), and as it prepares to swarm for reproduction, when the old queen will leave with as much as 60 percent of the bees in the hive to create a new colony.

Queen bee

After mating, the queen returns to the hive to lay her eggs

Emergency cells may be anywhere in the brood nest, although a group of two to three cells in a central position on the comb is common.

During **supersedure**, bees select a larva and begin feeding it with royal jelly. They build a supersedure cell around it, which hangs down from the face of the comb.

Before **swarming**, bees prepare queen cell cups where the queen lays eggs. A colony will then prepare 10–15 swarm cells, usually around the edges of the brood combs, often overhanging the bottom bar of the frames.

When rearing queens, beekeepers will manipulate a colony to duplicate one of these three natural circumstances.

How are queens reared?

Essential requirements for successful queen rearing

- A strong colony with healthy brood, well-supplied with royal jelly
- Apiaries with high population of selected drones (males) and mating nucleus colonies with 3000–4000 young bees
- Abundant pollen supply and honey food for the nurse bees and nucleus colonies
- Larvae (12–24 hours old) for grafting, and adequate time to confine them in the starter colony as quickly as possible
- Stimulative sugar syrup for feeding after every manipulation, to keep bees active

A mating nucleus colony

Selecting brood stock and breeder colonies

Brood stock colonies should be selected from a well-defined, indigenous race which meets key quality parameters of behaviour, resistance to pests and diseases, and honey yield.

Breeder (or mother) colonies should be strong, healthy and populous to ensure an abundant supply of healthy larvae for grafting queens.

Ensuring that colonies are free of pests like the varroa mite is a key parameter for selecting brood stock. Here, beekeepers test for varroa using the sugar shake (left), which dislodges mites (right). Where varroa mites are detected, bees from that colony should not be mixed with healthy bees.

▶ Developing starter colonies

Hives are traditionally kept in sets of two, one on top of the other. The starter colony is on top, with the established colony underneath. The beekeeper prepares the top colony for its new queen by transferring frames of brood and honey from the bottom colony to nurture her.

A starter colony holds the newly grafted cells for 24–36 hours. It must be prepared carefully by the removal of its own queen. This ensures high rates of acceptance of grafted larvae, and high quality new queens. An abundant supply of pollen is also needed for the nurse bees and additional emerging brood.

Transferring frames of brood and honey from the established colony to the starter colony to nurture the new queen.

▶ Producing royal cells

The beekeeper provides a frame holding 25–30 artificial beeswax queen cell cups measuring 8–9 mm in diameter at the rim. When the larvae are between 12 and 24 hours old, they are transferred to the cups using a grafting needle. The nurse bees then use wax to create royal cells the size of a peanut shell over the artificial queen cells, and rear the queens.

Young larvae are transferred to the frame of artificial queen cells (left). Nurse bees create royal cells of *Apis mellifera scutellata* (right).

Transferring to a finisher colony

A finisher colony is a queenless colony or section to which the developing queen cells are transferred after they are removed from the starter colony, 24 hours after grafting. The finisher colony continues to nourish the developing queen cells until they are ready to be transferred once again.

Introducing queen cells to a mating nucleus colony

Queen cells are sealed by the worker bees on the fourth to fifth day, and on the ninth or tenth day, the developing queen cells are separated and introduced into the mating nucleus colony (or nuc). These small colonies comprise three to five frames containing sealed brood, pollen and honey. They must be prepared on the eighth day, and must contain enough bees of different ages to provide warmth to the queen cells and provide sufficient food for the newly emerged queens.

On the ninth or tenth day, the queen cells are introduced to a nucleus colony

Fertilising the queens

Fertilisation of the queens can be natural or artificial. Natural fertilisation occurs when the queen is allowed to go for her nuptial flight and to mate with several drones in the drone congregation area. Artificial insemination with semen collected from selected mature, healthy drones can be carried out in a laboratory using instrumental insemination.

Rearing drones

Rearing drones is one of the most difficult and important operations in queen rearing, yet it is the one most often ignored or left to chance. The best way to avoid the queen mating with genetically weak drones is to start drone rearing two weeks before queen rearing, so that by the time the queens are ready for fertilisation, the drones are mature enough to produce semen. Drone rearing should use a mother with the desired characteristics.

Ensuring a supply of strong, mature drones to mate with the queen is essential to successful queen rearing

▶ Instrumental insemination

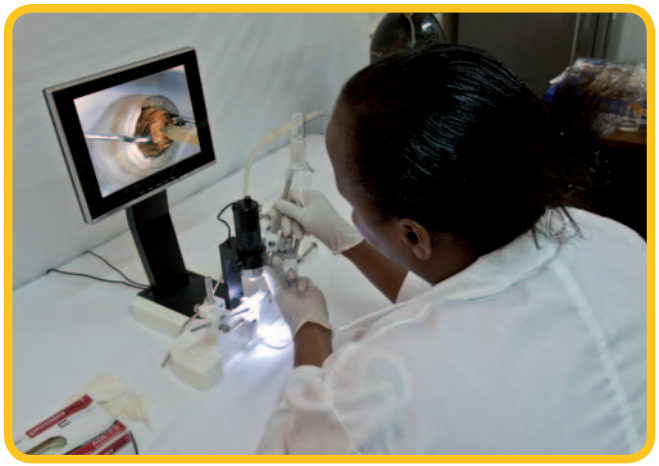
Compared with natural fertilisation, artificial insemination results in more successful, controlled mating. One of its major applications is the maintenance of indigenous brood stock over several generations. The technique requires specialised equipment to anaesthetise and immobilise the queen and to collect and deliver semen from the drones.



Sperm is harvested from an *Apis mellifera scutellata* drone (left) using a capillary applied to the tip of the endophallus, which is exposed by gently squeezing the thorax. First, saline solution or an acceptable substitute liquid is drawn into the tiny syringe. This is the capillary buffer, which ensures the flow of liquid and prevents the semen from drying. The queen is transferred into a holding cage and anaesthetised using filtered carbon dioxide; her genitalia are stretched open (centre) and the capillary is inserted into the canal (right).

Ten microlitres (10 µl) of semen are injected into the queen's vaginal cavity without touching the capillary to the inner walls, after which she is removed from the holding cage and transferred back to the queen cage. She revives after ten to fifteen minutes and is then re-introduced to the nucleus colony accompanied by candy, a mixture of icing sugar and honey. The nurse bees will chew the candy, and their close proximity allows for an exchange of pheromones among them so that they eventually accept the new queen.

The beekeeper must provide an empty comb for egg laying four days after insemination, and should thereafter check the laying pattern and monitor the queen's progress. This nucleus colony can now be sold or transferred to a complete hive.



A scientist carries out artificial insemination under the microscope

What is the impact of rearing queen honeybees?

- Increased honey productivity, agricultural and rural growth, and income generation
- Enhanced capacity and income among beekeepers
- Development of hive management strategies
- Foundations laid for a bee-breeding programme to develop a commercial stock of bees, and for the incorporation of this knowledge into national development strategies and policies

Current research questions

- What is the estimated monetary value of queen rearing?
- What is the impact of queen rearing on beekeeping?
- How are communities benefiting from queen rearing?
- What is the precise impact of queen replacement on aggressiveness, pest and diseases, and honey production?

icipe: home of the African Reference Laboratory for Bee Health

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