Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

**Faculty of Natural Resources and Agricultural Sciences**

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Independent project in Biology • 15 hec
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Uppsala 2019

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|---|---|
| **Credits:** | 15 hec |
| **Level:** | G2E |
| **Course title:** | Independent project in Biology |
| **Course code:** | EX0894 |
| **Programme/education:** | Agriculture Program – Plant and Soil Sciences |
| **Course coordinating department:** | Department of Aquatic Sciences and Assessment |
| **Place of publication:** | Uppsala |
| **Year of publication:** | 2019 |
| **Cover picture:** | Ida Johansson |
| **Online publication:** | https://stud.epsilon.slu.se |
| **Keywords:** | Pollination, wax moth, Kenya, bees, beekeeping |

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## Abstract

The bee wax moth (*Galleria mellonella*) is a troublesome pest of the honeybees that can cause substantial financial losses that can be devastating for the beekeepers. The moth is a universal pest but thrives in a warmer climate, the insect is nocturnal and feed on pollen, wax and other impurities. The eggs are laid in crevice's and other small spaces where the bees cannot reach them. When feeding through the comb the moth larvae can cause damage on bee larvae, combs and cause honey leakage. Although the African honeybee (*Apis mellifera ssp scutellate*) is more resistant to pests than the European honeybee (*Apis mellifera*) the African honeybee has a major problem with the wax moth.

The aim of this study was to investigate Kenyan beekeepers' awareness of the wax moth and the occurrence of the pest. The interviews revealed that the majority of farmers considered the wax moth as the largest pest problem in the bee hives and the most difficult to handle. Even after performing control measures to prevent infestations of the moth the problem remained. They cleaned the ground but still had issues and after invasion of the moth they cleaned the hives and fumigated them. The reason why they keep bees differs; most of the beekeepers wanted some extra income and a few of them also consider the contribution to pollination of their crops important. Beside the pests, the lack of equipment is a problem. Only one farmer has a bee suit and therefore they are the only ones who can visit and inspect the hives. An additional problem is the lack of an extractor machine. Instead of extracting the honey from the intact wax combs they need to cut off all the wax combs and cannot harvest as often as they want. Although the bee wax moth was the major problem according to the majority of the farmers in this study.

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# 1 Introduction

Pollination is utterly important because the majority of plants are dependent on pollination to set fruits. Bees are significant as they are key pollinators of a large amount of plant species. The economic value of pollination is significantly higher than the value of honey harvest, in Africa it is worth approximately 100 times more (FAO, 2018). Nevertheless, this important work of pollination is still underestimated, not known by people and a high quantity of bees die due to negligent usage of pesticides in general (FAO, 2018). It is important to talk to the beekeepers since they are the ones who actually work with the bees, to understand what causes problems for them. The purpose of this study is to find out how the beekeepers in Kenya work and the attitude and awareness they have of different pests, especially the bee wax moth. How does the bee wax moth affect the beekeepers in Kenya and what control methods do they use?

## 1.1 Background

### 1.1.1 Honeybees and Pollination

Pollination is a process that can occur in many ways: by wind, precipitation, self-pollination, birds or by insects. Since about 80% of the plants that blooms are depending on getting pollinated by insects, bees play a very important role. Approximately one third of the crops we use for food rely on the pollination done by bees (Bradbear, 2009). Crops pollinated by bees often results in a higher quality and quantity of fruits such as higher oil content in *Brassica* seeds, better developed strawberries and apples (Bradbear, 2009).

Over the last 50 years, the agricultural production that rest on the work of pollinators has increased by 300 % which indicates how significant this is. Some crops mass bloom in a short time period. That requires a large number of active pollinators and the absence of these could result in a yield loss around 75 % of the crops. Changes in landscapes, intense practices such as pesticides, climate change and monoculture lead to a loss of habitats for the pollinators (FAO, 2018).

