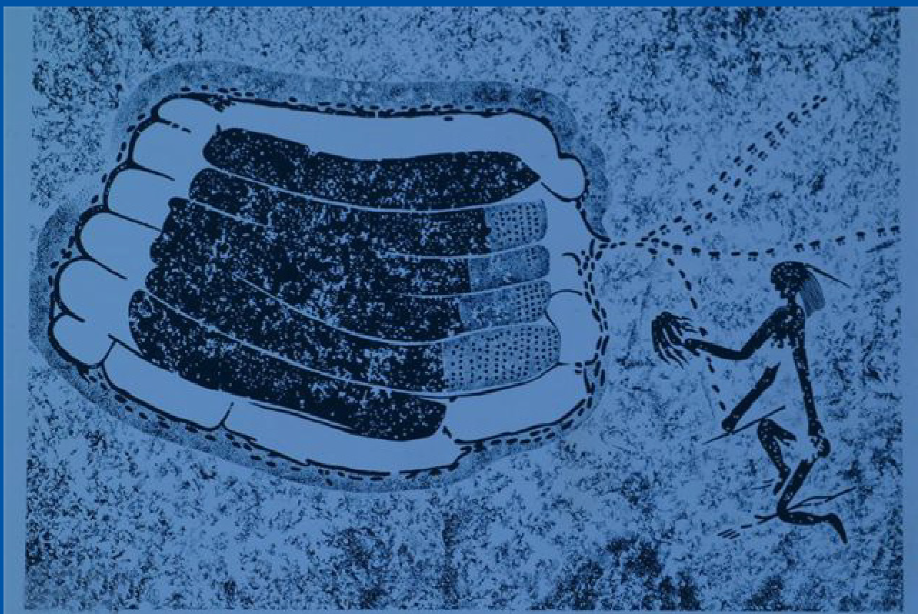
Flavio Braidotti Pietro Lorenzi

APICULTURE IN SUB-SAHARAN AFRICA

A Manual for Trainers



This manual focuses on modern beekeeping in Sub-Saharan Africa. It attempts to upgrade and refine the knowledge of trainers/field workers within government departments or organizations/NGOs on the correct use of modern beekeeping techniques. The final aim is that competent services will be provided to farmers/beekeepers and appropriate transfer of know-how will be accomplished to the same. It is hoped that this will contribute to the creation of a new generation of beekeepers in the Region.

The main targets of the manual are trainers, government institutions, private and public organisations including NGOs, entrepreneurs and established beekeepers operating in the Sub-Saharan African region.

CEFA is an Italian Non-Government Organization of International Voluntary Service. CEFA's goal is that everyone everywhere in the world can become a protagonist of development and an active agent of democracy and peace.

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C-MAD is a Kenyan based Non-Government Organisation. C-MAD envisages a world where men and women live dignified and prosperous lives with a mission of enabling communities in Kenya to improve their livelihoods, live dignified, healthy and prosperous lives through capacity building, collaboration and service delivery.

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A Manual for Trainers

by Flavio Braidotti - Pietro Lorenzi

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FIRST PAGE COVER ART:
Rock art. The use of smoke in prehistoric times (Matopo Hills, Zimbabwe, Africa).
This is probably the oldest representation of smoke in apiculture.

In memory of Joseph M. Mathuva,

dedicated advisor and good friend

ABOUT THE ORGANISATIONS

CEFA is a Non-Government Organisation of International Voluntary Service.

It was established in 1972 by a Group of Agricultural Cooperatives to carry out projects that help local populations in an enduring way, to combat starvation and to promote a society where men, women and children can live in peace.

CEFA gives priority to those projects that aim at food self-sufficiency and that meet the primary needs of the population (food, water, health, education, social organisation). Each project tries to combine direct productive interventions with actions aimed at cultural and social improvement.

CEFA is founded on the principles of solidarity among the different regions of the world in the name of justice, human rights and peace.

It is a non-profit organisation and uses only 10% of the contributions for its organisational costs. CEFA's contributions come from members of the public, private companies and institutions.

It is a member of the FOCSIV (the Federation of Christian Organisations for Voluntary International Service) and is officially recognised by the Ministry of Foreign Affairs by a decree issued in 1974, by the European Union and by the UN.

CEFA's goal is that everyone everywhere in the world can become a protagonist of development and an active agent of democracy and peace.

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C-MAD started in 1987 as a project within the Catholic Diocese of Kisii (Mobilization Against Desertification MAD) to respond to recurrent famines that characterised the Southern Nyanza Lake basin in the early to mid 1980s. It was registered as a Non Government Organisation under the NGO Coordination Act of (1990) in 1995.

The organisation envisages a world where men and women live dignified and prosperous lives with a mission of enabling communities in Kenya to improve their livelihoods, live dignified, healthy and prosperous lives through capacity building, collaboration and service delivery.

C-MAD is founded on the principles of honesty and integrity, transparency, accountability, community-centred, teamwork, professionalism and non-discrimination.

C-MAD runs programmes addressing food security, agricultural marketing, natural resource management, preventive health, water and sanitation with a national mandate.

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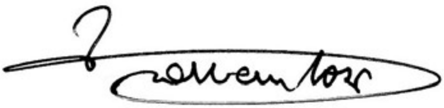
PREFACE

CEFA has been involved in international volunteering development programmes for nearly 30 years, especially in Africa. These rural programmes deal mainly with agriculture and animal husbandry. They promote the responsible and sustainable growth of local communities. The primary concern is food security and improvement in sanitation, the environment, cultural awareness, training, organisational capacity and democratic participation. To achieve this, CEFA's programmes foresee interventions that tackle both economic issues such as the improvement of production and marketing of agricultural products, and social and educational issues such as training, both of which are interlinked. Of primary importance is the involvement and participation of local communities through the presence of volunteers capable of working together with people and experts/officers at the local level. In other words, volunteers inspiring confidence in the successful achievements of the programmes through the wise use of human and natural resources. The aim is to assure that the benefits of the developmental projects will continue to multiply even after the official termination of the project and after the volunteers have returned to Italy. The publication of this apiculture manual falls within initiatives that provide growth in the long run, even beyond the place where they were conceived. Bees' work can be seen as a metaphor for the ideal approach to international cooperation for development: the bees, respecting the environment and favouring its development, work together to create a valuable product that allows many rural farmers to increase their income.



Francesco Tosi
(Former CEFA President)

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We are particularly grateful to the Officers engaged in the above-mentioned project in South Nyanza for their feedback, collection of data, sharing of ideas and support in letting us know that the training offered to them was somehow unique and empowering: Mr Robins John Oyia, Mr Daniel Nyambok, Mr Kennedy Ogoma, Mr Calleb Oyugi Adede, Ms Ednah Anyango Okello and Ms Nohla Achieng Onyuna. Thanks also to Felix Omondi Oluoch and Emily Anyango Okelo.

We are very grateful to Mr Ocharo, the District Livestock Production Officer in Homabay, for his kind support and help; to the Agricultural Training Centre (ATC) in Homabay and in particular to its principal Eric O. Adel, to the KARI (Kenya Agricultural Research Institute) branch in Homabay for the data provided; to Edward Caruso for his editing and to Laura di Bugno for all the useful advice provided.

Thanks to *maestro* Ezio Ruz from Aldeno (Trento, Italy), the main teacher and source of inspiration for this manual to Pietro Lorenzi, co-author, who had the opportunity to get to know CEFA during his several trips to Northern Kenya, which were sponsored by the Associazione "Serenella" (Rovereto, Italy).

A special thanks to the Associazione Veterinaria di Cooperazione con i Paesi in Via di Sviluppo - AVEC PVS (Biella-Italy, www.avec-pvs.org), particularly to Giovanni Guido and Gianluca Pressi for their kindness in reviewing this manual and the professionalism shown.

A sincere thanks to all C-MAD staff in Rongo; to CEFA in Nairobi, Kenya; and to its head office in Bologna, Italy. Also to Marco Lorenzetti, CEFA Regional Representative in Kenya, for his friendship and for his continuous back-up, and also to the Desk Officer in Italy, Pierpaolo Bergamini, for having supported us throughout.

Last but not least, even if it is not possible to mention all of them, thanks to the various CEFA volunteers around the world and to the donors, private and public local institutions, who have supported this and other projects in Kenya.

INTRODUCTION

This manual is the result of a consultancy carried out by Pietro Lorenzi in June/July 2009 in Western Kenya within the EU-funded project called "Strengthening Product Value Chain of Agro Business Enterprises in South Nyanza" implemented by CEFA in partnership with C-MAD in the districts of Homabay, Ndhiwa and Rachuonyo (South Nyanza). The project focuses on increasing the production and marketing of groundnut, sweet potato and beekeeping products adopting a value-chain approach to link farmers to markets. The project also foresees the provision of business-related services through a Business Development Service Centre to improve entrepreneur skills in the project area and foster value-adding activities.

Several visits were carried out in the project area to various farmers/beekeepers to gauge the reality of different beekeeping misconceptions and malpractices. This, together with previous work done in Northern Kenya (Turkana, Samburu areas), reinforced the need to prepare a manual to ensure that the main concepts for correct beekeeping could be transferred to as many people as possible within Kenya and Sub-Saharan Africa.

The main targets of the manual are trainers, government institutions, private and public organisations, entrepreneurs and established beekeepers operating in the Sub-Saharan African region. This manual focuses on modern beekeeping. It attempts to upgrade and refine the knowledge of trainers/field workers within government departments or organisations on the correct use of modern techniques so that the appropriate know-how is transferred to farmers/beekeepers. It is our hope that this will lead to improvements in the apiculture sector in Africa and to the creation of a new generation of beekeepers. Beekeepers or entrepreneurs wishing to improve their work practices can also benefit from this manual.

The first step of beekeeping is to love bees. This best comes through an understanding of the important role that bees play in nature, the amazing way in which they organise and communicate. The success of beekeepers consists in helping the bees to live as much as possible in harmony with their environment. For these reasons Part I focuses on bee ecology.

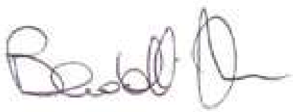
Botanical species play a vital role in beekeeping since they are the source from which bees collect their food (nectar and pollen) and substances like propolis. The composition of different species within an apiary and their proximity to it are therefore quite important factors to consider for a beekeeper. These aspects are examined in Part II.

In addition, bees play an important role in agriculture by not only contributing to crosspollination, but also by increasing the yield, number of seeds, size and quality of crops being cultivated close to the hives. This provides a mutual benefit to the farmer and beekeeper. Part III deals with these issues.

Part IV deals with the real operations that any beginner beekeeper dreams of, such as putting on a bee suit and gloves, and visiting the hives to collect honey at the end of the season. This part deals with topics such as proper apiary design, hive inspections, honey harvesting, how to strengthen an apiary, and swarming. The Langstroth hive, due to its comparative advantages, is referred to in this manual.

Part V focuses on different products that can be collected from bees. Such benefits can be a source of income for the beekeeper once he/she learns how to manage an apiary properly. Royal jelly and bee venom will not be considered in this manual. Part VI deals with the pests and diseases affecting bees, their dangers to the colony. Suggestions on how to treat each of them are provided. Finally, a cost margin analysis is supplied in the last part, with Kenya used as a case study.

While venturing through this manual be creative and encourage beekeepers to experiment with the practices that will be taught to them. Besides the basic concepts and suggestions provided herewith, it must be noted that nothing is absolute in beekeeping: it is an experience in continuous evolution. New ideas and thoughts should always be tried out to keep on learning and improving. Good luck!



Flavio Braidotti
(CEFA Value Chain Project Co-ordinator)

Chapter I

Bee Ecology

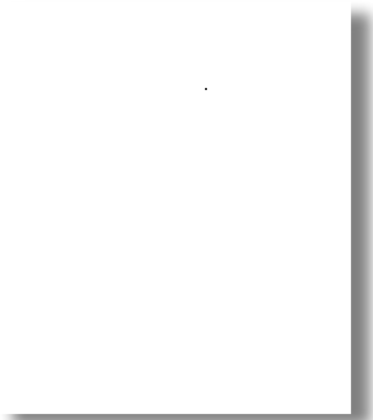
1 Honeybees, comb construction and reproduction system

Honeybees are flying insects closely related to wasps and ants. They live in colonies ranging from 10,000 to 100,000 bees.

Bees have been around for a long, long time, gathering nectar and pollinating flowers. They haven't changed much since dinosaurs roamed the earth.

The honeybee is characterised by a combination of individual traits and social cooperation that is unparallel and unique in the animal kingdom.

The African Honeybee is a subspecies found in Africa that is smaller than the European bee. Within Africa, in turn, different types of species are present. See **Fig. 1** below, which shows the geographical distribution of bee species in Africa.



Source: Winston (1987)

Fig. 1 – Geographical distribution of bee species in Africa

Honeybees are divided into three different castes (see **Fig. 2**):

- worker bees (unfertilised female)
- drones (male)
- the queen (fertilised female).

Each of them will be dealt in detail in ***Section 3***.

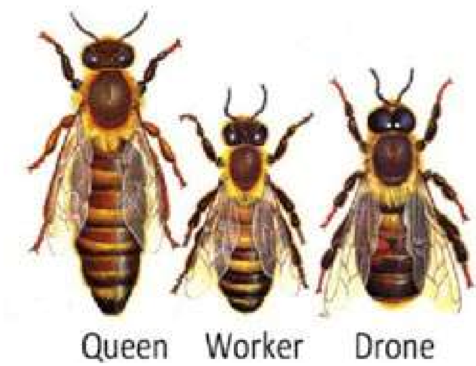


Fig. 2 – Different castes of bees

Bees usually build their nest in a dark, closed place such as cavities or hollow trees. The combs are made of wax, which is made by the worker bee through wax glands located on the underside of its abdomen. The construction of the combs begins always at the top and proceeds downwards.

The construction of the comb occurs as follows: the wax flakes are produced through the glands; the wax flakes are then removed from the abdomen via the forelegs and brought to the mouth where wax is chewed and positioned in the cells under construction (see **Fig. 3**).

Source:. Winston M. L. *Source:. Winston M. L.*

Fig. 3 – Constructing the comb with wax flakes from the glands

The combs consist of a regular back-to-back array of almost perfect hexagonal cells arranged in a parallel series (see **Fig. 4**).

Source:. Winston (1987)

Fig. 4 – Comb architecture

For a long time humans have tried to copy the way bees construct combs in nature and have created different types of artificial beehives for modern bee management and the collection of bee products. The most widely used and recommended artificial hive is the Langstroth hive, which will be considered in ***Section 12***.

The comb is essential for the colony, since the colony's brood rearing or honey and pollen storage cannot be done outside the comb. Within the Langstroth hive two main types of combs are found:

1) the *brood combs* where brood is raised and stock of honey is stored. These are located in the "brood chamber" (large box comprising the lower body of a Langstroth hive). The combs with brood are located in the middle of the hive while combs with a store of honey are located on the side.

2) the *honey combs* where bees store the nectar collected in the field, which is to be ripened into honey as a surplus food stock reserve. These are located in the "super" and this is the honey harvested by the beekeeper.

The brood combs used to raise new brood are organised in this manner. Most of the *brood cells* (where eggs, larvae and pupae are found) are located at the centre of the brood nest. Bees tend to store honey near the upper edges of the nest, while pollen is stored between the honey cells and the central brood area (see **Fig. 5**). This is the only place where pollen is stored within the hive. Honey and pollen is then used to feed the colony and the brood.

Source: Bonney (1993)

Source: Lorenzi Pietro

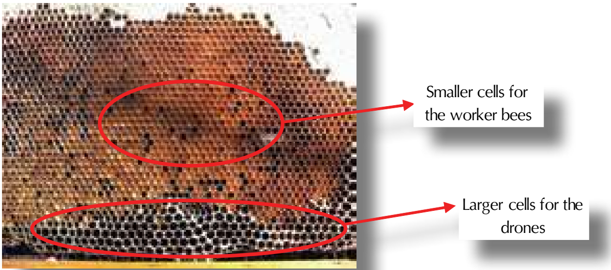
Source: Lorenzi Pietro

Source: Lorenzi Pietro

Fig. 5 – Distribution of brood cells, pollen and honey in the comb where brood is raised

Within the brood cells it is important to distinguish two main types of cells, which are identifiable according to the different size each of them has (see **Fig. 6**). Somehow they are linked to the castes mentioned above.

- The smallest cells are where the worker bees are reared. They are called the "worker cells".
- The larger cells are where the drones are reared. They are called the "drone cells". Usually they are located in the lower part of the brood comb.

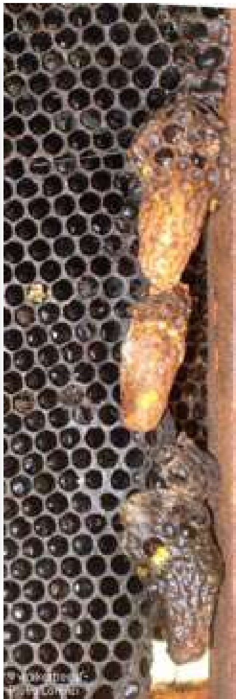


Source: Lorenzi Pietro

Fig. 6 – Cells for worker bees and drones

Besides these two, there is also another type of cell that is built when a new queen has to be reared. It is called the "queen cell" and has a pine nut shape. This is where the queen is reared (see **Fig. 7**).

Source: Bonney (1993)

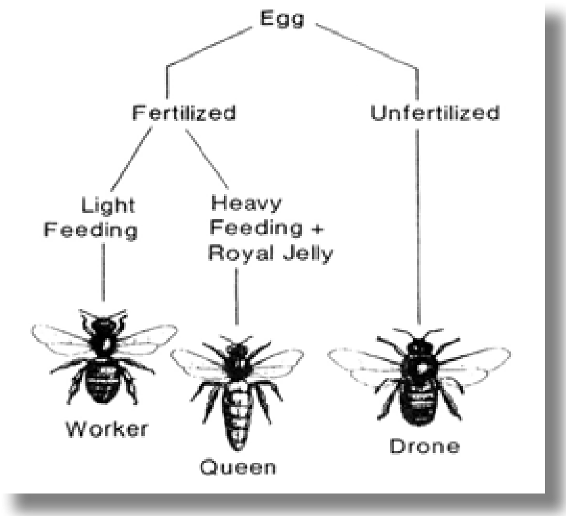


Source: Lorenzi Pietro

Fig. 7 – The pine nut shape queen cell

The size of the cells within the brood comb is one of the main factors determining the reproduction system of the bees (see **Fig. 8**). In fact, the queen, recognising the size of the cells, lays unfertilised eggs in the larger drone cells and fertilised eggs in the smaller worker cells. For this reason it is said that who determines the sex and the population size of the castes in the colony is not the queen but the workers who decide the number of worker cells and drone cells to construct.