To attract bees the flowers lure them in with nectar and pollen, the pollen grains adhere to the hair of the bee or place the grains in the so-called pollen basket on the hind legs. Honeybees are often the most important pollinator when it comes to crops due to the great number of bees in the colony, their capacity to pollinate and their way to communicate with each other. The honeybees, instead of flying to different species of flowers, stay true to one species until there are no more nectar or pollen to collect (Bradbear, 2009).

A lot of people do not distinguish between the African honeybee and the Africanized honeybee that is a cross-breed between the African honeybees and the European honeybee. However, the Africanized honeybee is almost genetically identical to the African honeybee and shows the same aggressive and defensive behaviour (Gary etc, 1985). The African honeybee (*Apis mellifera ssp scutellate*) has more aggressive ways than the European honeybee. One reason for this might be that "honey hunting" is more common in Africa and "beekeeping" in Europe. Honey hunting means that total destruction of the hive occurs when harvested and beekeeping means managing the bees so they will stay. Because of the destruction, *scutellate* could have developed a more defensive and aggressive behaviour around their nests. The bees in Africa are wild and not domesticated and they have more pressure on finding food and avoiding and managing pests and predators. They usually send out more guard bees than the European honeybees and can kill a mammal and are therefore avoided by many humans (Ellis & Ellis, 2019). In most European countries you can buy a colony of domesticated honeybees, but in Africa many beehives are places high above ground to attract and get colonized by the African honeybee. The reason for this is that there is no market for producing bee queens or colonies to sell (FAO, 2011).

The hives used in Africa can sometimes be the traditional ones, they are also called the log hive since it is in fact, a log. These tend to be more attractive for the African bees than other types of hives (Mwangi, 1985). The African honeybee also have a higher frequency of absconding and swarming than the European honeybee. When *Apis M. scutellate* nest is invaded by pests or the colony gets too big they will abscond the hive (Gary etc, 1985). Since the western honeybee are domesticated, they tend to have a weaker defence against different pests. The African bee are more resistant to several pests and have a higher chance to survive without the helping hand of humans (Ellis & Ellis, 2019). The African honeybee also prefers to build nest or colonize hives that are in the forest or under a tree instead of in an open landscape (Bradbear, 2009).

*Picture 1. the Traditional Hive. Johansson, I (2019)*

### 1.1.2 Bee Wax Moth

The bee wax moth is a pest that causes problems for beekeepers all around the world and it has been a problem for a long time. Bee wax moths are found almost everywhere one can find honey bees. There is a number of different wax moth species, but the most common ones are the greater wax moth (*Galleria mellonella*) and the lesser wax moth (*Achroia grisella*) and I have chosen to focus mainly on the greater wax moth (*Galleria mellonella*). This because it is the species that seem to be the major problem in Kenya. The wax moths are from the order of Lepidoptera and the family Pyralidae. It is not only considered a pest but is also being looks at as an alternative infection model as it shows similar immune response as the verbrates do (Tsai et al. 2016).

With a length of approximately 13-20 mm the greater wax moth is larger than the lesser (*Achroia grisella*) that is about 10-13 mm, the pigmentation varies between grey and brown. When folded the wings forms a roof-like shape (BeeAware, 2019). The white eggs with a size of roughly 0.4 mm can be hard to detect. When they hatch the larvae are 1-3 mm long and will grow to around 25-30 mm. The larvae (8-9 larval instars) have many feet, are a white-yellow colour, have several segments which are white in colour but darkens as they grow. When fully grown the larvae will spin a cocoon and pupate inside. The pupa is about 12-20 mm long and is initially yellow but will darken to a browner colour (Goodman, 2009).

The life cycle of four life stages; egg, larva, pupa and adult. The duration of the life cycle depends on both abiotic factors such as temperature and humidity and biotic factors that might include competition for food, cannibalism and parasitoids (Kwhada, 2017). The egg hatch after 3-5 days in a temperature of 29º C- 35º C but in lower temperature the egg hatch may be

postponed up to 30 days. Similarly, in an ideal temperature of 28º C- 33º C the larvae are fully grown in 19 days but can be delayed by five months if the temperature drops (Goodman, 2009). The female adult wax moth lays 300-600 eggs during her lifetime and usually lay them in batches. The preferred space to oviposit is in small spaces for instance cracks or gaps so the eggs are harder to detect for the bees, that will remove them if they find them, this increase the survival of both eggs and larvae. The hatched larvae move on to the combs for feeding on wax, honey and pollen while leaving a trail of webbing that is a typical sign of the presence of the pest.

*Picture 2, A Bee Wax Moth Larva. Johansson, I (2019)*

The adults, after pupation, fly from the hive to mate, this usually happens during nigh time since the wax moth is nocturnal (Kwhada, 2017). The procedure of mating is very interesting, the males use sound to excite females to fan the wings. The male moth has a sound producing organ which activates when the wings pushes towards each other. This motion creates a sequence of pulses that makes the females fan the wings in a low frequency, this makes the males release pheromones so they can locate each other (G. Spangler, 1988). After mating the female returns to a beehive. The greater bee wax moth can go through 4-6 generations per year when the conditions are ideal.

### 1.1.3 Damage and Pest Control

Damage to the combs happen when the wax moth larvae eats its way through the comb, it can also eat the cell cap of a bee larvae. This can cause deformation of the bee since the cell cap are meant for protection. The larvae feeds on wax and other impurities so dark combs are preferred since these are old brood combs. When feeding through the comb, honey may leak from the holes made from the wax moth leading to honey loss, the combs also gets weaken

and may break (Kwhada, 2017). Damage on the wooden frames or hives may occur when the larvae chews on these before spinning a cocoon. This weaken the frames that might break after a time and the condition of the hive drops costing money to replace. The quality of honey from an infested hive are ruined and will not be used which means a total loss of the honey yield. The products from moth infested hives cannot be used and replacing the wooden frames will lead to a considerable loss for the farmer (Goodman, 2009).

*Picture 3. Damage done by wax moths. Johansson, I (2019)*

The control of the bee wax moth can be both preventive and direct. The most effective way to avoid and control the moth is good hygiene and sanitation. Wax should not be left in unoccupied hives, bee feed should be provided when needed and last but not least the hives should be inspected on a regular basis. One can also replace frames and combs when needed and making sure that the colony is healthy and strong (Charrière & Lmdorf, 2004). If there is any possibility to store the equipment in cooler or warmer place than the preferred temperature of the moth, that would disturb the developmental cycle and is called temperature control. Since the wax moth lays eggs in cracks and other small spaces that is hard for the bees to clean, sealing those small spaces would prevent egg laying to a certain degree. Chemical fumigants are sometimes used as they destroy everything but the eggs. Fumigants are used after a colony of bees have absconded the hive or died. But since most of the chemicals used are poisonous both to insects and humans the only fumigant recommended is carbon dioxide. Other chemicals are strongly disapproved by both the laymen and by beekeeper's association as the chemicals can kill not only the moth but also other insects including the bees (Kwadha, 2017). Using pesticides should always be considered as the last resort because they are not healthy for human nor the environment.

There are biological control methods as well, one is the Cry protein from the bacteria *Bacillus thuringiensis* (Bt). A Bt-suspension can be sprayed on the frames in the hive or the frames can be dipped into the suspension. There are different varieties of Bt but if the strain for *Lepidoptera* is used (Bt kurstaki/aizawai) the bees will not be affected. The Cry protein cause damage on the intestinal walls of the larvae but since it is only the larvae that eats from the comb the adult is not harmed. There are a few parasitoids that can be used but since the interaction between these and the wax moth is unclear, and they have usually been tested under laboratory conditions they are not used in a large extent. Semiochemicals, substances released by different organisms into the environment, produce either a psychological or a behavioural response and can be used as a method of control. Examples of usage of these semiochemicals are pheromone traps that lure insects into a trap. The pheromone traps are not attractive over extensive distances for the greater wax moth as the sound the male produces work as a long-distance mating call (Kwadha, 2017).