The other important factor determining the reproduction system of the bees is the type of diet. The queen is fed for her entire life with royal jelly. This food, made in the bee's head gland, is sometimes referred to as bee milk. Worker bees and drones on the other hand are fed royal jelly in the first days; afterwards with water, pollen and honey.



Source:. Winston (1987)

Fig. 8 – Bees' reproduction system

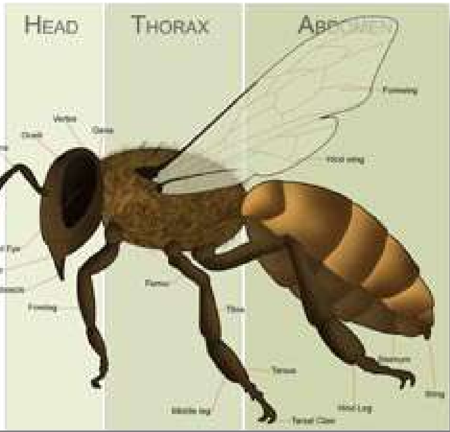
The ideal for a beekeeper is to have a strong and healthy colony, with many workers, and a strong queen that lays many eggs. A strong colony will be of great satisfaction to the beekeeper, even though from time to times he or she will have to deal with weak or queen-less families and with swarming or absconding events.

Like any other animal, even bees have their own natural biological cycle that can be partially altered by mankind. This is the reason why a good beekeeper must know the ecology of the bees in order to give them every possibility to follow their natural cycle.

2 Morphology

The bee, like any other insect, has a body divided into three main parts (see **Fig. 9**). These comprise the:

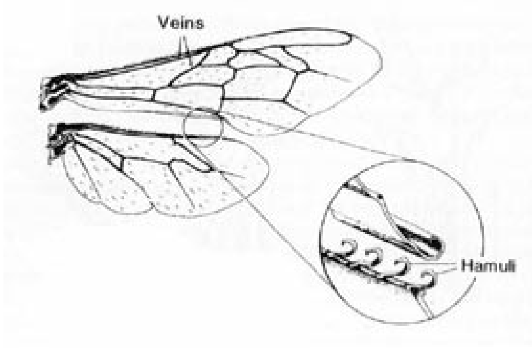
- head
- thorax
- abdomen.



Source: Wikipedia

Fig. 9 – Bee anatomy

A bee has six legs and is equipped with four wings. The forewing is larger and the hind wing is smaller. When flying, the two pairs of wings merge, forming a single block of wings (see **Fig. 10**).



Source:. Winston (1987)

Fig. 10 – Bee's wing system

Table 1 summarises the main morphological details of the three castes. Some of them will be considered further in the next section as well.

Table 1 – Summary of main morphological details of three bees' castes

	Queen	Drone	Worker bee
Body length	17–20 mm	15 mm	12–13 mm
Legs	Not well equipped	Not well equipped	Equipped for storage
Sting	Flat	Not present	Saw-shaped
Proboscis	Small	Small	5.5–7.1 mm
Duration of the metamorphosis*	16 days	24 days	21 days
Life duration	5–6 years	50 days	35–45 days
Characteristics		It has large wraparound eyes	

* Further research is needed to confirm if in Sub-Saharan Africa the duration of the metamorphosis for the queen is 15 days and for the worker bees 20 days.

3 The castes: development and tasks

3.1 The queen

The queen bee is the heart and soul of a colony. Without her presence the rest of the colony cannot survive. A good quality queen means a strong and productive colony. Only one queen lives in a given colony. The queen's two primarily purposes are (1) to produce chemical scents (called pheromones), which help to regulate the unity and stability of the colony, and (2) to lay eggs.

She is the only female with fully developed ovaries. She grows inside the pine nut shaped queen cell, and it takes three days to develop from the laid egg to the larvae state. Metamorphosis takes 15–17 days (see **Fig. 11**). She is fed royal jelly by worker bees for the whole of her life.

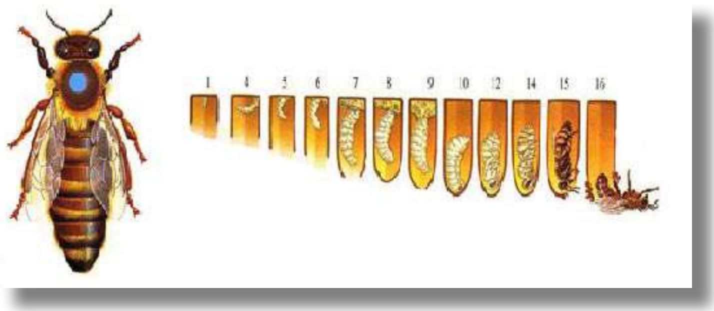


Fig. 11 – Metamorphosis of the queen

The worker bees raise the queen by constructing several queen cells (six to ten) when they perceive it is necessary to replace the queen (either because she is old or because of imminent swarming). Fertilised eggs are then laid by the existing queen in these cells. In case of the sudden death of the queen, on the other hand, the worker bees will modify the cells containing larvae younger than three days to construct the pine nut shaped cell. The diet will continue to be royal jelly throughout and the queen will be reared in this way. The first queen to hatch hurries in search of the cells where her sisters are preparing to hatch. She pierces them with her sting. If another queen manages to exit her cell, a fight between the two will follow and the winner will be the leader of the hive. Through this system of "natural selection" the colony has the highest chance of having the strongest queen.

The new queen will spend a few days in the hive and after five to 15 days (a range determined by external climatic conditions such as rain) she will start the so-called "mating flight" to be fertilised (see ***Section 4*** for more details about mating).

Two to six days after mating the queen will start to lay the eggs in the cells. Each day a queen may produce as many as 2,000 eggs. Sometimes, under exceptional circumstances, she will lay even 3,000 eggs per day. The number of eggs is negatively correlated to external factors such as drought, famine and cold. The queen must lay this range of eggs in order to keep a colony supplied with a large numbers of workers. She is fed and taken care of by the worker bees (see **Fig. 12**).

Fig. 12 – The queen attended by the worker bees

The queen can live up to five years, though her average lifespan is of three to four years. It is important to point out that after two years the egg-laying capacity of the queen slows, which results in less and less brood produced each season (this means a smaller and weaker colony). For this reason, the modern beekeeper should replace the queen after a couple of years in order to ensure maximum productivity.

The age of the queen can be assessed through observation. The young queen is active and energetic, the wings are well shaped, the hair in the thorax is thick, and the brood cells are ample and compacted. The old queen, on the other hand, has few and ruined wings, and lays eggs in a disordered manner.

In modern beekeeping there is a world-accepted method for recognising the age of a queen. It consists of marking the queen with different colours according to the year of birth, as shown in **Table 2** below.

Table 2 – How to recognise and mark the age of a queen

Years of birth	Colour assigned to queen
0 or 5	Blue
1 or 6	White
2 or 7	Yellow
3 or 8	Red
4–9	Green

A small circular device shown in **Fig. 13** is used to trap and mark the queen.

Source: Lorenzi Pietro

Source: Lorenzi Pietro

Fig. 13 – Device used to mark the queen

3.2 The drones

The drones are usually born near the end of the rain season in the large cells located in the lower side of the brood comb. In tropical areas, such as those in Africa, it may be the case that the drones are lower in number than in areas with a temperate climate, but they have a constant presence throughout the year. However, further research needs to be undertaken to confirm this hypothesis.

Drones, besides their bigger size, are recognisable from worker bees by their large wraparound eyes.

Drones make up a relatively small percentage of a colony's total population. In a hive the number of drones present on average during the year varies from 2,000 to 6,000.

The drone's metamorphosis occurs in 24 days and its main phases are pointed out below. During their first three days the larvae are fed with royal jelly, and after that, their diet consists mainly of water, pollen and honey. After six to seven days the bees seal the cell and the larvae become pupae. Twenty-four days later the drones leave the cell and start their lives (see **Fig. 14**). Even though they might be able to feed themselves, the drones prefer to be fed by the worker bees.

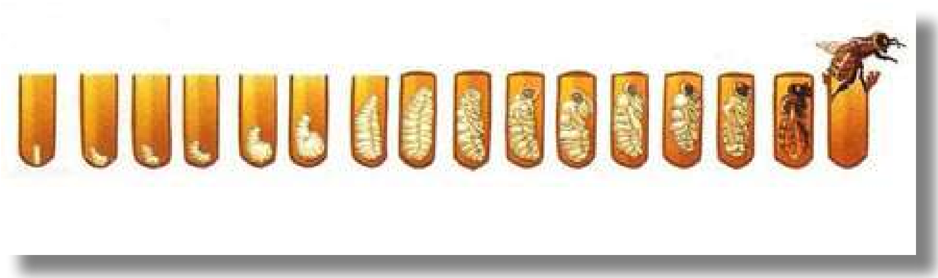


Fig. 14 – Metamorphosis of the drone (0–24 days)

After 10 days the drones start flying. Even though they can start copulating after 20 days, this tends to happen after 35 to 40 days. The lifespan of a drone is about 50 days, but it might be less. In temperate climates, once the weather gets cooler and the mating season comes to an end, the worker bees kill or expel them from the hive.

Procreation is the drone's primary purpose in life. Despite their high maintenance (they must be fed and cared for by the worker bees), drones are tolerated and allowed to remain in the hive because they may be needed to mate with a new virgin queen (when the old queen dies or she needs to be superseded). The drones' special morphology means they are not fit for any other activity in the hive. For example, drones have no sting so they cannot defend the colony. They are also unable to perform any of the worker bees' tasks, such as fanning the hive or collecting the nectar. However, it has been discovered recently that occasionally drones do, in certain circumstances, fulfil some other tasks besides procreation such as helping to feed the brood and keeping them warm.

Drones can move from one hive to another without causing fighting with the new families. These seem to tolerate the presence of this "strangers". This is something, as we shall see, that does not occur with the worker bees and the queen.

3.3 Worker bees

The majority of the hive's population consists of worker bees. Their metamorphosis takes 20–21 days.

Three days after an egg is placed in the cell the shell begins to sway, as the larva inside starts moving. Finally, the larva breaks the shell and escapes to the bottom of the cell. Nurse worker bees seem to be able to sense that the egg has hatched. They immediately enter and leave a tiny drop of royal jelly near the larva.

During the first five or six days after hatching, each larva receives as many as 2,000 visits from various nurse bees. The food (water, pollen and honey) is supplied only in 100 to 200 of these visits. The rest are "inspection" visits (see **Fig. 15**).

Source: Lorenzi Pietro

Fig. 15 – Brood with larvae

By the time a larva is six or seven days old, it becomes large enough to fill its cell. Worker bees then place a cap (made of a mix of wax and pollen) over the cell entrance. A few days later the larva sheds its skin and it turns into **pupa**. After a few more days the pupa gradually becomes tan in colour. Finally it becomes light brown, then a few hours later the pupa's skin splits and an adult worker bee comes out. This takes place on the twentieth to twenty-first day after the egg was first deposited in the brood cell. The new worker chews away the cell cap and crawls out to join the other bees (see **Fig.16**). Soon after leaving the cell the young bee looks very fragile and insecure and is completely harmless.

Fig. 16 – From egg to worker bee in the brood comb

It should be noted that the temperature of the hive plays an important role in the development of the larvae since too much heat or cold can cause the death of the bees. The temperature of the hive should always be between 33 to 36 °C.

On average, the lifespan of the workers ranges between 35 to 45 days.

From the moment a worker bee is hatched, she has many varied tasks clearly set out for her. The specific job and duties worker bees perform during their short life vary with age. The tasks can be grouped into two main phases of 21 days each: in the first phase worker bees take care of the hive and in the second phase they cover mainly the function of foraging while flying in the fields collecting pollen and nectar (see **Table 3** for more details).

Table 3 – Tasks performed by the worker bee at different stages of its life

Period (days)	Tasks performed
1–3	Cleaning, polishing the cells
4–10	Feeding and nursing
11–16	Building the wax comb
17–19	Receiving nectar and pollen, and storing it in the cells
20–21	Guarding the hive
22–42	Foraging and collecting nectar and pollen

Days 1 to 3

The first task is to clean out the cell from which she has just hatched. This and other cells will be cleaned and polished with propolis to disinfect them, and left immaculate to receive new eggs and to store nectar and pollen.

Days 4 to 10

The next task is to feed and care for the developing larvae – the role of nursing bees. Do you remember how larvae are fed? Young larva with royal jelly and then pollen, honey and water. They also feed the queen with royal jelly and even remove her excrement from the hive during the last part of this period. The number of days spent tending brood cells depends upon the quantity of such cells in the hive, and the urgency of other competing tasks.

Days 11 to 16

At this age the bees have matured enough to begin producing beeswax from the wax glands. They help with the building of new wax combs and in the capping of cells containing developing pupae and ripened honey.

Days 17 to 19

During this time young worker bees take nectar and the pollen from foraging field bees that are returning to the hive. This task is technically called "food exchange". Afterwards the nectar and pollen is stored in the honey combs' cells earmarked for this purpose.

Days 20 to 21

The last task of the house bee before she ventures out is guarding the hive against external threats. At this stage of maturity her sting glands have developed to contain a good amount of venom.

Days 22 to 42

Now the worker bee ventures outside the hive to become a foraging field bee. At this point she forages for pollen, nectar, water, propolis and honeydew (covered in ***Section 7***). The range of movement of the forager bee is about 3 km away from the hive. The foraging bee visits a range of 150 to 220 flowers each day, makes 20–50 trips per day at a speed of 20 km per hour. She usually operates from 6 am to 11 am and from 2 pm to 4–5 pm.

In addition, there are other tasks that worker bees carry out interchangeably when particular circumstances occur, such as taking care of the drones, fanning to regulate the temperature within the hive, and helping to direct other members of the colony back to the hive.

4 Mating

The queen is fertilised through the so-called "mating flight" or "nuptial flight". As these terms suggest, mating occurs outside the hive, in mid-flight, 200 to 300 feet in the air. The drone's large eyes come in handy for spotting the virgin queen during her nuptial flight. The priority of numerous drones (10 to 100) is to be in the appropriate place to follow the queen. However, only a few will succeed in mating with the queen. The queen, in fact, will be mounted and copulated by only six to 10 drones who will die after the mating (see **Fig. 17**).

Fig. 17 – The mating flight

Mating occurs in the hottest time of day, between 11 am and 1 pm. During this time potential predators (such as birds) are not so active due to the heat.

Note: The queen meets the male only once (during the mating flight) and the quantity of sperm provided will be enough for her to lay eggs for the rest of her life (five years). She subsequently never leaves her combs except during swarming.

In Europe the period of mating falls within April and May up to September. In Sub-Saharan Africa, where usually the seasons are characterised by two main rain seasons (short and long rains), the period of mating should be throughout the year with a slowdown during the two rain seasons.

5 Thermoregulation

Bees are heterothermal animals (the temperature of the body depends on the temperature of the environment). The temperature of the hive is very important for the proper growth of the larvae and for the health of the whole colony.

Do you know the ideal temperature inside a hive?

The larvae, to complete their metamorphosis, should have an ideal temperature ranging from 33°C to 36°C. Temperatures above 36°C for any appreciable time are harmful to the developing larvae and can cause developmental abnormalities and death.

When the temperature is cold, bees are able to generate warmth in the brood through the use of their pectoral muscles. To do this they need to increase the consumption of sugar (honey). Recent studies have shown that the bee is able to raise its own body temperature as much as 9.5°C.

In tropical countries, where temperatures can reach high levels, bees have to fan to lower the temperature and control humidity. To keep the optimum level within the hive, bees adopt various methods:

- ventilating the nest by fanning
- evaporating water.

In the first option, at the entrance of the hive bees start fanning, producing cool air currents that draw the warm air out of the nest. If fanning does not prove adequate, workers can still regulate the temperature of the nest through the utilisation of water, which is brought into the hive and is placed as hanging droplets in the empty cells. The high temperature in the hive will cause evaporation. This will reduce the temperature. It has been proved that in places where temperatures reach 70°C and where water can be collected, the bees are able to regulate the hive temperature to 35°C.

Bees can pour out of the hive in groups. This occurs when they lack space in the hive to spread out, or because the hive has many cracks and they are not able to regulate the temperature. On exit, they are attached to each other at the legs. In this case it is said that the bees make a **beard** (see **Fig. 18**).

Source:. Lorenzi Pietro

Fig. 18 – Small "beard" in the hive

When this happens the beekeeper should note that there is something wrong in the hive (the hive is not well sealed, has cracks, gaps and so on) and should try to find a remedy promptly. In ***Section 12*** the list of the main tools that should be used for the proper maintenance of the hive is provided.Bees, in their search for food, visit the botanical species rich in nectar and pollen. Sometimes they also collect other sacchariferous substances produced by plants or flowers.

6 Collection of food

They operate within a radius of about 3 km from the hive.

The bees are attracted by two basic characteristics:

- colour
- perfume.

Colours that attract the bees are:

- blue
- yellow (such as sunflowers)
- white (such as *moringa oleifera*)
- green-blue
- ultraviolet.

Black is also recognisable but it stimulates aggression, especially in proximity of the hive and when black objects are in motion.

Bees can be attracted by the colours of flowers even from afar. The scent, on the other hand, can be detected and can be a guide only in the proximity of the plant.

For the beekeeper it is important to allow the bees to find as much food (and water) as possible near the hive. This has dual benefits: to the beekeeper who can harvest a good amount of honey and to the bee who will spend less energy to look for them.

Note: Bees, when starting to forage for pollen or nectar from a flower with a certain colour, will not pay attention to any other before exhausting the reserves of that specific botanical species. In other words, rather than hopping from one flower type to another (like other insects), bees are flower-consistent.

This focus makes pollination effective because, for example, the pollen of the paw paw flower would never fertilise a watermelon flower. It has important implications also when deciding, for example, to produce a mono-flora honey (made mainly from the nectar of one plant). In this case the place to grow the plant should be identified according to the orientation of the hive (south-east), and the entrance to the hive should face the field with the botanical species of interest. If the field with the crop/plant already exists, then the apiary should be positioned in a south-easterly direction (see ***Section 13***).

7 What bees collect: nectar, pollen, honeydew, water and propolis

Nectar

The nectar is the main source from which honey originates, and it is found in the special organs of the flowers located inside the corolla, or sometimes from extra-floral or honeydew secreted by plant-feeding insects.

The nectar, collected by the foraging field bee, is drawn in through its mouth apparatus, deposited in the honey stomach and transported into the hive. Once back from her trip, the bee regurgitates the nectar fluid and this is supplied to the receiving bee. The food exchange is done through the proboscis (see **Fig. 19**). The nectar is then stored in the appropriate comb cells to be ripened into honey.

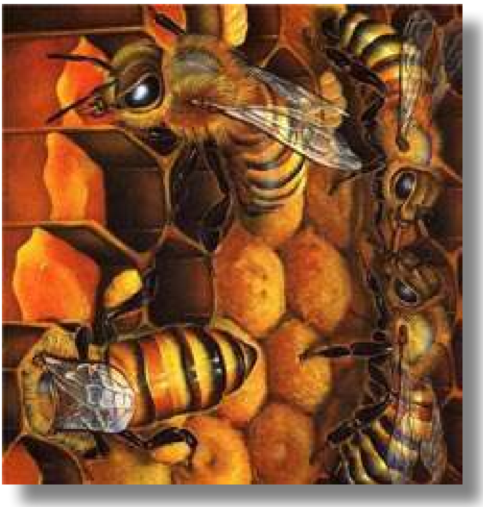


Fig. 19 – Food exchange and storage

During this food exchange, the enzymes present in special glands located within the honey stomach of the bee are added to the nectar. These enzymes have the function to break down the sucrose (which is the sugary part of the nectar) into fructose and glucose, which are easily digestible by humans.

The water content of the nectar evaporates by the repeated folding and unfolding of the nectar on the worker's tongue, and then by placing it in the cells for further evaporation. When the enzymatic activity is completed and the humidity of the nectar has reached 18%, the nectar is considered to be "ripe" and can now be called honey. The ripened honey will then be capped with a layer of wax (see **Fig. 20**).

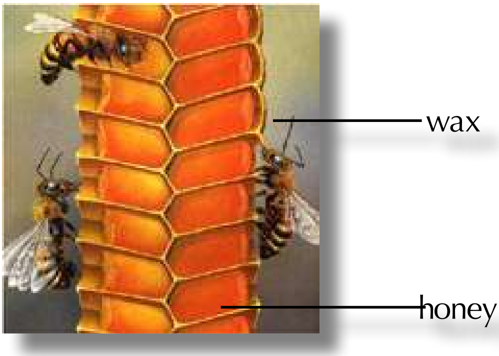


Fig. 20 – From nectar to honey

In order to collect a litre of nectar, forager bees do about 25,000 trips.

The quantity and quality of the nectar is related to environmental conditions such as the sun, humidity, wind and temperature of the place where the plants producing the nectar are located.

Pollen
Pollen is the male element of flowers and it looks like microscopic grains contained in the anthers of the stamen (see **Fig. 21**). Pollen is gathered when flowers blossom. The bees use the pollen for food, but in the process of collecting nectar and pollen, sufficient pollen grains are left on its hairy body and are transferred between flowers to effect pollination.

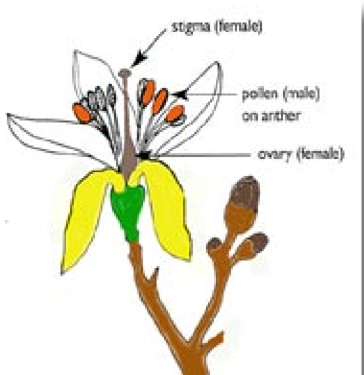


Fig. 21 – Pollen and flower

Forager bees have the task of gathering pollen for the brood during several trips that vary according to the size of the colony present in the hive. The higher the demand for pollen due to the presence of a big brood, the higher will be the number of forager bees required to gather pollen for them.

Pollen is the bees' only source of protein, vitamins and of other substances essential for the proper growth and development of the colony. For this reason pollen is also called "the bees' bread". Pollen can be of different colours and the factors determining it vary.

Pollen is collected and packed by the bee in the following manner. The bee's anatomy is well suited to carry pollen since her body and legs are covered with branched hairs that catch and hold pollen grains. When the bee is covered with pollen grains, during flight, she removes the pollen through the front legs and mixes it together with nectar to create a ball. The ball is passed into pollen baskets located in the hind legs (see **Fig. 22**).

Fig. 22 – Collecting and transporting pollen through baskets

Each pollen basket carries 7.5 mg of pollen. Once in the hive, the foragers will take care of the pollen, storing it in the cells after having sprinkled it with honey. It has been calculated that a strong colony can in one year collect an amount of pollen equal to 40 to 50 kgs.

Honeydew

Honeydew is the sweet secretion of several plant sap-sucking insects such as aphids. The aphids suck the sap of a plant and the secretion is the sugar-rich sticky substance noted in this section.

When aphids are present in trees, bees do many trips to collect honeydew. This work is done at dawn when the drops of honeydew are available in liquid form and are therefore easier to collect. During the day, due to the effect of the sun and the rise in temperature, the drops dry and their collection becomes harder for the bees.

The production of honeydew, determined by the presence of aphids, varies according to the meteorological conditions that most favour its reproduction (warm–humid).

Water

Water for bees serves two main purposes:

1) to reduce the temperature of the hive
2) to prepare the food for the worker bees and drones' larvae older than three days.

For food preparation, bees search for water that is rich in salt and organic substances.

The amount of water collected depends on different factors: seasonality, climatic conditions and latitude.

Nectar contains a lot of water (40–80%). For this reason the higher the availability of nectar, the lower the need for water. But during the period of scarcity of flowers and nectar, the foraging bees must supplement this by searching for water. Without water a colony dies within days.

For these reasons, it is a good practice for the beekeeper to avail water in the vicinity of the apiary (10–15 metres). On average, the daily need of water for a colony, under very harsh conditions, is about 5 litres.

Propolis

Propolis is a sticky resinous material secreted by plants to protect the buds in particular periods of the year. It can also be produced by the bark of a tree.

Bees collect and package the propolis through the pollen baskets on their hind legs (see Fig. 23). However, the size of the ball of propolis carried by the bee in the pollen basket is smaller than the one for pollen. Propolis collection occurs during the hottest time of the day because at this time the resin is soft and easier to collect.

Source:. Winston (1987)

Fig. 23 – Collecting propolis

Propolis is used by the worker bees to cement mobile objects within the hive (like the inner cover to the brood chamber), to seal small holes or cracks up to 6–7 mm thick and to "embalm" carcasses of intruders that have been killed, but are too large to transport out of the nest, such as a mice. Propolis is also used to clean and disinfect brood cells.

8 How bees communicate

In general, communication can be established in different ways such as through touch, visual and acoustic means. Communication is very important for bees, especially when considering that life inside the hive is quite dark. In this type of environment "touch" is the most effective way to communicate within the colony. For bees this is done through a series of dances performed by the foraging workers returning from the field and whose message is understood by the surrounding bees through their antennae.

The foraging bees dance on the comb using precise patterns that can provide news about the exact location of nectar, pollen and water that they have discovered.

The two most common types of dance are the so-called round dance and the waggle dance.

The round dance (see Fig. 24) communicates that the food source is near the hive (50–100 metres).

Fig. 24 – The round dance

The waggle dance (see Fig. 25) on the other hand is performed when the food source is found at a greater distance from the hive (more than 100 metres). It involves a shivering side-to-side motion of the abdomen by the dancing bee while she forms a figure eight. The vigour of the waggle, the number of times it is repeated, the direction of the dance and the sounds that the bee makes, communicates precise information about the location of the food source.

Fig. 25 – The waggle dance forming a figure eight shape

The distance of the food source from the hive is determined by the speed and frequency of rotations done in a particular period of time. For example, nine to 10 rotations done in 15 seconds indicates that the source is near; two to three rotations done in 15 seconds means that it is further than 2 km.

Note: The information provided for the direction of the food is done based on the position of the sun (see Fig. 26).

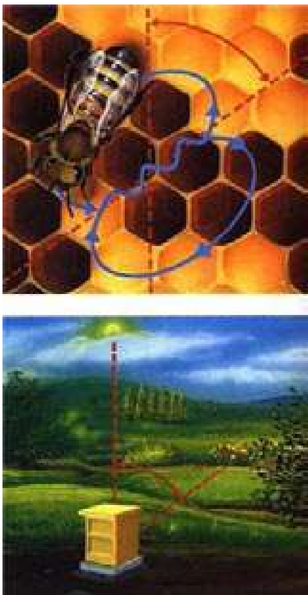


Fig. 26 – The position of the sun determines information passed on during the dance

The dancing bees pause between performances to offer potential recruits a taste of the wonders they bring back to the hive. Combined with the dancing, the samples provide additional information about where the food can be found and what type of flower it is coming from.

Another important way of communication is through so-called pheromones, a chemical signal released by the bees that can serve many functions.

The most famous is the pheromones produced by the queen (known as queen substance), through which she lets the colony know that she is in residence. This stimulates worker bee activity.

The Nasonov pheromone is released by worker bees to orientate returning forager bees back to the colony. To broadcast this scent, bees raise their abdomens, which contain the Nasonov glands, and fan their wings vigorously.

Box 1 – Bee stings: what to do

If a bee stings and you are in the proximity of an apiary, the first thing to do is to run as far as possible. This is because the pheromones emanated from the bees that stung you will attract others.

It is advisable not to remove the sting from the top pressing it outwards, because this will result in more venom being injected into the body. Remove the sting from the side with a sharp flat device (like a knife). In certain countries a remedy against a bee sting is to rub a bulb onion in the stung area since it acts as a disinfectant and is anti-inflammatory.

Another pheromone is produced when a bee stings and it calls others for help (see Box 1).

Chapter II

Bee Botany

9 Bee botany

Bees visit many botanical species to collect the pollen and nectar necessary for the life of the family and the production of honey. It is of crucial importance for the colony to have various botanical species producing nectar and pollen within the apiary.

Tables 4 and 5 list some botanical species (both in the wild and in agriculture) of particular importance in Sub-Saharan Africa for the production of pollen and nectar that the beekeeper should keep in mind when starting a new activity or expanding the present one.

The last column of each table refers mainly to Kenya. Particular reference is given (when available) to the major ecological zones of Kenya shown in Fig. 27. Names highlighted in red are those that fall in the ecological area of particular interest in Western Kenya where the research was undertaken. (Zone L. Due to its proximity even zone H was included.)

Table 4 – Wild bee botanical species of relevance in Sub-Saharan Africa and Western Kenya

Scientific name*	Common name	Value	Ecological area kenya (from fig. 27)
Acacia abyssinica (26 – 32)	Umbrella thorn	Nectar and Pollen	H
Acacia albida (n/a – 33)	Apple ring Acacia	Pollen	A, C
Acacia brevispica (n/a – 34)	Wait a bit thorn	Pollen	A
Acacia elatior (n/a – 35)		Pollen	A
Acacia gerrardii (n/a – 36)		Pollen	A, H
Accacia mearnsii 31 – 39	Black wattle	Pollen	H
Acacia mellifera 191 -40	Hook thorn	Nectar and Pollen	A, C

Scientific name*	Common name	Value	Ecological area kenya (from fig. 27)
Acacia nilotica 32 – 41	Egyptian thorn	Nectar and Pollen	A, C
Acacia polyacantha (n/a – 42)	Falcon's claw acacia	Pollen	A,H,L,C
Acacia Senegal (n/a – 43)	Gum Arabic	Pollen	A, C
Acacia Seyal		Pollen	L, A
Acacia xanthophloea (38 – 46)	Naivasha thorn	Nectar and Pollen	
Acokanthera Schimperi (n/a – 47)	Poison arrow tree	Nectar and Pollen	H
Adansonia digitata (42 -49)	Baobab	Nectar and Pollen	C
Afzelia Quanzensis (n/a – 51)	Mahogany bean	Pollen	C
Albizia coriana (n/a – 53)		Pollen	L
Albizia gummifera (45 – 54)	Peacock flower	Nectar and Pollen	H
Albizia lebbeck (n/a – 55)	Siris tree	Nectar and Pollen	
Anacardium occidantale (49 -56)	Cashew nut	Nectar	C
Azadirachta indica (55 -58)	Neem tree	Nectar and Pollen	A, C
Azanza garckeana (n/a – 59)		Nectar and Pollen	A
Berchemia discolor (n/a – 64)	Wild almond	Pollen	A, C
Boscia coriacea (n/a – 66)		Nectar and Pollen	A
Casealpina decapetala (n/a – 71)	Mauritius thorn	Nectar and Pollen	L, H, C
Cajanus cajan (n/a -72)	Pigeon pea	Nectar and Pollen	A
Calliandra calothyrsus (n/a – 73)	Calliandra	Nectar and Pollen	L, H
Callistemon citrinus (62 – 74)	Bottle brush	Nectar and Pollen	L, H
Calodendrum capense (63 – 75)	Cape chestnut	Nectar and Pollen	H
Cassia Siamea (n/a – 77)		Nectar and Pollen	A, H, L, C
Cassia Spectabilis (n/a – 78)	Cassia	Nectar and Pollen	L, H, C
Ceiba pentandra (68 – 81)	Kapok tree	Nectar and Pollen	
Combretum molle (n/a - 82)		Nectar and Pollen	A, L, H, C
Combretum schumannii (n/a – 83)		Pollen	C
Conocarpus lancifoglius (n/a – 86)		Nectar and Pollen	C
Cordeauxia edulis (n/a – 87)	Yeheb nut	Nectar and Pollen	A
Cordia africana (72 – 88)		Nectar and Pollen	H
Cordia sinensis (n/a – 89)		Nectar and Pollen	A
Croton macrostachyus (74 –n/a)		Nectar and Pollen	L, H
Croton megalocarpus (75 – 92)		Nectar and Pollen	A, L, H

Scientific name*	Common name	Value	Ecological area kenya (from fig. 27)
Dalbergia sissoo (n/a – 95)	Sissoo	Nectar	H
Delonix regia (84 – 96)	Flamboyant	Nectar and Pollen	L, C
Dicrostachys cinerea (n/a – 97)		Pollen	L, A, C, H
Diospyros mespiliformis (n/a – 98)	African ebony	Pollen	A, H
Dodonea angustifoglia (n/a – 101)	Hopbush	Nectar and Pollen	A,H,L, C
Dombeya goetzenii (86 – 102)		Nectar and Pollen	H
Dombeya rotundifoglia (n/a – 103)	White Dombeya	Nectar and Pollen	A
Dovyalis caffra (224 – 104)	Kei apple	Nectar and Pollen	H
Ekebergia capensis no. 105		Nectar and Pollen	L, H, C
Eriobitrya japonica (92 – 107)	Loquat	Nectar and Pollen	H
Erythrina abyssinica (93 – 108)	Flame tree	Nectar and Pollen	
Eucalyptus camaldulensis (n/a – 109)	River red gum	Nectar and Pollen	A, C
Eucalyptus citriodora (96 – 110)	Spotted gum (lemon-scented gum)	Nectar and Pollen	L, H
Eucalyptus globulus (n/a – 111)	Tasmanian blue gum	Nectar and Pollen	H
Eucalyptus saligna (n/a – 112)	Sydney blue gum	Nectar and Pollen	H
Faurea saligna (n/a – 115)	Beech wood	Nectar and Pollen	H
Fraxinus pennsylvanica (n/a – 120)	Mexican ash	Pollen	H
Gliricidia sepium (n/a – 122)	Mother of cocoa, tree of iron, Mexican lilac, quick stick	Pollen	C, L
Gmelina arborea (n/a – 123)		Nectar and Pollen	C
Grevillea robusta (116 – 124)	Silk oak	Nectar and Pollen	L, H
Grewia bicolor (236 – 125)		Nectar and Pollen	
Jacaranda mimosifotia (120 – 131)	Jacaranda	Nectar and Pollen	H, L
Kigelia africana (122 – 133)	Sausage	Nectar and Pollen	A
Leucaena lucocephila (246 – 136)	Leucaena	Nectar and Pollen	C, L, H
Macademia tetraphylla (123 – 137)	Macadamia nut	Nectar and Pollen	H

Scientific name*	Common name	Value	Ecological area kenya (from fig. 27)
Markhamia lutea (n/a – 143)		Nectar and Pollen	L, H
Melia azedarach (127 – 144)	Persia lilac	Nectar and Pollen	A, C
Melia volkensii (n/a – 145)		Pollen	A, C
Moringa oleifera (130 – 149)	Horse radish tree	Nectar and Pollen	A, C
Olea europaea (128 – 154)	African wild olive	Nectar	H
Pappea capensis (n/a – 158)		Pollen	A, L,H
Parkinsonia aculeate (141 – 159)	Jerusalem thorn	Nectar and Pollen	A, L, C
Piliostigma thonningii (n/a – 163)	Camel's foot tree	Nectar and Pollen	L, A, C
Pithecellobium dulce (n/a – 165)	Madras thorn	Pollen	C
Prosopis chilensis (n/a – 169)	Mesquite	Pollen	A
Prosopis juliflora (253 – 170)	Mesquite, Algarroba	Nectar and Pollen	A
Prunus africana (150 – 171)	Red stink wood	Nectar and Pollen	H
Schinus molle (155 – 176)	Pepper tree	Nectar and Pollen	H, A, L
Sesbania sesban (270 – 178)		Nectar and Pollen	
Spahodea campanulata (n/a – 179)	Nandi flame, African tulip tree	Nectar and Pollen	L, H, C
Syzyginon cuminii (167 – 182)	Java palm	Nectar and Pollen	H, C
Syzyginon guineense (n/a – 183)	Waterberry	Nectar and Pollen	L,H,C
Tamarindus indica (170 184)	Tamarind	Nectar and Pollen	A, L, C
Trema orientalis (180 – 194)		Nectar	
Vangueria infansta		Nectar and Pollen	
Vernonia amygdalino (n/a – 197)	Bitter leaf	Nectar and Pollen	
Vitex kienensis (183 – 199)	Meru Oak	Nectar and Pollen	

* Please note that the numbers in the column "scientific name" refers to the page number of the following books where more details for each specific species can be found.
Number on the left: "Field guide to common trees and shrubs of East Africa" by Najma Dharani.
Number on the right: "A Selection of Useful Trees and Shrubs for Kenya" by ICRAF International Center for Research in Agroforestry.

Table 5 – Botanical species used in agriculture in Sub-Saharan Africa and Western Kenya

Scientific name*	Common name	Value	Ecological area (from Fig. 27)
Agava siselana	Sisal	Nectar and Pollen	
Citrus grape	Grapefruit	Nectar and Pollen	
Citrus lemone	Lemon	Nectar and Pollen	

Scientific name*	Common name	Value	Ecological area (from Fig. 27)
Citrus sinensis	Orange	Nectar and Pollen	
Coffea arabica	Coffee	Nectar and Pollen	
Curcubita sp.	Pumpkin variety	Nectar and Pollen	
Gusypium hirstum	Cotton	Nectar and Pollen	
Helianthus annus	Sunflower	Nectar and Pollen	
Ipome batatas	Sweet potatoes	Nectar and Pollen	
Mangifera indica (125 – 140)	Mango tree	Nectar and Pollen	A, L, C
Morus alba (132 – 150)	Mulberry	Nectar and Pollen	L, C
Musa sp. (Cavendish)	Banana	Nectar and Pollen	
Persea americana 143 - 160	Avocado	Nectar and Pollen	
Psidium guajava (152 – 172)	Guava	Nectar and Pollen	
Rhus natalensis (258 – 173)	Red currant	Nectar and Pollen	
Zea mays	Maize	Pollen	

* Please note that the numbers in the column "scientific name" refers to the page number of the following books where more details for each specific species can be found.
Number on the left: "Field guide to common trees and shrubs of East Africa" by Najma Dharani.
Number on the right: "A Selection of Useful Trees and Shrubs for Kenya" by ICRAF International Center for Research in Agroforestry.