# 2 Method

## 2.1 Fieldwork

With help from my co-supervisor from Embu Univeristy, Dr Muturi, me and my co-worker Sanna got in contact with a chairman of a big bee group in Embu county and the first day in the field I went with Dr Muturi and visited him. The chairman agreed to contact several bee farmers I could visit the following days. Every farmer was interviewed alone and two with the help of an interpreter as the language was something else than English. Seven farmers outside the bee group was also interviewed to get a broader perspective and two farmers from the Mt Kenya forest. As far as I know there were not any beekeepers who did not want to be interviewed but I did not have time to interview them all.

The method used is a qualitative method consisting of 21 questions, these questions are listed in the Appendix. As I interviewed the farmers, I wrote down all the answers. The method was selected because of a better understanding of knowledge the beekeepers have and to get to talk to them instead of reading or hearing from a secondary source. Also instead of using a printed questionnaire using a interview to get a better and deeper contact with the farmer and to assist in the best way possible if they had any questions.

The positive with this kind of method is that it is easier to establish a better connection with the interviewed person. Some negative aspects of this method are that the interviewer can affect the situation by reacting to something spoken or misinterpret something and also lead to

incorrect information in the study. This could be a problem since the results is best if they are neutral and have no misinterpretations.

# 3 Results

## 3.1 General information of the beekeepers in Kenya

I met with 20 beekeepers at their homes to interview them and discuss the questions. The age of the beekeepers ranged from 35 years to 90 years (Figure 1) and the majority of farmers were between 60-65 years old. Most of the farmers were men and only a few women, 16 males and 4 females.

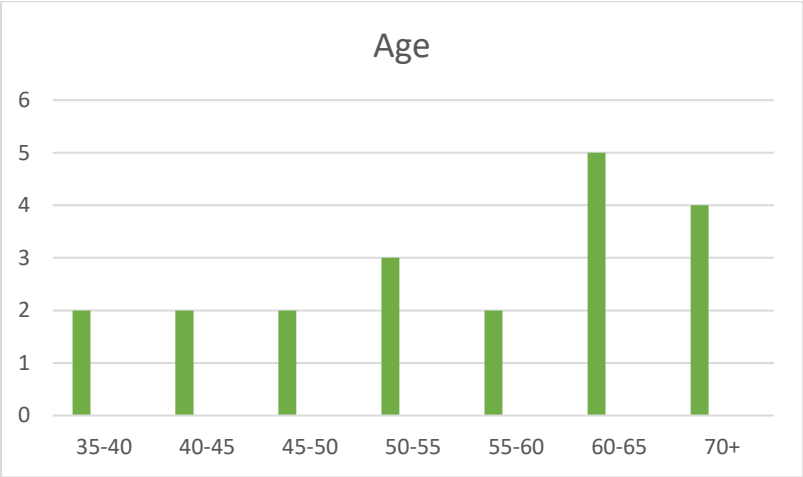


*Figure 1 Age of bee farmers (X) and how many bee farmers (Y)*

The farmers were often a part of a group of beekeepers that differs in sizes. Thirteen were members of the same group and only two people were not part of any group. One reason behind organizing the bee groups is a lack of equipment among beekeepers. Logically, because of the risk to get stung the beekeepers are reluctant to scout the hives without proper equipment. Therefore persons that have the equipment goes around to the group members to take care of the hives. They become group leaders and are usually called chairman. The usual tasks for the chairman are to check the hives to see how the colony is doing, to see if there is any pests, cleaning the ground beneath the apiary, harvesting if honey is present and to take measures against different pests. The time between the visits vary between one month and three months depending on what condition the hives are in and whether the chairman have time or not. Since the chairman generally require payments the visits may vary depending on if the farmer wants and can to spend money on the apiary. The bee groups have meetings regularly to share ideas, compare what works bests, motivate each other, help finding a market to sell honey. Sometimes they visit different beekeepers to compare and see if anyone

has new types of hives or control methods. Another activity that is common is a merry-go-around, or a “table bank”, where they meet up together with a specific amount of money, mostly profit from selling honey. If there is anyone in the group who has problems with money that time, whether if it is a school fee, medical bills or other bills, that person will get the money. If there are several members who are in need of money they draw lots.