Source: ICRAF (1992)

Fig. 27 – Major agro-ecological zones of Kenya

Chapter III

Bees and Agriculture

10 The importance of bees in agriculture

The quality and the quantity of agricultural products have increased thanks to the utilisation of pollinators (insects favouring pollination). In fact, almost 85% of the pollination that occurs in plants and flowers is entomophilous (provoked by the insects).

The effects of bees' pollination activities will yield produce with the following characteristics:

- larger in size
- higher numbers of seeds
- a longer period of preservation
- higher sugar content.

Honeybee pollination increases the number of seeds, fruit size and yield of the following crops:

- Almond
- Apple
- Apricot
- Asparagus
- Avocado
- Banana
- Brassica species such as cabbage, cauliflower, Chinese cabbage, mustard, oilseed rape, sarson, swede and turnip
- Buckwheat
- Cardamom
- Carrot
- Cherry

- Coconut palm
- Coffee
- Coriander
- Cotton
- Clove
- Cucumber
- Eggplant
- Field bean
- Grapefruit
- Guava
- Lemon
- Macadamia
- Mandarin-orange
- Mango
- Melon
- Mulberry
- Onion
- Papaya
- Peach
- Pear
- Pimento
- Plum
- Pumpkin
- Radish
- Rambutan
- Raspberry
- Red Currant
- Runner bean
- Sunflower
- Straw berry
- Sweet potatoes
- Water melon

The number of hives also plays an important role in determining the yield of crops. It was discovered that by positioning a certain number of hives close to fields growing fruits, vegetables and species that produce seeds (for example, sunflowers), the quantity and quality of the products increased by 200–300%. To achieve this it is important to know how many hives per hectare should be placed near the crops to be well pollinated. Some examples are provided below:

For fruits trees 6–10 hives per ha.
For cucurbits (watermelon, coquettes, pumpkins, sweet potato): 4–6 hives per ha.
For coffee: 6 hives per ha.
For legumes (beans, chick peas): 4–6 hives per ha.
For sunflower: 8–10 hives per ha.
For berries (strawberry, raspberry, blackcurrant etc.): 2–4 hives per ha.

Note: Hives should be placed in the proximity of a field with crops to be pollinated only when at least 20–25% of their flowers are in blossom.

The hives should be positioned in two groups at the opposite corners as shown in Fig. 28 to have better results.

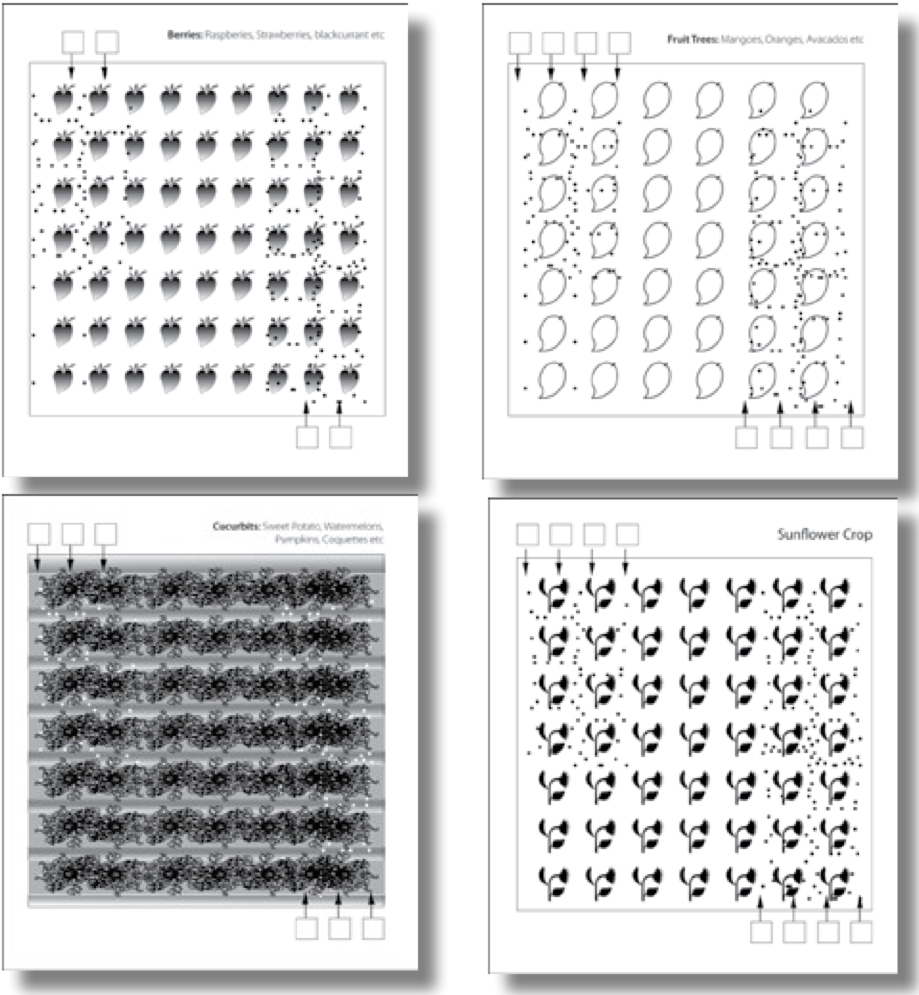


Fig 28 – Number of hives per hectare for different species

For the reasons explained above, in some countries it is common practice for beekeepers to "migrate" hives in the farmers' field for payment. In this way both the beekeeper and the farmer share benefits. The beekeeper will have hives with an abundance of pollen and a good stock of honey, while farmers will have their fruit plants well pollinated. Something important to keep in mind is that during the "migration" the hives should be taken at least 3 km away from the apiary. Failure to do so will see the bees travel back to their place of origin.

The rule that the hives in an apiary should face south/south-east (see Section 13) will be exempted in this case. Considering that the migration practice is done during a specific time of year, this shouldn't pose a big problem.

TIP: The Egyptians 5,000 years ago practised "nomadism" or "migration" of the hives, placing them along the river Nile at certain times of year.

Even the distance between the crops and the hive plays an important role in the final yield obtained. Table 6 shows how sunflower yields increase the more the hives are placed closer to the crop. Please note that in the table the range in the production of seeds is due to the different climatic condition determining the yield.

Table 6 – Yield of sunflower seeds related to the distance of hive from the field

Species	Distance from hive (m)	Yield of seeds (kg/ha)
Sunflower	15 m	1,500–5,500
	400 m	820–2,510

Note: It is strongly advised that during the period of pollination no treatment against pests be applied to crops.

Fig. 29 contains a hypothetical example of how a 2 ha farm with an apiary should be designed in order to obtain the best agronomical and apicultural yields, thanks to the presence of different species and to their rotational blossoming periods.

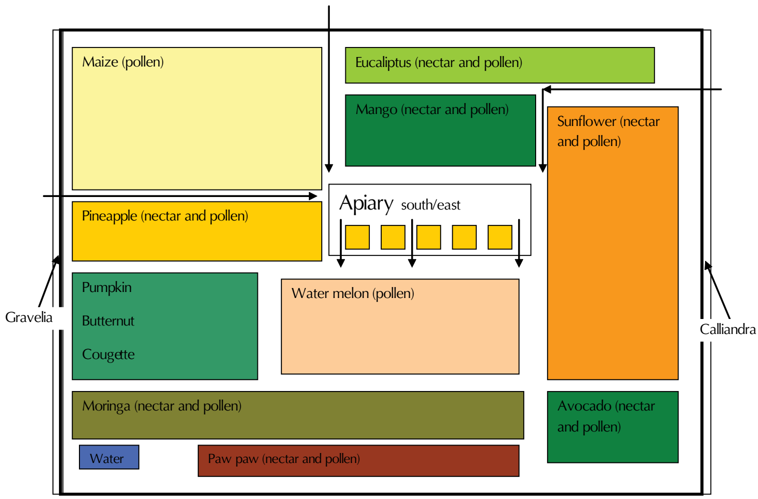


Fig 29 – Selection and distribution of bee botanical species for a 2 ha farm with an apiary

Table 7 shows data collected in Western Kenya (Southern Nyanza) on blossoming times and their duration for several relevant botanical species present in the area (wild flowers excluded). This case study can be a handy reference to beekeepers to better manage their agricultural and beekeeping farm activities. It also helps for preparing the beekeeper's calendar (see Section 24).

Table 7 – Blossoming distribution over the year for some agro-botanical species in Western Kenya

Month	Species of bee botany blossoming in the area during the concerned month	Total number of species blossoming
January	Moringa – Banana – Papaya	3
February	Moringa – Banana – Papaya	3
March	Moringa – Banana – Papaya - Tobacco	4
April	Moringa – Banana – Papaya – Tobacco – Beans	5
May	Moringa – Banana – Papaya – Tobacco – Beans – Chilli – Maize – Mulberry – Passion Fruit – Water Melon – Pumpkin – Sweet Potato – Sunflower	13
June	Moringa – Banana – Papaya – Chilly – Maize – Mulberry – Passion Fruit – Water Melon – Pumpkin – Sweet Potato – Sunflower – Avocado – Coffee – Eucalyptus – Mango – Gravellia – Calliandra	17
July	Moringa – Banana – Papaya – Passion Fruit – Sweet Potato – Avocado – Coffee – Cotton – Eucalyptus – Mango – Gravellia – Calliandra	12
August	Moringa – Banana – Papaya – Cotton	4
September	Moringa – Banana – Sweet Potato – Papaya – Beans	5
October	Moringa – Banana – Sweet Potato – Papaya – Chilli – Sunflower – Maize – Pumpkin – Water Melon	9
November	Moringa – Banana – Papaya – Chilli – Maize – Pineapple – Passion Fruit – Water Melon – Pumpkin – Sweet Potato – Sunflower – Avocado – Coffee – Eucalyptus – Mango – Gravellia – Calliandra	17
December	Moringa – Banana – Papaya – Pineapple – Passion Fruit – Avocado – Coffee – Eucalyptus – Mango – Gravellia - Calliandra	11

Chapter IV

Management of an Apiary

11 Essential rules of modern beekeeping

These are the essential rules that a modern beekeeper should follow:

- The space of the hive should be proportionate to the size of the colony: use a separator screen and fewer frames at the beginning, and add the frames as the colony grows.
- Brood, food for the brood, and stocks of honey for the worker bees are the requirements that will allow a colony to always be strong.
- In case nectar and pollen are not available around the hive due to unfavourable external conditions (for example, rain or few plants are blossoming) the beekeeper should help the colony with sugar syrup/sugar candy (see ***Section 19.1*** for the recipe).
- The collection of pollen and nectar is related to the number of foraging bees present in the colony.
- The number of foraging bees is related to the number of eggs laid by the queen (more eggs equals more foraging bees that have to bring food for the brood and the colony).
- The queen must be young (ideally up to two years of age).
- The colonies that experience swarming will produce little honey for the season concerned.
- A strong family is able to overcome risky and critical moments (related to the external climate, parasites and so on).

The **five essential tasks** that any beekeeper (even a beginner) should follow are:

1) check soon after the rainy season that the queen lays eggs
2) observe if the foraging bees bring pollen to the hive
3) choose the right time to add the super (see ***Section 16*** for more details)

4) remove the super and harvest it only when the cell are capped
5) check the health status of the colony before the rainy season and make sure there is enough stock of food.

12 The Langstroth hive

Beehives come in many different sizes and type. Worldwide, the most common is the 10-frame *Langstroth hive*, whose adoption is recommended in this manual. The reason for this is that it has been proved that the yield in terms of honey production is higher than any other type of hive (see **Table 8**). This is mainly due to the division between the brood chamber and the honey super so that only the honey available in the super is taken. Also, the frames of the super fit perfectly into the extractor and in this way the combs are not destroyed every time. In addition, the Langstroth hive is less disruptive to the bees when doing the periodic inspections.

Table 8 – Annual production (in kgs) of different types of hives

Hive type	Ave prod. in kg (annual)
Langstroth	40
Kenya top bar hive	30
Traditional log hive	20
Others	10

Besides yield and the fact that combs don't have to be destroyed all the time, the Langstroth hive has other advantages: easier to move (for migration, for example), easier to capture a swarm with, and most of all it allows better quality honey since less smoke is required. The disadvantages on the other hand are that it is more costly, it requires more knowledge of the cycles and ecology of the bees, and that the wood should be well seasoned.

This manual will focus on the Langstroth hive. **Fig. 30** gives an idea of what the Kenya top bar hive and the traditional log hive look like.

Source: Lorenzi Pietro

Source: Lorenzi Pietro

Fig. 30 – Traditional log hive (left) and Kenya top bar hive (right)

The essential components of the Langstroth hive (see **Fig. 31**) comprise the following:

1) floor board
2) brood chamber (sometimes also called deep super)
3) queen excluder
4) super (called also shallow super)
5) clearer board
6) frame for the entrance to protect bees against the wind and to provide a comfortable landing space (in case it is not available)
7) inner cover
8) outer cover
9) angle line
10) two screen separators.

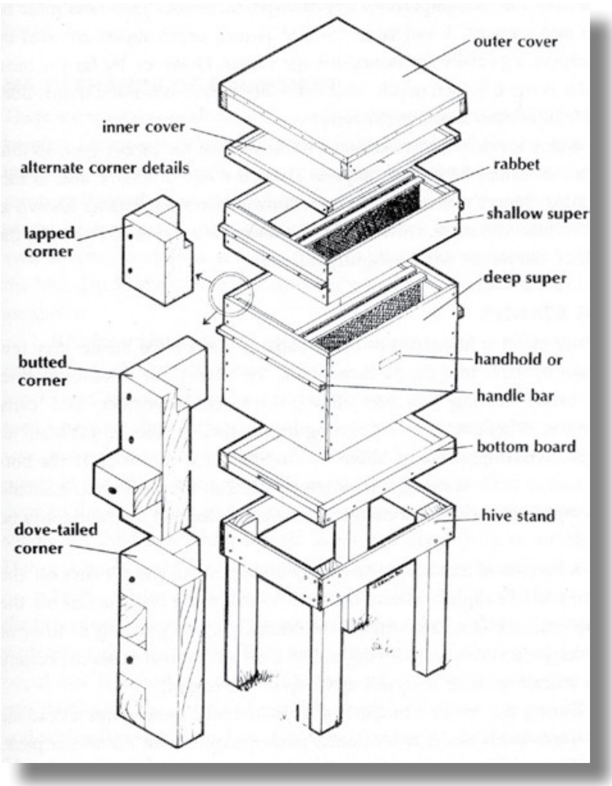
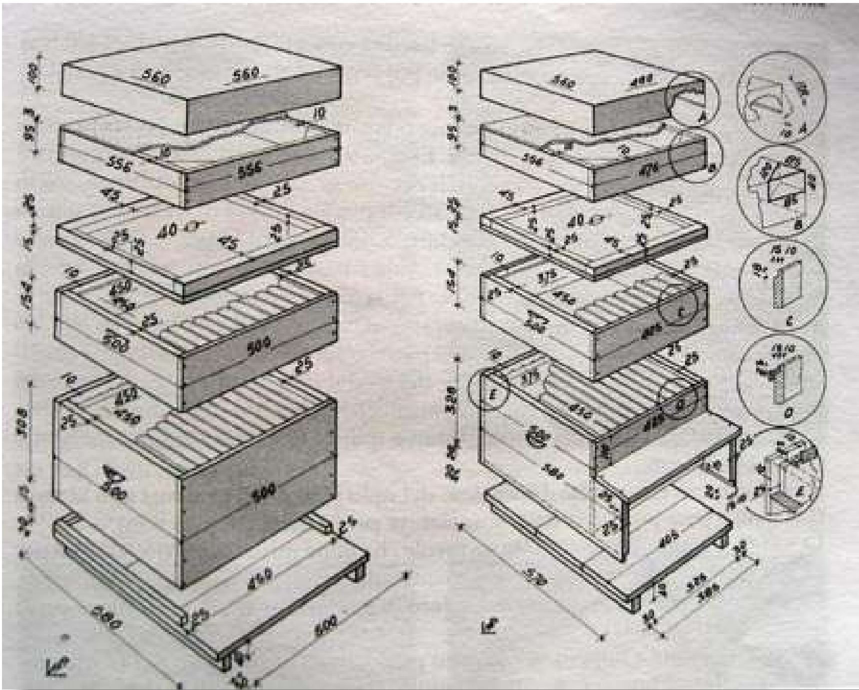


Fig. 31 – Components of the Langstroth hive

The parts of a hive should follow the required dimensions (see **Fig. 32**) and have each component fitting well with one another. Besides this, as mentioned above,

it is of extreme importance to use *well-seasoned wood*. The type of wood used varies from country to country, but use hard wood. Pine or cypress might be used though *gravelia robusta* can also be used in countries where it is readily available and is cheaper. Avoid knots when making a hive since it is likely that they will cause the formation of cracks.



Source: Pistoia A. (1993)

Fig. 32 – Standard measurement of Langstroth hives with 10 and 12 frames

When the quality of beehives available in a certain area is poor (for example, the wood is not seasoned or there is the presence of gaps and cracks), the following tools should be used for their proper maintenance: a wood file, a hack-saw, wood screws, a screwdriver, wood plaster, a spatula for plastering and wood glue.

A flame should be used where appropriate in the angles and joints of the hive box and frames to kill parasites that hide there. This applies particularly after clearing out a hive that was infested by the wax moth, for example. This pest is treated in ***Section 33***.

13 Design of an apiary

The three most important factors to consider when designing an apiary are:

- the botanical species available (wild plants and shrubs, vegetables, fruits and cereals)
- the possibility of introducing new bee botanical species (for example, moringa, caliandra and gravelia)

- knowledge of the blossoming period of the species concerned (covered in ***Part III – Bees and Agriculture***).

Generally, the flowers and cultivations (sources of nectar and pollen) should be as close as possible to the hive. Even though bees operate within a radius of 3 km, the closer the source of food the higher will be the number of trips to collect it. In fact, the ideal sources of food should be within a radius of 1 km.

Other important factors to consider when designing an apiary are:

- facing the hive **south-east** or **south** to anticipate the bees' work in the morning. If this means that the hive will face a thick forest or vegetation, it is advisable to cut the vegetation and create some corridors whereby bees can easily move in and out
- positioning the hives at a minimum height of 50 cm from the ground in order to prevent humidity. Humidity in fact can be as harmful as the heat
- if positioning the hives in a row, keep a sideward distance of about 50 cm from one another. This helps positioning the outer cover on top of the closer hive during inspections
- positioning the hives one in front of the other at a distance of about 3 m
- ensuring that bees can locate a water source 20 to 30 meters from the hive
- checking if the wind (either cold or warm) negatively affects the bees at work. Therefore the apiary should be positioned in areas not affected by harsh winds. Otherwise, protect the apiary through shrubs or plants that can diminish the force of the wind. Having a frame in the hive's entrance also helps to protect the bees against the wind
- having good aeration and positioning in a sunlit area
- access to the hives being easy, comfortable and designed in a way that the entrance will lead towards the back of the hives
- in hot areas with high temperatures or that are subject to heavy rains, covering the hives with a roof made of tree branches, entwined grass, canvass or mats. A corrugated sheet should be avoided since it will heat up the hive underneath.

TIP: If the hive is, for any reason, exposed to the sun during the day, two sheets of newspaper should be placed between the inner cover and outer cover to help insulation.

- not positioning the hives inside a bush or forest area where there is thick vegetation due to the high rate of humidity and wetness. This negatively affects the bees and encourages moulds to develop, spoiling the hive.

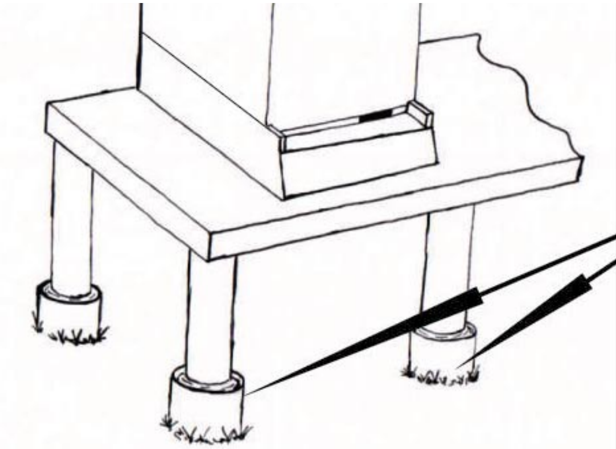


Fig. 33 – Termites and ants prevention

- positioning it down-hill from the source of food. This facilitates the work of the bees that don't have to climb up when overloaded with food
- ensuring that the grass around the hive is cut short to allow easy movement. High grass might hide predators and be an obstacle to the flight of bees
- having a young tree or shrub close by so that in case of swarming it could be the place where bees will go (and it can be easily recognised)
- if hives are close to each other, applying different colours to them (for example, yellow, white, blue or green-blue) or placing a shape (such as a cross, triangle or circle) in front of the entrance to help bees to find the hive quicker.
- To prevent termites and ants see **Box 2** and **Fig. 33**.

Box 2 – Termites and ants: what to do

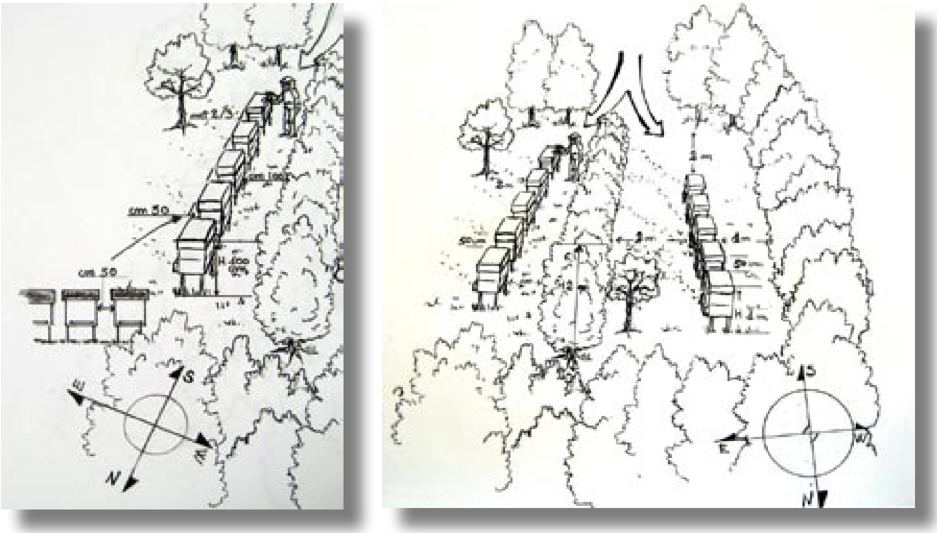
The poles of benches supporting the hives are where termites and ants enter. To avoid this, scorch the poles with fire and place them inside metal or glass cans/containers. The containers should be filled with water so that ant and termites will drown. Some also use engine oil (see **Fig. 33**)

Don't position the hives directly under tree branches or shrubs.

If ants enter the hive the only way to remove them is through the use of aids and then by passing a flame over all the cracks and joints to kill any eggs and larvae.

Some spread grease along the poles to prevent the ascent of all types of insects, but this has mixed results.

Fig. 34 shows the hypothetical design of an apiary with an area of 25 m².



Source: Lorenzi Pietro *Source: Lorenzi Pietro*

Fig. 34 – Hypothetical design of an apiary with one row (left) and two rows (right) of hives

14 Inspecting the hive: equipment and general rules

When visiting the hives it is very important to wear/carry the following equipment:

1) **Smoker**: the smoke drives the bees into the hive to defend the colony.
2) **Hive tool**: to remove the parts of the hive previously sealed by bees with propolis.
3) **Brush**: to move the bees during the inspection of the brood chamber or to remove the bees left in the super before removing the frames for harvesting.
4) **Bee suit** (or at least the veil) to protect the body against the bees' stings. The face and the neck are however the part most at risk for the beekeeper.
5) **Gloves**: well-protected hands allow the beekeeper to work with ease and security. Latex gloves are recommended.
6) **Gum boots**: to prevent bees from entering through the bottom of the trousers.
7) **Tape**: to seal any openings in the clothing where bees can enter. This applies especially to the wrists and the ankles (see **Fig. 35**).

Source: Rogez L. (2000)

Source: Rogez L. (2000)

Source: African Beekeepers Ltd-Nairobi

Fig. 35 – Some beekeeping equipment (bee suit with gloves, smoker, brush, hive tool)

Note: The hive should be approached from the rear and the work done at this end. This is in order to avoid obstructing the passage of the forager bees.

The following procedures should be followed to ensure the correct inspection of hives (see **Fig. 36**):

1) Light the smoker. Do this by using a rolled corrugated carton paper. After rolling it, light the paper with a match. Make sure that the carton is positioned in the smoker vertically. Leave the smoker open and pump it until the smoke comes out. Close the smoker and make few more pumps till the smoker is well lit.
2) Put on a bee suit, gloves and gumboots and seal wrists and ankles with tape.
3) Approach the hive from the rear or from the side.
4) Blow three to four puffs of smoke towards the hive's entrance.
5) Inspect from the back of the hive.
6) Lift the outer cover.
7) Position the outer cover **upside down** with its underside **facing skyward** in the nearby hive or on the ground.
8) With the hive tool slowly unseal the inner cover.
9) Avoid shaking and any noise that could disturb the bees.
10) While removing the inner cover, blow some smoke inside the brood chamber.
11) At this point most of the bees should be gathered inside the hive with only a few guardian bees flying around. Inspection can now be performed.
12) Continue to use the smoker if necessary.

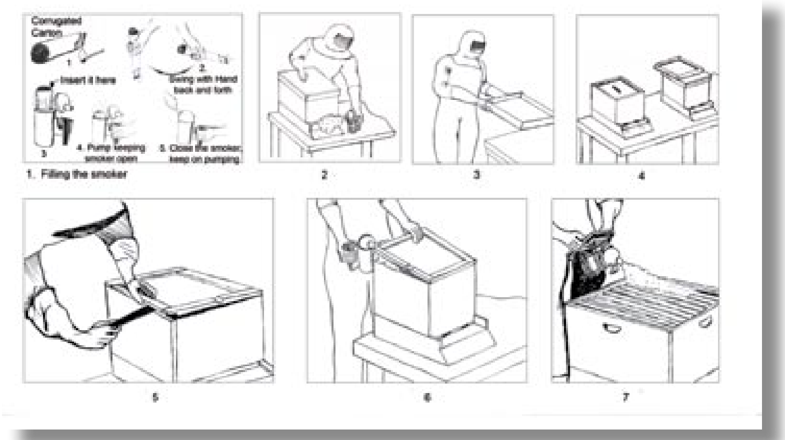


Fig. 36 – How to carry out an inspection and approach an apiary

Two types of inspections can be undertaken:

1) a **general** one to see the general health status of the colony
2) a **specific** one for the brood only.

1) The **general inspection** consists of checking all the combs one by one. To do so:

- remove the first frame from your right
- inspect it
- place it outside the hive (usually on the side)
- remove and inspect the second frame and place it on in its right where the first frame previously was
- do the same for the other frames, placing them sequentially rightwards
- take the first frame and place it on the last holder on the left side of the hive
- close the hive with the inner and outer cover.

2) The **specific inspection** of the brood consists of checking exclusively the combs positioned in the middle of the hive (usually fourth, fifth, sixth and seventh). In order to do this, it is good practice to start by selecting, for example, the third comb from the right and to move it slightly towards the right. This will create more space for removing the fourth comb comfortably, avoiding the killing of the queen or other bees by the friction of the two combs that otherwise might have happened. Inspect the fourth comb and place it outside the hive. Remove

and inspect sequentially the fifth, sixth and seventh combs, and place all the combs back in their original positions.

The most important things to look for when performing an inspection are:

- **the reserves:** if the frames located on the side of the hive are full of honey, the reserves are enough to overcome long periods of rain or drought
- **the condition of the brood:** the brood combs, located in the middle of the hive, should be 75% occupied by the brood and 25% by reserves of pollen and honey
- **age of the brood combs:** when constructed, the brood combs look very clear, but as time passes their colour changes to straw yellow, then to light brown and finally to a dark brown which is almost black. Besides the colour, it is possible to confirm the age of a brood comb through a simple trick. If the comb is lifted to the sun and it is not possible to see through it, then it is a very old comb. Old brood combs should be disposed and used for wax collection purposes, thus allowing the colony to build a new one. Reasons for this are: 1) the older and more used the comb the smaller the cells. As a consequence, future bees will be smaller and weaker. This will lead to a weak colony in the long run; 2) old combs attract the wax moth due to their high content of mineral salts.

Some important rules to keep in mind during an inspection:

- It should be carried out during morning hours (8 am–12 noon). In particular weather conditions (in mountain areas), the inspection can be done in the first hours of the afternoon (2 pm–4 pm). During this time most of the forager bees are out in the field collecting food and therefore there are less bees in the hive. In addition, the other bees are busy taking care of the hive and in this case they tend, unless directly threatened, to just focus on their work.
- The inspections should always be done under optimal climatic conditions. Avoid any inspection when it is raining or cloudy, when rain is expected or when there are strong winds.
- If, for any reason, the colony looks in a pretty nervous state, it is mandatory to postpone the inspection.
- Inspections should be done quickly to avoid any prolonged change of temperature that might affect the colony and the brood. Inspections carried out during the evening usually have a bigger impact on the temperature of the brood combs.
- If the colony is repeatedly aggressive it is advisable to replace the queen (preferably after the rain season when food is readily available).
- When searching for the queen, gently use the brush to remove the bees and ensure that they are not damaged.

15 Inspecting the hive from outside

It is possible to see the health status of the colony by observing the movement of the bees from outside without obstructing their work.

The most important things to look for are:

- If movement in the hive's entrance is limited to a few bees, the causes can be many but the most common are:
  1) the colony is weak due to pests (that is, wax moth)
  2) the colony is queen-less.
- If dead bees are spotted in the front entrance the colony is sick.
- If there are pieces of comb wax in front of the hive this means there are predators.
- If there is excrement around the hive's entrance and front wall this means that the bees have diarrhoea.
- When knocking on the hive, if the buzz is soft and brief, most likely the colony is queen-less (the queen has died) or is in a critical condition. If the buzz is noisy and lengthy the colony is strong.
- Monitor the weight of the hive by lifting it up carefully, either by hand or by using a small spring scale. This should be done at regular basis to gauge the increase of honey production over time.

16 The right time to place the super and how to manage it

The right time to add the honey super (which is shallower than the brood chamber by half) is when it is ascertained through a visual inspection that in the brood chamber:

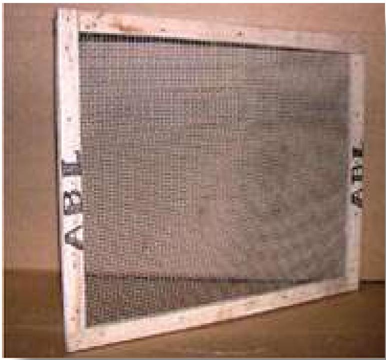
- the honey combs utilised for storing the reserve honey are full
- there is new wax on the top part of the hive frames.

Some experienced beekeepers can judge if the honeycombs are full by weighing the hive over time. This avoids opening the hive and disrupting the colony, as might happen with the visual inspection.

The purpose of adding the super is to give bees the opportunity to store the honey inside. When the super fills it is time to harvest the honey.

Note: It is not a good practice to put the super together with the brood chamber without waiting for the appropriate time. As a result, the bees may waste energy thermo regulating the hive instead of producing honey.

Before adding the super it is important to place the **queen excluder** (see **Fig. 37**) on top of the brood chamber in order to prevent the queen from moving up and laying eggs in the super. The queen excluder will be therefore positioned in between the brood chamber and the super.



Source: African Beekeepers Ltd-Nairobi

Fig. 37 – Queen excluder

More than one super can be applied on top of the brood chamber. In this case the empty super should be positioned above the brood chamber and the full supers on top of the empty one. This is done in order to harvest all the supers at once.

17 Harvesting the honey

For harvesting it is important to have the proper equipment. The main components needed for harvesting the honey comprise the following (see **Fig. 38**):

1) **Honey extractor**. This is a device that spins honey from the comb cells using a centrifugal force. Different types are available: hand-crank models and ones with an electric motor; small models with few frame holders and large ones. Some are made of plastic or stainless steel. Stainless steel extractors far outlast good plastic ones.
2) **Honey strainers**. Two strainers are needed: one of 2 mm net and one of 0.5 mm.
3) **Uncapping knife**. This helps to remove the wax of the capped honey before the harvest. A good sharp knife will do the trick. However, there are also electric knives that heat up the blade and make the slicing easier.
4) **Uncapping tank**. This device is used to collect the wax cappings as they are sliced off the comb.
5) **Uncapping fork**. This is used to uncap those surfaces of the comb too low for the knife.

6) **Normal bucket.** This is used to gather the first honey harvested from the extractor.

7) **Bottling bucket.** This is made with food-grade plastic and includes a honey gate (placed about 2 cm from the bottom to avoid eventual impurities deposited there). Its function is to lay the honey for 20 to 30 days before bottling.

Source: African Beekeepers Ltd-Nairobi

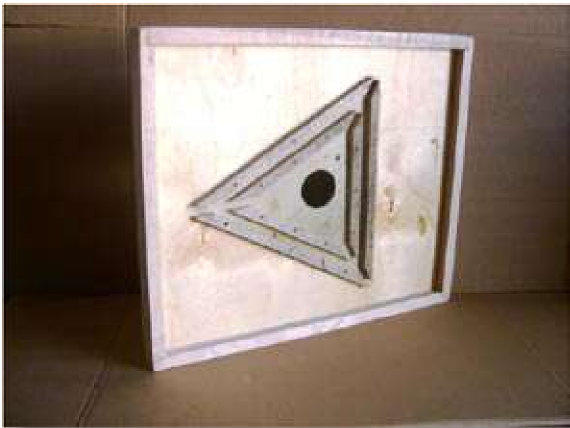
Fig. 38 – Some harvesting equipment

The honey is ready to be harvested when at least 80% of the comb of the super is capped (see **Fig. 39**). Only capped cells should be harvested since these are the ones whose nectar has reached the optimum level of humidity (18%) to become pure honey.

Source: Lorenzi Pietro

Fig. 39 – Fully capped combs ready for harvest

Twenty-four hours before gathering the super combs for harvest, it is advisable to position the **clearer board** (see **Fig. 40**). The clearer board has to be situated in between the brood chamber and the super in place of the queen excluder. This device allows the bees to travel down to the brood nest, but prevents any movement back into the honey supers. In this way the super will have only a few bees and the combs can be easily removed. Make sure, while removing the queen excluder, that the queen is not damaged.



Source: African Beekeepers Ltd-Nairobi

Fig. 40 – Clearer board

TIP: Combs should be collected from the super 24 hours before harvest and stored inside a well-sealed plastic or gunny bag in a cool and dark place. This helps to reduce the chances that combs will break down in the centrifuge due to the fact that they are still warm.

Placing the super's combs inside a bag will avoid attracting bees and therefore the risk of having them colonised again. In this way, bees will not enter the house where supers are stored, which is quite a widespread fear among families and beekeepers in Sub-Saharan Africa.

A costly alternative to plastic or gunny bags is a plastic box in which to place the super combs (see **Fig. 41**).

Source: Lega Faenza – Costruzioni Apistiche

Fig. 41 – Plastic box with cover to place super combs

Super's combs should be removed for harvesting either early in the morning (8 am) or late in the afternoon (6 pm).

At this point the super combs are ready to be harvested. The correct procedures for harvesting honey are:

1) Use a knife to remove the wax cappings that cover the honey cells. Keep the comb in a vertical position and slice the wax upwards, starting from the bottom and moving up.
2) Use a fork to uncap manually those cells that were not uncapped by the knife.
3) Place the uncapped super combs inside the honey extractor.
4) For a full extraction of the honey, spin the extractor 50 turns clockwise and 40 turns anticlockwise.
5) Place the bucket underneath the extractor valve and collect the harvested honey. It is advisable to place a metal or plastic strainer of 2 mm net on top of the bucket to gather all the impurities present in the extracted honey (wax, legs, wings and so on).
6) Pour the honey into the bottling bucket using a strainer of 0.5 mm net. This will prevent any type of impurity entering the bucket.
7) At this point the honey should be left in the bottling bucket for 20 to 30 days before bottling in glass or plastic containers. The bucket should be covered with a cotton cloth during this time.
8) Honey should be kept in a dark and cool place for a longer conservation period (3 years).

Honey extraction should be carried out in a closed place to avoid the smell of the honey attracting bees.