*Picture 4. One Chairman in action. Johansson, I (2019)*

When asked if there are any benefits of being in a group the majority answered that the most important benefit was that they can trust each other and especially the chairman. Some have had problems with thieves trying to steal honey or someone faking to scout their hives when they really stole the honey. If they are a part of the same group and they know everyone they feel more secure. The chairman is known and trusted among the farmers and they feel safe that he or she will take good care of both them and the beehives. Another benefit according to many is that they can arrange the “table bank” described above.

When comparing the members of the group and the ones independent there were not much difference in management of the hives. They all clean beneath the apiary, have the same control method and had the similar pest problems. The main difference concerned pest problems by beekeepers in the farmlands and the forest.

Most of the interviewed farmers had just started or been active beekeepers for up to five years. The most experienced beekeeper has been active for 37 years (Figure 3). Many of the farmers had just started or did not have the opportunity to keep bees until recently. The ones

who have years of experience started very early in their lives and most of them got the interest from their parents.

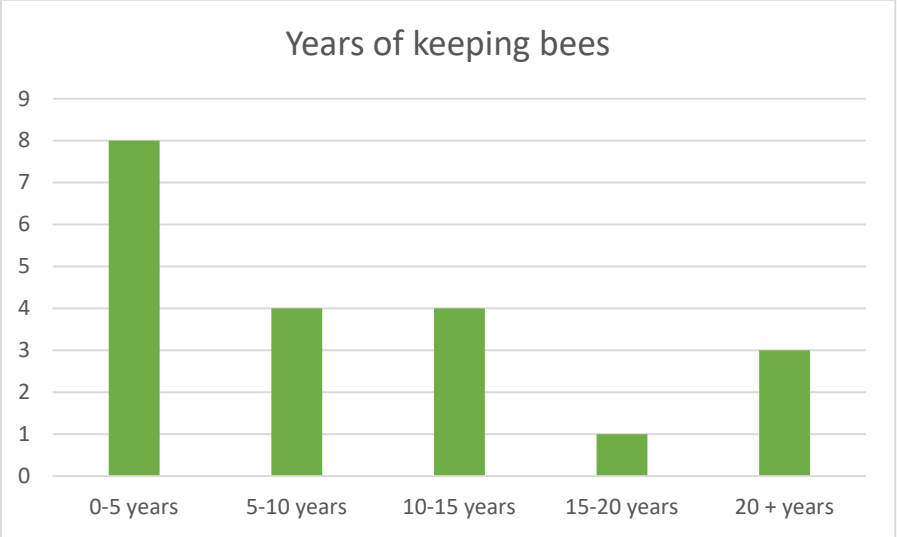


*Figure 2 Number of years they have been keeping bees (X) and number of beekeepers (Y)*

### 3.2 Why Keep Bees?

The most common reason doing apiculture were for the extra money, the farmers wanted an extra source of income (Figure 4). Some of the beekeepers kept bees for medicinal reasons. Some beekeepers used honey for cough medicine consisting of a mixture of hot water, honey and lemon. The same mixture was used by a few to remedy chest pains and one farmer used pure honey on cut wounds to help them heal. Two of the interviewed beekeepers expressed that bees are important and that they want people to learn about them and learn how to help the bees survive better. One of the farmers was the principal of a primary school and had the apiary for the students to learn and every student had their own beehive. The idea was to get more pupils interested in beekeeping so they might get their own when they got older. This was especially important since a few of the farmers expressed a worry that the younger generation did not have the same interest in bees as they have. Most farmers had their apiaries in farmlands with a lot of crops surrounding the hives. Some of those farmers considered the pollination as an important reason to keep bees, they said that they wanted their crops to get a lot of fruits and be able to reproduce.

Even though money was a common reason, only one of the beekeepers used more than just the honey as products. He used the wax to make soap or a cream and if he could he used the propolis as medicine for coughing. Propolis is nutritious and consists of a mixture of saliva from bees, pollen, resin etc that bees use for sealing small spaces in the hives.

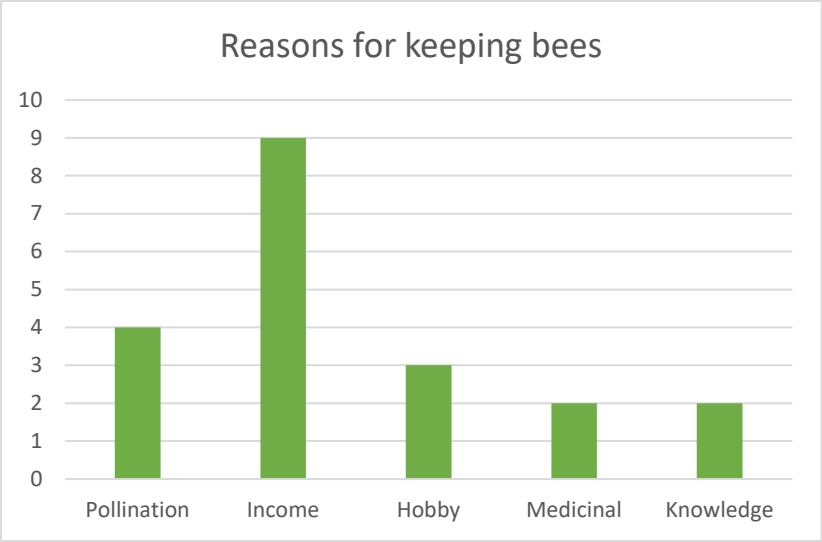


*Figure 3 Reasons for keeping bees*

Most of the farmers do not own any equipment and are hence dependent on the chairman to do their work. Even though the chairman does most of the work a lot of interest among the farmers were noted, to start doing everything by themselves and wanted to obtain their own equipment when they had the money. All farmers, except for two had the extractor machine as their top most wanted equipment. The ones in the bee groups wanted to get an extractor machine together and share so they do not have to stand for the cost alone. They said that they wanted to harvest more often but since the method of harvesting currently is just cutting all the wax off it takes 2-3 months for the bees to produce enough honey again. They then put the honeycombs in a bucket and crush them and let it sit for a while, using a fine net to remove all the small pieces of wax. This method takes a while from harvesting to getting the final product. With the extractor machine they could reuse the frames, that way the bees do not need to start from scratch. Although this might lead to more brown combs, which are preferred by the wax moth. The two who had the machine could harvest more often and could get more product out of their hives. Other were not that keen of getting started by themselves so they rely on the chairman but they still wanted the machine.

### 3.3 What kind of pests is a problem?

The bee wax moth was considered the most prominent problem among 12 of the farmers. The other major pests were spiders and ants. Four of the beekeepers were not sure what kind of pest was the biggest problem. They were not sure because they did not have the right knowledge about the pests or because they thought the pests were equally bad (Figure 5). When asked why the wax moth was the major issue most farmers stated that the wax moth can fly and the hives are not safe anywhere and they are hard to control.

*Picture 5. A Pupae of the Wax Moth. Johansson, I (2019)*

When asked the same about the ants it was because the ants usually enter the hive in a great number and the bees tend to abscond. With the spiders two of the farmers said that the spiders sealed the entrance of the hives and the bees could not leave.

The two beekeepers who had hives in the Mt Kenya forest had different problems with pests. The pests stated as problematic were leopards, wax moth, honey badgers and spiders. The hives in the forest are hung high up trees and therefore the beekeepers do not feel the need to clean the ground.