For the full process of honey harvesting please see **Fig. 42** below.

Fig. 42 – The process of harvesting honey

Explanatory notes for Fig. 42

A: Capped super combs are ready to be harvested and are placed in well-sealed plastic/gunny bags or a covered plastic container.

B: After 24 hours the combs are placed into the uncapping tank. The capping wax that covers the honey is removed (from down upwards) with knifes and forks.

C: The uncapped super combs are placed inside the honey centrifuge. Spin the centrifuge for honey extraction. Use a strainer of 2 mm net on top of the bucket to avoid impurities.

D: The honey is poured into the bottling bucket (with capacities ranging from 50 to 200 kg) and filtered through a strainer of 0.5 mm net and covered with a cotton cloth. After 20–30 days the honey is ready to be bottled.

After harvesting it is advisable to wait 24 hours before placing the combs back into the super. This is to avoid any looting of the hive by other colonies that would be attracted by the smell of fresh honey still in the combs. A couple of days after placing the combs back into the super the bees will have cleared all the honey from the cells.

At this point, if a second harvest won't be possible due to environmental conditions, the super combs should be removed and stored in a cool place inside well-sealed plastic or gunny bags to be utilised again the next time. In this case remove the super box on top of the brood chamber, remove the clearer board and cover it again with an inner and outer cover.

In case climatic conditions are favourable and the botanical species around the apiary are blossoming, you might consider leaving the combs in the super for the second harvest. In this case remove the clearer board and replace it with the queen excluder.

TIP: In order to help the bees to fill the super with more honey, place the filled combs on the side and the empty frames in the middle of the super.

18 Super with brood: what to do

If a wise beekeeper does his or her job properly, the queen shouldn't enter to lay eggs in the super. However, if for any reason this does happen, three options are available:

1) **Move the colony back into the brood chamber.** The combs of the super should be placed at the centre of the brood chamber. After checking that the queen has entered it, remove the super and the queen excluder. Close the brood chamber with the inner and outer cover. After 13 days, check whether the brood completed its metamorphosis and replace the super combs with new brood chamber frames.
2) **Strengthen another colony**. If within the apiary there are weak families, the super's combs with brood can be used to strengthen them. In this case, place the super's comb with brood in the middle of the weak hive. If together with the brood, there is need to move some worker bees, then it is compulsory to spread the combs and the weak hive with flour to confuse the scent and avoid eventual fights between the two colonies and the death of many bees (for pictures about use of flour see ***Section 19.2***). During these movements it is very important that the queen is not removed from the weak hive. Doing this may mean that the hive will not be fully operational for about 60 days (it takes 16 days for the metamorphosis of the queen, six days for mating and the laying of eggs, 21 days for the metamorphosis of the worker bees and 21 days for the worker bees to start foraging).
3) **Start a new colony**. When, for example, dividing one strong hive, some super combs with brood might be placed in the split strong hive or in the new family

(see ***Section 19.1.1*** for more details about this practice).

19 Strengthening and increasing colonies within the apiary

The operations that will be covered in this section, besides providing ways to strengthen the apiary and ensuring strong colonies, also aim to prevent or slow down natural swarming. These include:

- dividing a strong colony into two
- obtaining an extra family from three existing strong colonies
- strengthening a weak family
- combining two weak families
- providing a queen to queen-less families.

The best time to carry out these operations is in the morning (8 am to 12 noon), except for the combination of two weak families, which should be done at dusk when all the bees are back.

We shall consider each of these factors in the following sections.

19.1 Increasing the apiary using strong colonies

It is important to note that the division of families explained in the next two sections should be *done when plants are blossoming* (after the rainy season) so that there is plenty of food available to the colony.

19.1.1 Divide a strong colony into two

This option looks at increasing the size of the apiary through the use of the beekeeper's own hives and through dividing in two a strong family in order to create a new nucleus.

This practice might be relevant in Sub-Saharan Africa where the hives remain within the individual farms and where it is difficult to exchange colonies between beekeepers more than 3 km apart.

TIP: When moving a hive, it is important to know that it should be moved more than 3 km. Failure to do so will cause the bees to go back to their original location.

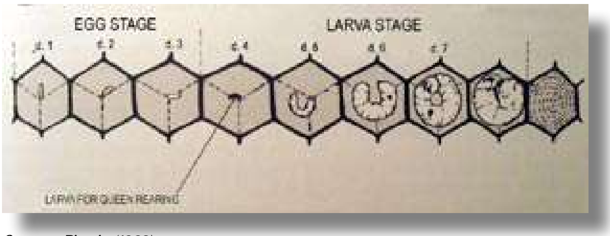
In order to get two hives out of one, the following equipment is required:

- a strong colony in a hive with 10 combs (we shall call it "the initial colony")
- one new (empty) hive
- two screen separators.

The procedure is as follows:

- Insert five combs into the new hive from the "initial colony". Make sure that they keep the same position and order.
- Two important things that have to be considered are:
  (a) not to remove the queen from the initial colony;
  (b) to insert in the new hive at least one comb with brood having larvae less than three days old.

TIP: Larva more than three days old appears as a ring formation. In other words, tail and head have merged together. You should therefore check that larvae have the "C" shape to be sure that they are less than 3 days old (meaning 6 days from the egg-stage). See **Fig. 43**.



Source: Pistoia (1993)

Fig. 43 – Steps from egg to larva. Larva with "C" shape up to 6th day (3rd day of larva)

- In both hives (the initial and the new one) use the screen separator to divide the empty space from the occupied part. Remember to close the entrance on the side that is unoccupied. This is done in order to guarantee the ideal thermoregulation of the space occupied by the bees and prevents them from wasting a lot of energy for this activity.
- Close the hives.
- Move the initial colony from its original position, placing it sideward at least 5 to 6 metres away. Transfer the new hive in place of the original colony. This is referred to as the "**exchanging method**". The forager bees that come back from the field with food will enter the new hive, colonising it, thinking it is still their previous house (this can occur without any fight between the two colonies because bees bringing food into a colony are not considered a threat by the guardian bees). On the other hand, the initial family, having lost many forager bees that went into the other hive, will need assistance. Provide them sugar

Box 3–Sugar candy recipe

Boil a litre of water. Turn off the heat and add 2 kg of sugarcane. Stir until it completely dissolves. Let it cool for one day.

Place the sugar candy obtained into a well-sealed plastic bag. Apply a small cross-shaped cut to the middle of the plastic bag and place it in the inner cover, where through the opening the bees will swarm to the candy.

candy. See **Box 3** for a sugar candy recipe and points on its use.

- Add more combs as both families increase in size.

For the whole process see **Fig. 44** below.

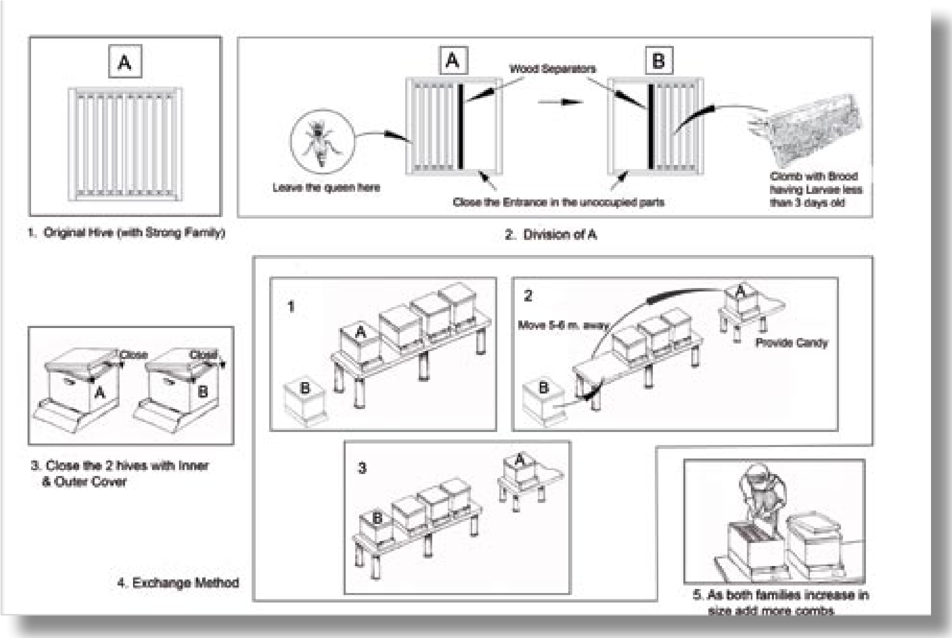
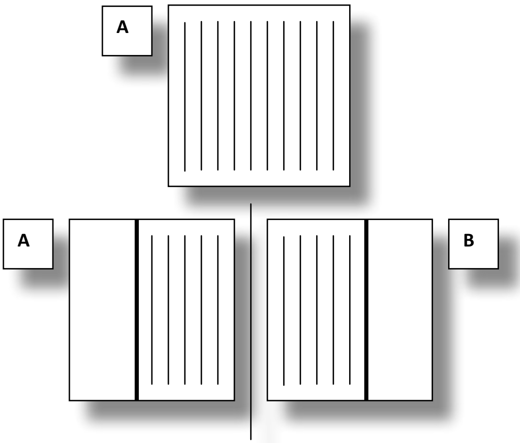


Fig. 44 – Division of one strong colony into two through the exchanging method

Alternatively, the two hives can be placed next to each other as shown in **Fig. 45** below. In this way, both colonies can have the opportunity to receive forager bees coming back from the field.



Source: Lorenzi Pietro

Fig. 45 – Division of one strong colony into two by placing hives next to each other

19.1.2 One new family from three strong colonies

It is possible to create a new colony from three strong colonies within the apiary.

Note: When unifying the different families there is no competition among bees and they merge peacefully. There is no need in this case to use flour to confuse the scent of the three families.

The following steps show what to do.

- Remove two combs from each strong colony and place them in the new hive. The combs must have a young brood (with larvae of less than three days, with a "C" shape as shown in **Fig. 43**) and reserves of pollen and honey.
- Place a screen separator in the new hive in order to separate the occupied and unoccupied space within the hive.
- In the hives from which the combs were removed, bring the remaining combs nearer and in the two empty spaces place two new frames (or combs if available).
- Make sure that the queens are not removed from their original hives.
- Close the hives.
- Apply the "exchanging method" (see previous ***Section 19.1.1***), positioning the new (queen-less) family in the space previously occupied by the strongest family of the three hives. This colony, on the other hand, will be moved sideward at a distance of 5 to 6 metres from its original place.
- Provide this hive with candy since many forager bees are missing, having gone to the new hive. See ***Section 19.1.1*** above for the sugar candy recipe.

19.2 Strengthening a weak family

To strengthen a weak family (one, for example, with an old queen, diseases, old brood combs or few forager bees) the following procedures are recommended:

- remove from a strong family a comb with brood (with capped cells) together with bees
- spread some white flour on the comb (see **Fig. 46**)
- position it in the middle section of the weak hive
- spread white flour on the weak hive as well
- move the combs towards the centre of the original strong family and in the empty space insert a new comb.

The use of flour will help prevent dangerous competition from bees belonging to other families, since their different scents will be blocked out by the flour.

Make sure that the queen is not removed from the original hive as usual.

Source: Lorenzi Pietro

Fig. 46 – The process of flour application when inserting a comb and bees into a different hive

19.3 Combine two weak families to make a strong one

Two weak families can be combined to create a strong, robust colony. The two colonies must be combined slowly and systematically so that the families' scents merge gradually.

For this reason the common method used is the **newspaper method**, which consists of the following.

1) Remove the inner and outer cover from the first hive.
2) Place a sheet of newspaper on top of the first hive.
3) Make several small holes in the newspaper with a pin.
4) Place the second hive on top of the first one.
5) Close the second hive with the inner and outer cover.

6) After six to eight days check that the colonies are joined together in the bottom hive. (The time taken by the two colonies to chew away the newspaper will help to form a single scent that will be recognised by the bees as the smell of a single family).
7) Remove the top hive, freeing it from the last bees left over.
8) Close the bottom hive with the inner and outer cover (see **Fig. 47**).

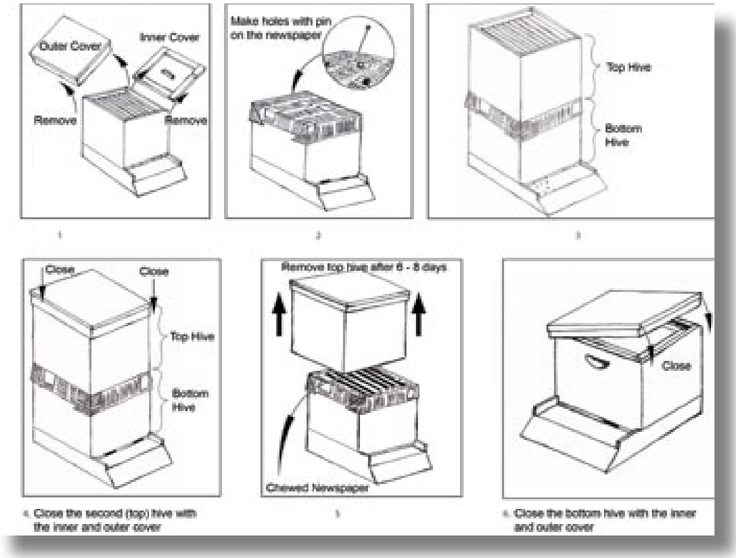


Fig. 47 – Combining two weak hives with the newspaper method

TIP: Once the two families are successfully combined, if on the top hive there are combs with brood and combs with honey, place them in the new hive in the following way: brood combs in the middle and combs with reserves of stock of honey at the sides.

To give to the new family a single queen, three possible options are available:

1) Leave the two queens to fight each other so that the strongest will prevail.
2) Place the queen excluder between the two hives on top of the newspaper in order to reutilise the queen of the top hive.
3) If the ages of the queens are known, kill the oldest.

The operations to combine two hives should be done at dusk.

Having a strong hive means that the family has a better chance of overcoming diseases and remaining healthy, and subsequently there are more potential returns in terms of honey. This is the reason why it is better to have one strong colony rather than two weak colonies.

If the hives have a floorboard fixed to the brood chamber:

- position two empty supers on top of the bottom hive
- move the comb frames of the second hive into the two empty supers (note that the size of two supers will equal the size of one brood chamber).

19. 4 The queen-less families: what to do

A colony can remain without a queen for different reasons, such as the sudden death of a queen, the death of the queen during mating or due to infertility. The fact that the queen is not in the hive is recognisable by the lack of young brood.

In this case, follow the steps below in order to provide the colony with a new queen.

- Take from a strong hive a comb with young broods of larvae at a maximum of three days (having still the "C" shape).
- Position the comb in the queen-less hive.
- In proximity to the young larvae cells, the bees will build various queen cells and from there the queen will be raised.
- Check after two to three days that the queen cells have been constructed.

Alternatively, it is also possible to use the newspaper method (***Section 19.3***) and combine the queen-less hive with another one.

20 Swarming

20.1 Definition and causes

Swarming occurs when 25 to 40% (10,000–12,000 bees) of the colony packs up with the queen and moves away. Swarming is a natural biological event for the bees, but when it happens to a professional beekeeper it means there will be less honey to harvest. In addition, after swarming the colony tends to weaken. On the other hand, the positive side effect of swarming is that, when the swarm is captured, there is a chance to build a new, strong family.

Swarming occurs mainly due to the following reasons:

- congestion/surplus of bees
- scarce aeration in the hive
- few cells available for laying eggs
- old and ruined brood combs
- excess gathering of pollen and nectar.

A colony about to swarm can be identified in several ways. First by noting during the inspections if there are queen cells built on some combs. Second, by checking if there are many bees outside the entrance showing a certain nervousness. Often this behaviour prevents an imminent swarming.

Normally, the first swarming goes to a shrub or tree near the apiary (this is the reason why a small tree or shrub should always be considered during the design of an apiary). The bees will remain clustered together to defend the queen while scout bees look for a new suitable spot. At this point, it is important to capture the swarm, before the second swarming will take the bees further away.

20.2 How to capture a swarm

Bees are quite harmless during swarming, since their stomachs are packed with honey and they cannot sting.

Once the swarm has been identified and you are sure that it is located in a secure and easily accessible place, the best method to capture it is as follows:

1) Prepare a hive with only five combs positioned on one side. The comb frames can be empty with wax foundation in it or with the nests already built.
2) Place the hive beneath the swarm.
3) Hit the branch where the bees are. Dislodge the swarm so that it falls into the hive.
4) Wait a few minutes for the bees that fell outside the hive to have enough time to enter it. If they do, there is the guarantee that the queen was captured and is within.
5) With a screen separator, limit the hive to the space necessary to accommodate five combs and close the entrance on the side not occupied.
6) Cover the hive with the inner and outer cover.
7) During the following weeks inspect the hive regularly and add new combs up to completion of the hive as the family develops (see **Fig. 48** for the whole process).

Note: It is important to capture the first swarm close to the apiary since it can relocated back to the apiary without any problem.

On the other hand, if a “second” swarming (with nest built), or a wild nest is captured, it must be taken at least 3 km away to avoid the bees going back to their original place.

The captured swarm may be used for two purposes:

1) as a new nucleus to start colonising a new hive. In this case, increase the number of frames in the hive as the colony will grow
2) use the newspaper method ***(see Section 19.3)*** to strengthen a weak colony with

the captured swarm.

It is very important therefore that the beekeeper controls the swarming, capturing it within the apiary in order to increase or strengthen it.

The swarm captured within the apiary can be relocated back to the apiary on the same day or on the next day before the dawn. Never do this operation by night or in the evening.

If the swarm is a wild nest or a "second swarming", the transportation (at least 3 km away) should occur strictly in the evening or soon before dawn. This is because in this way you are assured of transferring the whole colony since all the forager bees will be back in the hive by that time. Remember that the hive should be well closed and sealed before transportation.

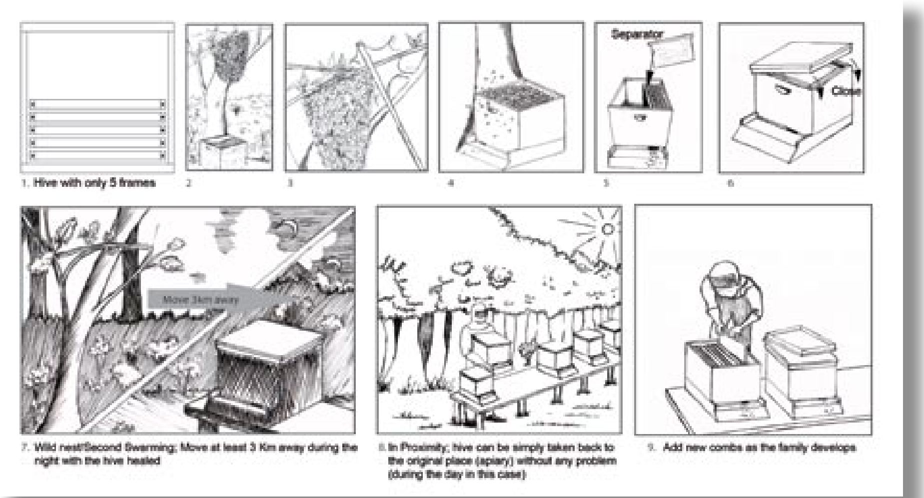


Fig. 48 – The process of capturing a swarm within the apiary

20.3 How to prevent a swarming

Should swarming be imminent, regular inspection of the hives at risk is very important. During these visits it may be noted that queen cells have been constructed in some combs. To avoid swarming, the beekeeper should remove them.