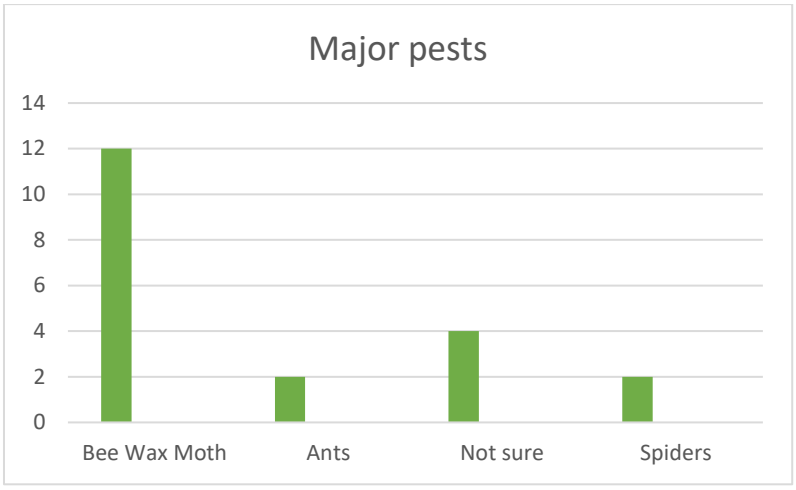


*Figure 4 The major pests according to the bee farmers*

There were many different pests considered as a challenge. Disclaimer for the figure is that each farmer can stand for more than one pest, so the total numbers do not represent the number of farmers. A few beekeepers stated the change in climate a problem, they meant that the change in temperature and more frequent droughts causes problems both for the bees but also for them. They also said that the blooming changes with the climate so flowers do not

bloom the same time they used to. Beehives in the forest are prone to leopards and honey badgers, the beehives in the farmlands however do not have a problem with these. The leopards climb the trees and somehow pushes the hive down and then eat the honey. These farmers had the traditional logs and they said the honey badger can open the lid, put its tail inside and makes the bees angry. After making the bees defensive the honey badger runs away and brushes away the bees on the ground. After a few times the majority of bees are on the ground and the honey badger can get the honey. It was unclear if the beekeepers had actually seen this or if it was only a story.

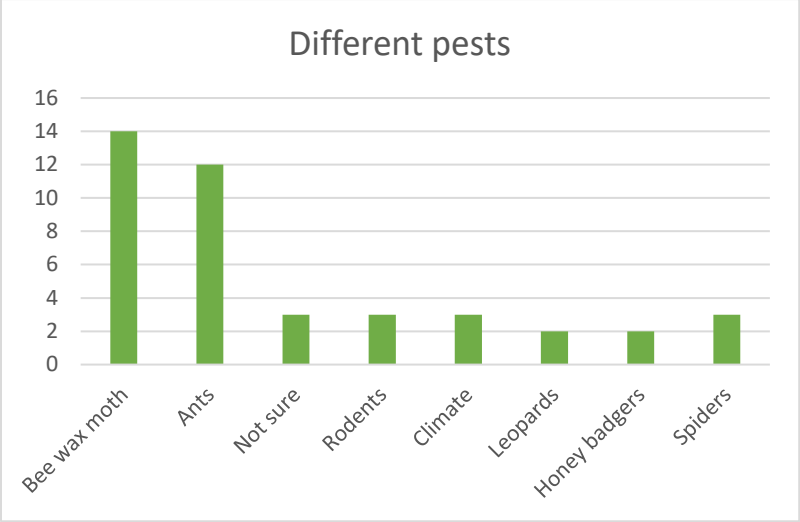


*Figure 5 the different pests that bee farmers have a problem with. A farmer can stand for more than one pest*

### 3.4 Pest control and common factors

The question about pest control when it comes to the wax moth was answered in the same way by 18 of the beekeepers. They clean the ground beneath the hives and around. The cleaning makes it harder for the moth to hide in the organic matter and, according to the farmers, therefore the infestation rate drops. After the infestation the farmers burn the remains of the moth (larvae, pupae, eggs and webbing) and clean the hive with water and/or with branches. After this process they use smoke to fumigate the hives to make it cleaner, the smoke intoxicates the remaining alive wax moths. If ants become a problem, they put grease on the poles that the beehives are located on since that prevents the ants from accessing the hive.