After this, it is necessary to provide more space to the queen where she can lay eggs. For this reason, the beekeeper needs to insert new combs in the brooder chamber, or eventually add the super.

In this situation some combs with brood might become available. If this is the case, it can be a good opportunity to take advantage of this when there is need to strengthen weak colonies within the apiary (for more details about this see ***Section 19.2***).

Note: It is advisable to let the natural swarming occur and subsequently to capture the swarm and start a new family. In this situation the new and old families need to be provided with sugar candy until they grow strong.

21 Absconding

When absconding happens, the entire colony flies away, not leaving a single bee behind. The main reason for this is the presence of pests, mites and diseases. Hives that are overrun with insects (ants, wax moth) or infested with mites may be abandoned.

22 The queen: rearing and its scope

It will be necessary to rear a new queen to:

- replace an old queen
- fill a queen-less hive
- start a new family
- replace a queen that generated a nervous family
- replace a queen that lies only few eggs.

The proper equipment needed to rear queens is a special hive consisting of three frames. One comb is for the brood, one is for the stock of honey and one is kept empty. In the event that a hive with three combs is not available, a normal hive can be used, limiting it to three combs with a screen separator.

The procedure to rear a queen is as follows:

1) Remove from a hive the queen cell intended for rearing. Make sure that the queen cell taken is already capped.
2) Place it in the appropriate three-comb hive. Make sure that worker bees and drones are introduced into the hive as well.
3) Fix the queen cell in the combs with brood using a pin or a toothpick.
4) Check that the queen has started to lay eggs 15 days after the queen cell was placed.
5) Once verified that the queen is laying eggs, place the queen inside a small queen cage together with seven to eight worker bees. Provide them also with some sugar candy **(Fig. 49)**.
6) At this point the queen cage can be sold to other beekeepers or kept for other use.

Source: Lorenzi Pietro

Fig. 49 – Queen cage: positioning it into the hive and different types (plastic and wooden)

The queen cage has to be placed in a new queen-less hive, in between the two combs located in the middle of the hive, and left there for six to eight days. This is the appropriate time span to allow the queen to get the scent of the hive and to be recognised by the other bees. At the end of the period make sure that the queen has come out of the cage (this happens when the worker bees have eaten the candy and opened up the hole in the cage). If this does not happen, then the queen should be taken out of the cage.

Something important to consider in rearing a queen is that the family of the origin should be manageable and that the mother of the queen had a good fertility record (a strong queen means a strong family and this also leads to strong daughters).

23 How to colonise a new hive

Different methods can be used in order to colonise a new hive. They are briefly explained below.

- Capture a swarm and place it into the new hive as explained in ***Section 20.2***. The swarm captured in the proximity of the apiary can be placed back into it without any inconveniences (the operation should be done during the day). In case of a wild nest or a "second" swarming with the nest already built, the new hive with the captured colony should be moved at least 3 km away from the place where the swarm was captured.
- Use the method explained in ***Section 19.1.1*** where a strong family is divided in two.

The new hive will be used to divide the strong family.

- If an established company or beekeeper sells colonised hives (free of pests!) in the area, an alternative would be to buy a nucleus of five to six combs. The hive, as usual, should be sealed and transported at least 3 km away from its original place. The purchased nucleus of five to six combs should be placed afterwards in the new 10-frame hive. In this case use the separators to reduce space and add combs as the family expands.

In the international markets there are available hives with five to six frames made of polystyrene, plastic or wood (see **Fig. 50**). These hives will be appropriate to capture a swarm and transport it 3 km away from the original place, or to sell a nucleus of five to six combs. The advantage of this small hive is that it is easier for transportation. Alternatively, the five to six combs can be accommodated in a common 10-frame hive and closed up with separators. Whichever the case, the five to six combs will need to be moved into a 10-frame hive sooner or later.

An appropriate space is reserved within the small hive to place the candy in case the colony needs it (see **Fig. 50**) (when it rains and forager bees don't go out, when there are few flowers blossoming around the apiary and so on).

Source: Lorenzi Pietro

Source: Lega Faenza – Costruzioni Apistiche

Fig. 50 – Small hive of six frames made of polystyrene with space on the side for candy

24 Beekeeper's calendar

Table 9, based on research undertaken in Western Kenya (South Nyanza), comprises a year-long beekeepers' guide.

Table 9 – Beekeeper's calendar

Month	N. botanic species blossoming in the period (except wild flowers) (*from Table 7*)	Beekeeper tasks
January	3	Check supers and harvesting
February	3	Check supers and harvesting
March	4	Inspect the family inside the hives: health status, brood and food reserve
April	5	Inspect the family inside the hives: health status, brood and food reserve, propolis collection
May	13	Check the brood, inspect from outside the hive (forager bees), propolis collection
June	17	Check eventual queen cells for swarming, wax production, add the supers, pollen collection
July	12	Check supers
August	4	Check supers, harvesting and food stocks in the brood chamber
September	5	Check supers, harvesting and food stocks in the brood chamber
October	9	Check that the queen is laying eggs and for the presence of drones, propolis collection
November	17	Inspect from outside the hive (forager bees), pollen collection, propolis collection.
December	11	Add the supers

The beekeepers' calendar provides a list of activities to be undertaken during the year. It is based on the number of plant species blossoming. This knowledge provides a guide to the highest production of nectar and pollen during the year and the subsequent

beekeeping activities linked to it. **Table 9** is an example on how to prepare a beekeeper calendar. However, this is a reference point only and should be adapted to the different meteorological conditions present in a particular area.

An example of this can be seen from **Tables 10** and **11** below, which show the average rainfall and average minimum and maximum temperatures recorded in Homabay for the period 2004–2008.

Table 10 – Average monthly rainfall (mm) and temperature (C°) in Homabay – Western Kenya for the years 2004–2008

Month	Rainfall (mm) (average period 2004–2008 in Homabay)	Temperature C° (average min. and max. period 2004–2008 in Homabay)
January	36	24.1–324
February	57	22.8–33.8
March	170	23.3–32.7
April	191	23.7–30.5
May	166	22.8–31.1
June	69	22.7–28
July	78	22.9–30.8
August	84	23.9–31.1
September	81	22.8–32.7
October	79	24–33.2
November	112	24.8–31.5
December	89	23.3–31.2

Source: Kari (Kenya Agriculture Research Institute) Homabay Branch

Table 11 – Year rainfall (mm) in Homabay – Western Kenya for the years 2004–2008

Year	Average rainfall (mm)
2004	103
2005	88
2006	108
2007	84
2008	121

Source: Kari (Kenya Agriculture Research Institute) Homabay Branch

According to **Tables 10 and 11** rainfall in Homabay varies between and within years. This can influence and change the work pattern of bees, since rain prevents forager bees from searching for pollen and nectar. These are some of the factors that a beekeeper should consider when deciding which tasks to implement in each period of the year.

Chapter V

Bee Products

25 Honey

Honey has been an important product since the time of the ancient Egyptians who used to call it "the god's nectar". It has since been used mainly for sweetening purposes. Since 1750, thanks to sugarcane and beetroot sugar, honey lost its importance and was relegated to use in bakeries. Nowadays honey has regained its status as a natural and healthy product.

Its flavour and scent may vary depending on the predominant plant species visited by the bees.

Honey's sweet sustenance contains various elements that make it important in terms of nourishment (see **Box 4**).

Box 4–Comparative nutritional value of honey

30 g of honey = approx. 81 calories (one teaspoon)
30 g of meat = approx. 56 calories
30 g of potatoes = approx. 30 calories

Some of the components present in honey are: water (18%), saccharine 75–80%, as well as acids, enzymes, mineral aromatic matters and vitamins. Pollen grains and vegetable fibres may also be present. Some of the most important are considered briefly below.

- **Water**: Water content in honey must not exceed 18%. If it does, it may ferment and becomes inedible.
- **Sugar**: Saccharine has the strongest presence in ripened honey. Glucose and fructose are the most important. They provide honey with a high energy content and they are easily assimilated by humans.
- **Acids**: These include organic acids (such as acetic, butyric, formic and citric) and inorganic acids (such as hydrochloric and phosphoric acids). These give honey its characteristic aroma.

- **Enzymes**: Bees add vegetable and animal enzymes to honey during the transformation process.
- **Aromatic substances**: These allow us to recognise the origin of the different botanical species visited by bees.
- **Vitamins**: A, B1, B2, B6 and C are present in honey, though in a limited percentage.

Note: Honey is affected by temperatures above 41 C° (for example, when using honey to sweeten hot drinks) where it loses most of its nutritive value due to the loss of enzymes and vitamins. In this case it preserves only its saccharine contents and serves to function as a sweetener.

Source: Lorenzi Pietro

Source: Lorenzi Pietro

Fig. 51 – Honey with bees in the comb (left) and packed honey products (right)

Depending on the herbal origin of nectar, honey can be divided into monoflora and poliflora honey. Mono-flora honey is made predominantly from the nectar of one plant species. Honey derived from at least 80% of a single plant species is considered to be mono-floral honey or high-quality honey. For some tips on how to grow monoflora honey see ***Section 6***. The colour of honey is also determined by the types of plants visited by bees. Colour can vary from dark amber to lighter shades.

The crystallisation of honey is a natural physical and chemical process that depends on the type of nectar gathered by the bees. It doesn't change the characteristics of honey, thus allowing it to keep all of its therapeutic and nutritious qualities. Crystallisation of honey is a sign that it is pure since it has not been subject to the process of "pasteurisation". This practice consists of bringing the temperature of honey up to 73–78 C° for six to seven minutes and then to subject the honey to a sudden cooling. This destroys all the micro-organisms and the crystallised nuclei present in the honey. This ensures that the honey remains in its liquid form throughout. If, for any reason, there is the wish to de-crystallise the honey to transform it to its original state follow these steps: immerse the jar/bottle (with the cap open) in a bain-marie with lukewarm water and make sure that the water temperature does not exceed 41 C° for the reasons explained above.

For procedures and equipment needed for harvesting honey please refer to ***Section 17***.

Honey can be packaged and stored in glass (preferably) or plastic bottles that are hermetically sealed. Fresh, new comb is sometimes sold and used intact as honeycomb (see **Fig. 51**). Most important of all, honey should be stored in a cool, dry and dark place.

For trading purposes, the expiry date required is usually two years. However, if stored properly honey can last forever.

26 Pollen

Pollen is collected by the beekeeper through special traps positioned in the entrance of the hive.

Traps of different kinds are available, but it is important that all of them don't harm bees. Generally, the device forces the bee to enter through a hole whose dimensions allow comfortable access to the head and the thorax. However, the bee may have difficulty in entering with its legs, since they are full of pollen and the entrance hole is smaller than the pollen ball. The balls of pollen are repeatedly rubbed while the bee tries to enter into the hole. Eventually they are dropped into a container positioned below the trap from where the beekeeper collects the pollen (see **Fig. 52**).

Source: Lega Faenza – Costruzioni Apistiche

Source: Lorenzi Pietro

Fig. 52 – Pollen trap and collection

A good beekeeper knows that pollen is essential to the colony, so he or she should take only 10–12% of the total pollen collected by the bees. For this reason pollen traps are positioned only for a period of a maximum of 10 to 15 days at regular intervals during the year.

The best period to use the traps is when there are plenty of blossoming flowers and bees are able to collect plenty of pollen.

Since bees mix the pollen with water and honey to shape it into a small ball that is placed in the pollen baskets, the pollen has a high rate of humidity. For this reason pollen should be dried with special drying machines in order to avoid moulds that will damage the product. If the pollen drying machine is not available, it is best to dry the pollen using hot air currents (see **Fig. 53**). Once dried, the pollen can be placed in glass containers or cotton sacks.

Source: Lorenzi Pietro

Fig. 53 – Dried pollen

Pollen is used as a tonic and booster since it improves metabolism. Its many properties means that it is used in circumstances such as: lack of appetite, nervous breakdowns, in cases of anorexia, and as an important element against high cholesterol levels. Its use should be proportionate to the weight and age of the person, but it should not exceed three weeks in duration (one teaspoon in the morning and one in the evening). Its taste may seem unpleasant (grass like), but it can be combined with sweet substances (like sugar or honey) or mixed with yoghurt or warm milk. Pollen should be kept in a cool, dark place because being "alive", too much humidity or light may spoil it. It can be preserved better if kept in the fridge.

One of the possible buyers of pollen is the pharmaceutical industry.

27 Wax

Wax can be a good source of extra income for the beekeeper.

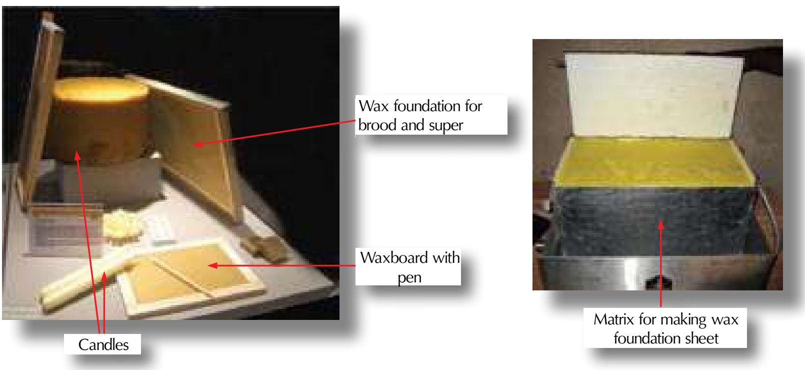
There are two types of wax:

1) that in brood combs
2) that used to cap the cells of ripened honey and which is collected in the uncapping tank during the process of harvesting the honey.

The second type is the most sought-after thanks to its purity, and it is utilised by the pharmaceutical and cosmetic industries. This wax fetches a better price than other types of wax.

The wax from the brood combs, on the other hand, is usually extracted from combs that are old (recognisable by their dark-brown colour) and that, as we have seen, should be replaced from the hive since they attract pests and weaken the hive. Also, super combs that with time break after many harvests can be used for wax. This type of wax is used mainly for candles and as a lubricant for mechanical spare parts, for polishing and for making the wax starter (or foundation) sheets that are placed in the new comb frames (see **Fig. 54**).

The way to extract wax is through a **wax extractor**. This is a device made of a wooden or plastic box and is covered with a glass sheet on top. The extractor is placed in the sun and the internal temperature rises to 62–64°C. At this temperature the combs will start to melt. The extractor should be slightly inclined so that the melted wax will slide downwards and can be easily collected in a container. It is advisable to place the comb into a net positioned inside the wax extractor and held with a hook.



Source: Lorenzi Pietro

Fig. 54 – What to do with wax

28 Propolis

Propolis is a natural product since 90% comes from the resin that the bees collect from the buds and bark of trees. These resins are used by the trees to protect young buds against the cold and rain, and in certain occasions to heal any cuts or scars inflicted on the plant.

Since propolis is used to seal and close objects inside the hive, it can be harvested by scraping it from the top of the brooder chamber or the super. The drawback of this method is that wood and other impurities may also be collected.

On the market, propolis has to be clear and pure. Recently, many techniques have been used to collect it for sales purposes. The most used method is that of placing a net in the hive. The procedure is explained below.

Source: Lorenzi Pietro

Fig 55 – Collecting propolis with a net

On top of the brooder chamber's combs put three to four wooden sticks and on top of them position a plastic net as shown in **Fig 55**. Bees tend to close all the holes and gaps that they find and therefore will start filling the gaps of the net with propolis. When the bees have completed their work, the net will be taken. Being propolis, a resin mixed by the bees, it is subject to external temperatures that, if hot, render the propolis quite soft. In this case the beekeeper needs to store the net full of propolis in a cool place (preferably a fridge). After a few hours it will fall to pieces when shaken. To preserve it, the propolis, should be placed in glass containers and kept in a dark and cool environment.

Propolis is used as an anti-inflammatory and antibiotic agent by pharmaceutical companies. It can be used in households as an anti-inflammatory antidote for the nose and throat (see **Box 5**).

Box 5 – Propolis syrup recipe

Put 30 grams of raw (clean) propolis in a 200 cl of 75% pure alcohol. Leave the mix in a dark place for about 30 days.

A practical use
For throat inflammation pour five drops of the syrup into a teaspoon of sugar. For children use a drop or two less.

Chapter VI

Potential dangers to bees and the colony

29 Faulty hives

Many insects can enter through the cracks and holes in a faulty hive. The most common are:

- the death's-head hawkmoth (*Acherontia Atropos*)
- hornets (*Vespa Crabro*)
- wasps
- saurians, reptiles such as lizards
- amphibians (frogs and toads).
- rats.

These insects, if killed, are afterwards literally embalmed with propolis by the bees to avoid spread of infections.

Another potential threat to a colony living inside a faulty hive is the bees of other colonies. During periods of food scarcity the families living in faulty hives may be attacked by other families and be subject to "looting". These bees are attracted by the smell of honey pouring out from the ruptures present in the hive. During such periods of food scarcity weak families are more likely to be subject to looting than stronger families.

30 Varroa mite

Varroa is a mite of a brown or reddish colour (see **Fig. 56**). It is the size of a pinhead and attaches itself to a bee and feeds on its lymph. The varroa starts its reproduction cycle when brood is available. The eggs are laid inside the cells of worker bees and drones (though the mite preferentially infests drone cells) two to three days before the cells that host the future bee are capped. The number of eggs laid inside a cell ranges from five to 30, of which one is male and the others are females.

Source: Lorenzi Pietro

Fig. 56 – A varroa mite as it appears under the microscope

The metamorphosis takes about 10 days, at the end of which the mites are already able to reproduce. Varroa is fed with the lymph of the larvae and of the bees. This leads in time to the birth of deformed and weak bees, sometimes even causing their death.

Over the last 40 years – with the trade of queens, combs and colonies – the varroa, originally from Java, has spread to many countries throughout the world. With time, it weakens the affected colony and leads to the death of bees and absconding of the colony. Often underestimated, it is a widespread and dangerous pest.

The varroa mite can be identified through a careful inspection. An alternative method is to remove a piece of capped cell with brood from the brood comb. Considering that varroa mites tend to attack the drones, it would be preferable to take drone cells. By opening the capped cells, the red body of the mite can be easily identified from the white colour of the pupae (see **Fig. 57**).

Source: Lorenzi Pietro

Source: Lorenzi Pietro

Fig. 57 – Checking for varroa mites from capped drone cells

Numerous solutions have been adopted to solve or contain the varroa mite. The most common are tablets imbued with essential oils such as Api Life Var, Apistan and Apiguard.

In case they are not available, oxalic acid could be used. Some traditional treatments using medicinal herds and spices have also been reported. **The most effective control against the varroa mite, however, is maintaining colony strength.**

Note: Do not treat bees with any medication when the honey super is placed on top of the brooder chamber. In this case, the honey may become contaminated and it will not be suitable for human consumption.

Oxalic acid. Each beekeeper has his or her secret formula, but as a general rule for a Langstroth hive the following might apply: 80 grams of oxalic acid, 500 grams of sugar and a litre of water (distilled water preferred). Mix the oxalic acid in the warmed water and then add the sugar. The dosage is of 5 mL per comb. This dosage should be spread with a syringe in between the combs, trying to reach as many bees as possible. Importantly, the treatment should be applied only to those combs where bees are present (brood combs). See **Fig. 58**. The combs on the side with stock of food and few bees should be avoided. Particular attention should be given to the eyes, mouth and nose during the handling of the oxalic acid.

Source: Lorenzi Pietro

Source: Lorenzi Pietro

Fig. 58 – Application of oxalic acid against the varroa mite

Treatments should be implemented during the hottest time of the day and strictly after honey extraction. Treatment should also be done without the presence of brood. Due to favourable climatic conditions, in Sub-Saharan Africa the queen basically lays eggs throughout the year, so there is a need to prevent the queen from not doing so. This will render the treatment more effective since it kills the existing varroa and stops its reproduction system, which occurs inside the brood cells.

For this reason it is important to trap the queen and place her into a small cage for about 26–27 days. (see **Fig. 49** for pictures about the queen cage). The cage will be placed in the middle of the combs. The bees will still feed the queen from the cage during this time. During the treatment attention should be paid not to pour the solution on to the queen. This system of the "capture of the queen" might be avoided in those areas where due to certain climatic conditions (mountainous, cold areas, for example) the queen naturally stops her activity for a certain period of time and no brood is therefore present.

Considering the toxicity of the oxalic acid, the treatment should be done at most twice a year and only when varroa is detected. The first treatment can start soon after the queen is trapped and placed in a cage. The second treatment should be applied after four to five months.

Apiguard. This contains thymol and is used as a remedy against the varroa. Thymol is an active ingredient of thyme oil that acts in the nervous system of the varroa. A small box containing Apiguard should be placed in the hives and left for 10 to 15 days. The treatment should be repeated.

Apistan. This mainly contains tau-fluvalinate. Place two plastic strips, one between the third and fourth comb, and the other between the seventh and eighth comb. They should be left inside the hive for six to eight weeks.

Api life var. This comprises the essential oils of thymol, camphor, eucalyptus and menthol. The treatment consists of four bars. Each bar is divided in turn into four parts. Position the parts in the respective corners of the hive and remove them after one week. Repeat the treatment for four weeks.

Please note that thymol is toxic at temperatures slightly above 30°C and for tau-fluvalinate there are serious risks that remain in the honey and/or wax.

31 Tracheal mite (Acarapis woodi)

This pest can't be seen with the naked eye. Dissecting an adult bee and examining its trachea under a microscope is the only way to identify a tracheal mite infestation.

As its name implies, this mite lives most of its life within the bee's trachea. Once the mite finds a newly emerged bee, she attaches to the young host (whether bee, drone or the queen) and enters its tracheal tubes through one of the bee's spiracles. Within the trachea the mite lays eggs and raises a new generation. The most affected bees are the young, since they haven't developed the hairs to defend against this mite.

The effects of this mite include: closure of the trachea, circulation problems and internal injuries, and death by suffocation. The disease is observable through different means: bees crawl in front of the hive or try to climb a blade of grass but can't make it. The disease spreads through contagion during swarming or through buying the colonised hives of other beekeepers that have the disease.

Recently, it has been discovered that the treatments against the varroa mite are also effective against the tracheal mite. These treatments, aimed at reducing the development of the mite, should be applied if few colonies have been affected by the disease.
If the disease is widespread, on the other hand, sulphur cubes should be applied in order to kill the colony through fumigation from the sulphur vapours. For this purpose the hive should be well sealed. The dead bees should be burnt afterwards and the hive reutilised after disinfection.

It is important to apply these treatments always at night when the colony is in the hive.

32 Wax moth (Galleria melonella); small wax moth (Ahcroia grisella)

This is a night moth that once in the hive lays its eggs.

The larvae of the moth eat the wax and do large-scale damage in a weak hive, especially if numerous. The main damage caused by the wax moth consists of the following:

- reduced space available to bees within the comb affecting their work
- the threat that the pupae form prevents the bees from doing their work properly
- a consistent presence of wax moth in a hive leading to the absconding and swarming of the colony
- extensive damage to the hive and the frames (see **Fig. 59**).

Source: www.vc66.co.uk/mothweb/aug04/4/DSCN6984.jpg

Source: Lorenzi Pietro

Source: www.tc.umn.edu/~reute001/images/Wax-moth-damage6.jpg

Source: African Beekeepers Ltd-Nairobi

Fig. 59 – Wax moth and damage done to the hives

The important thing to do, especially in the weak hives, is to inspect them frequently and eventually to kill the moth. The combs most at risk are those unused by the beekeeper and those not properly stored, or the old brood combs that attract the moth due to their high content of mineral salts.

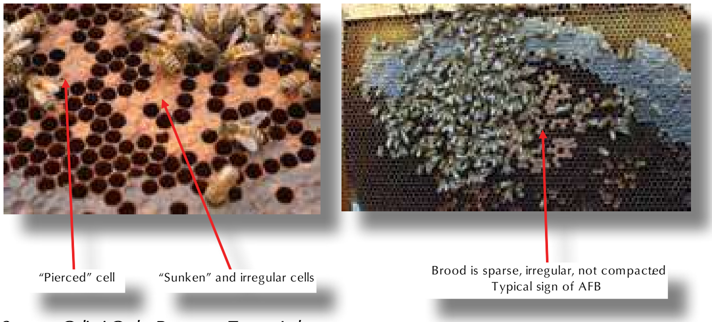
Possible treatments vary from pest fumigations with sulphur-content tablets to cleaning the infested frames and hives with soda and water, through the use of a brush and then passing a flame over all the cracks and joints in the hive in order to kill any larvae that hide there.

Fumigation of new or spare combs through the use of sulphur is the only guarantee of comb re-use without incurring the risk of getting the wax moth again.

33 American Foulbrood

The American foulbrood (AFB) is caused by spore-forming bacteria (*Paenibacillus larvae*). It affects brood only. Specifically, the spores are carried in brood food that infect larvae when the worker bees feed them. The spores germinate and multiply in the larval gut and the larvae die.

It is recognisable by the presence of "sunken" cells, by the fact that the brood is not uniform and notably by the rotten, putrefied odour coming from the hive (see **Fig. 60**). When the cells are uncapped it is possible to notice the presence of a semi liquid, coffee-brown colour substance.



Source: Caliari Carlo-Rovereto, Trento-Italy

Fig. 60 – Effects of the American Foulbrood

The bacteria provoking the disease can survive up to 30 years. It is therefore advisable to be very cautious in buying hives or nucleolus of uncertain origin.

The only remedy against AFB is to destroy and burn the whole hive. In order to destroy it, the colony should be killed through fumigation with sulphur vapours. This operation should be carried out in the evening or very early in the morning when the colony is present in the hive, and the hive should be well sealed during the fumigation. Dig a hole 50–60 cm deep, place the hive in it and burn it. To be 100% sure, bury the remnants of the burnt hive.

34 Small hive beetle – Aethina tumida (MURRAY)

The adult beetle is dark-brown to black and about a half centimetre in length(see **Fig. 61**). It can be a destructive pest for the colonies, causing damage to combs, stored honey and pollen. If a beetle infestation is sufficiently heavy, they may cause bees to abandon their hive. The primary damage to colonies and stored honey caused by the small hive beetle is through the feeding activity of the larvae. Larvae tunnel through combs with stored honey or pollen, damaging or destroying cappings and combs together with the honey that becomes contaminated by beetle faeces.

Source: Aspromiele Piemonte (2004)

Fig. 61 – The small hive beetle

Like other pests, the beetle is most often found in weak or failing hives and rarely affects strong hives.

One of the remedies to stop the development of the *Aethina* is to disinfect the ground area surrounding the affected hives with pyrethroids-based drugs in order to kill the beetle at their larva state.

35 Nosema (Nosema apis)

This is a protozoan that multiples in the stomach of the bees. The most important symptoms are: swollen abdomen and dysentery that leave yellow strips just in the outer side of the hive.

The disease is contracted by bees when they drink infected water or eat honey that contains the spores of the protozoan. Weak colonies should be eliminated through fumigation via a sulphur tablet burnt inside the hive. To be effective, this application should be done in a well-sealed hive. The dead bees should be removed and the hive cleaned with soda. Also, pass a small flame inside and outside the hive, especially in the joints.

Strong colonies, on the other hand, can be treated with FUMIDIL or CIBAZOL, which are mixed with sugar candy and given to the bees as food.

36 Amoebiasis

This disease is caused by a protozoan called *mellificae melphigamoeba*. It is a gastrointestinal infection that causes bees to defecate outside the hive or even inside the combs.

The symptoms are similar to Nosema: colony collapse, crawling bees outside the hive unable to fly, diarrhoea and watery faeces of a yellowish coloration.

Bees affected by the Amoebiasis (and even Nosema) don't take care of the queen.

There is no known medical treatment against Amoebiasis.

Chapter VII

Gross Margin Analysis

37 Gross margin analysis for honey

This calculation considers an apiary of two hives during its first two years and the purchase of an extra two hives during the third year. In both cases, the first year of the purchase assumes one harvest per hive. Subsequent years assume two harvests per year per hive.

Table 12 - Estimated Gross Margin analysis for the first five years of beekeeping activities focusing on honey in Western Kenya targeting the local market

	1ST YEAR	2ND YEAR	3RD YEAR	4TH YEAR	5TH YEAR
(N. of hives in the apiary)	(2)	(2)	(4)	(4)	(4)
Harvest of 2 hives (first 2 years) and 4 hives (3rd year onward) with an average of 10 kg per hive	20 kg	40 kg	60 kg	80 kg	80 kg
Price of sale (Ksh) per kg	350	350	350	350	350
Total income (Ksh)	**7,000**	**14,000**	**21,000**	**28,000**	**28,000**
Cost for purchase of 2 hives and clearer board (Ksh)	10,000	–	10,000		
Purchase of equipment (bee suit, gloves, tool, brush) (Ksh)	6,500				
Cost for using the centrifuge (50 Ksh/kg harvested)	1,000	2,000	3,000	4,000	4,000
Total cost of 500 g bottles (25 Ksh per bottle)	1,000	2,000	3,000	4,000	4,000
Total costs (Ksh)	**18,500**	**4,000**	**16,000**	**8,000**	**8,000**
Profit/Loss (total income – total costs) – Ksh	**–11,500**	**10,000**	**5,000**	**20,000**	**20,000**

Figures used in the calculations were collected from secondary sources.
(Prices are in Kenyan shillings (Ksh). The exchange rate in November 2009 is approximately 1 USD = 75 Ksh)

Considerations

For a beginner beekeeper it is advisable to start with two hives and to add to them progressively once experience, skills and good results are achieved with the hives. This might mean a relative low return in the first years, but this should be taken into account before investing or asking for a loan.

However, we consider this the best approach to follow: to start small and grow gradually over time.

Often there is the temptation to have many hives at once. Field experience has shown that the risk is having many uncolonised or weak hives (with the consequences of diseases and pests). In the long run this may lead to heavy losses.

Bibliography

Anderson C., Ratnieks F.L.W., 1999. *Worker allocation in insect societies: coordinationof nectar foragers and nectar receivers in honey bee (Apis mellifera) colonies.* Behav Ecol Cociobiol, 46:73–81 Springer-Verlag.

Anderson L.D., Treuman J.W.H., 2000. *Varroa jacobsoni (Avari: Varroidae) is more than one species.* Exsperimental & AppliedAcaralogy, 24:165–189.

Asencot, M., 1984. *Juvenile hormone induction of "queenliness" on female honey bee* (*Apis mellifera* L.) *larvae reared on worker jelly and on stored royal jelly*. Comp. Biochem. Physiol. 78b: 109-117.

Aspromiele Piemonte, 2004, *Dossier Aethina Tumida*, LAPIS, Torino, Italy

Aumeier P., Rosenkranz P., Francke W., 2002. *Cuticular volatiles, attractivity of worker larvae and invasion of brood cells by Varroa mites. A comparison of Africanized and European honey bees*. Chemoecology Abstract volume 12 Issue 2, pp. 65–75.

Bonney R. E., 1993. *Beekeeping: a practical guide*, Sandra Webb.

Bozzi R., 1987. *Il confino della regina ostacola l'evolversi della varroa*. Apitalia, anno XIV. Roma.

Caillas, A., 1970. *Il Polline*. Edizioni Apimondia, Roma-Bucarest.

Caillas, A., 1992. *Manuale pratico del produttore di pappa reale*. Edizioni Fe3derazione Apicoltori Italiani, Roma.

Cirone R., 1984. *La pappa reale*. Studio Edizioni Milano.

Caron, D. M., 1978. *Marsupial and mammals. In Honey bee pests, predators, and diseases*, ed. R. A. Morse, pp.227–256. Ithaca, Cornell Univ. Press.

Contessi A., 2004. *Le api biologia, allevamento, prodotti*. Edagricole, Bologna.

Chandler, M. T. 1976. *The African honey bee Apis mellifera adansonii: the biological basis of its management. In Apiculture in tropical climates*, ed. E.Crane, pp.61–68. London, International Bee Research Association.

Chauvin, R., 1956. *Les facteurs qui gouverment la ponte la reine des abeilles*. Insectes Sociaux 3. 499–504.

De Belfever, B. e Gautrelet, M., 1993. *La pappa reale*, Edizioni Tecniche Nuove.

Dharani N., 2002. *Field guide to common trees and shrubs of East Africa*. Struick publisher.

Drum, N. H., and W. C. Rothenbuhler. 1984. *Effect of temperature on nonstinging aggressive responses of worker honeybees to diseases and healthy bees.* J. Apic. Res. 23:82–87.

Fert, G., 1988. *L'elevage des reines*. OPIDIA Centre Apicole Echauffour, F61370 Sainte Gauburge, France.

Fletcher, D. J. C., 1978. *The African bee, Apis mellifera adansonii*, in Africa. *Ann. Rev. Entomol.* 23:151–171.

Fletcher, D. J. C., and G. D. Tribe., 1977. *Natural emergency queen rearing by the African bee A. m. Adansonii and its relevance for successful queen production by beekeepers, I and II. In African bees*: *Taxonomy, biology, and economic use*, ed. D.J. C. Fletcher, pp. 132–140, 161–168. Pretoria, Apimondia International Symposium.

Frediani, D., 1991. *Le malattie delle api*, Edizioni Federazione Apicoltori Italiani, Roma.

Habermann, E., 1971. Chemistry, pharmacology, and toxicology of bee, wasps, and hornet venoms. In *Venomous animals and their venoms*, Vol 3 of Venomous invertebrates, ed. B. Cherl, W. Buchley and E. Buchley. New York Acadenic Press.

Heinrich, B., 1981c. *The mechanisms and energetics of honeybee swarm temperature regulation*. J. Exp. Biol. 91:25–55.

Kuwabara, M., 1947. *Ueber die Regulation im weisellosen Volke der Honig-biene, besonders die Bestimmung des neuen Weisels*. J. Fac. Sci. Hokkaido univ, (ser. 6) 9:359–381.

ICRAF (International Center for Research in Agroforestry), 1992, *A Selection of Useful Trees and Shrubs for Kenya: Notes on their identification, propagation and management for use by Agricultural and pastoral communities.* ICRAF.

Lee, P. C., and M. L. Winston, 1985a. *The influence of swarm population on brood production and emergent worker weight in newly founded honey bee colonies* (*Apis mellifera* L.). Insectes Sociaux 32:96–103.

Meyer, W., 1956. *"Propolis bees" and their activities*. Bee World 37:25.36.

Minieri L., Perrucci G., Nizza A., 1980. *Composizione, proprietà ed utilizzazione del veleno d'api.* L'apicoltore moderno 71, 123–125, 163–169, 203–208, Torino.

Nardi, U. 1992., *Apiterapia – curarsi con il miele, polline,propoli, pappa reale e veleno d'api.* Aporie Edizioni, Viale Tito Livio130, 00136 Roma.

Nunez, J. A., 1982. *Honeybee foraging strategies at a food source in relation to its distance from the hive and the hive and the rate of sugar flow*. J. Apic. Res. 21:139–150.

Pistoia A., 1993, Apicoltura Tecnica e Pratica. Edizioni l'Informatore Agrario, Verona.

Ravazzi G., 2004. *Las abejas*. Editorial De Vecchi, Barcelona.

Rogez L., 2000 *La Ruche. Carnets de nature*, Toulose, France

Simpson, J., 1961. *Nest climate regulation in honeybee colonies*. Science 133:1327–33.

Wille, H., 1991. *Strategia di sopravvivenza delle colonie d'api*. Edizioni Federazione Apicoltori Italiani, Roma.

Winston, M., 1982 *Foraging differences between cross-fostered honeybee workers* (*Apis mellifera* L.) *of European and Africanized races*. Behav. Ecol. Soc.10: 125–129.

Winston, M. L., O.R. Taylor, and G. W. Otis, 1983. *Some differences between temperate European and Tropical African and South American honeybee*. Bee World 64: 12–21.

Winston, M. L., 1987. *The Biology of the Honey Bee*. Harvard University Press Cambridge, Massachusetts, London. England.

NOTES

The End

This manual focuses on modern beekeeping in Sub-Saharan Africa. It attempts to upgrade and refine the knowledge of trainers/field workers within government departments or organizations/NGOs on the correct use of modern beekeeping techniques. The final aim is that competent services will be provided to farmers/beekeepers and appropriate transfer of know-how will be accomplished to the same. It is hoped that this will contribute to the creation of a new generation of beekeepers in the Region.

The main targets of the manual are trainers, government institutions, private and public organisations including NGOs, entrepreneurs and established beekeepers operating in the Sub-Saharan African region.

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