The dry seasons are, according to eight farmers, the seasons when the bee wax moth is the most severe, they mean that drought and sun makes it easier for the moth to hide beneath the organic matter on the ground. Six of the farmers said that during the raining seasons and when it is wet, they have a large problem with the wax moth. None of the farmers knew why the

wax moth was a problem during that specific season. The remaining beekeepers were not certain if the season mattered and believed that the moth is a problem during the entire year.

All though many bee famers had a sense of which season meant the most infestation of the wax moth they were not as sure if there were any common factors for infestation of bee wax moth. Four of the farmers said that if their hives were located low and not high up they could see a higher rate of the bee wax moth, one said that the traditional hive (or the log) do not have problems with the pest. If the hives are located in the shadow two said they would get more problems and one said that if the hives are located in an open space and in the sun the problem with wax moth increased.

The different hives the beekeepers have is the traditional, Langtstroth and top bar (Figure 7, Pictures 6, 7, 8, 9, 10).

*Picture 6 & 7, Langstroth hives. Johansson, I (2019)*

*Picture 8 & 9, Top bar hives. Johansson, I (2019)*

*Picture 10, A traditional hive. Johansson, I (2019)*

Langstroth is the most popular one since it is these frames that fit in the extractor machine and the farmers can re-use the frames, the two farmers who have only the traditional hives use those as they are the only hives that gets colonized by bees in the forest. The other beekeepers use a variety of hives as they do not have the problem of uncolonized hives. Only one of the beekeepers said that the type of hive matters when it comes to infestation of bee wax moth. Two farmers stated that which way the entrance is located is a factor if the bees will colonize. If the entrance is facing the sun, those hives tend to have a higher frequency of colonization than the ones facing shadow according to the beekeepers.

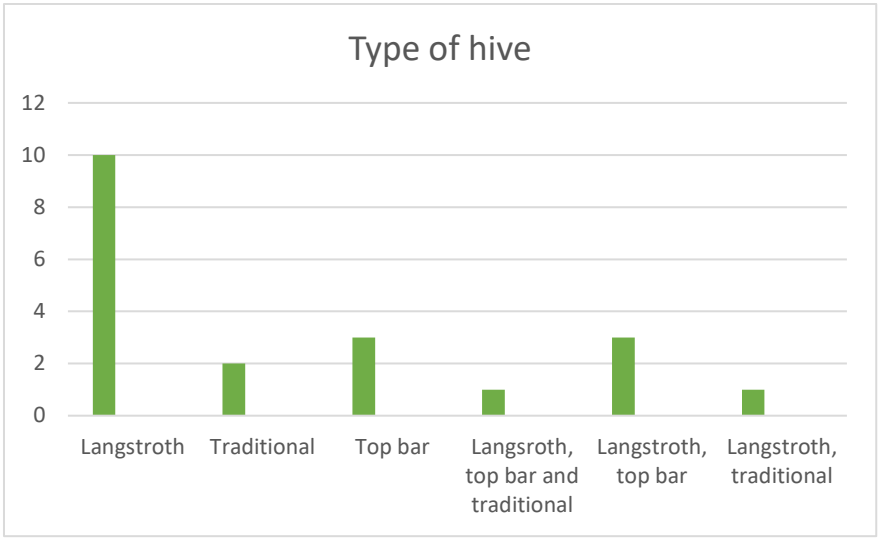


*Figure 6 Different types of hives*

Out of 20 farmers 17 have had problems or do have a problem with bee wax moth, only three were unsure if they have had any infections. Most of the farmers who are aware of the bee wax moth stated that the pest has been a problem for long and three said that they have only had wax moth once.

# 4 Discussion

## 4.1 The Main Result

So how do the bee wax moth effect the beekeepers?

As expected from the research, bee wax moth was the pest that the majority found as the greatest and most problematic. This was also stated in previous studies about how common the wax moth is (Tsai et al. 2016). The beekeepers also stated that the wax moth has been a problem for long. The wax moth is a widespread pest so it was no surprise that these beekeepers had issues. As the beekeepers did not check the beehives that often they have a larger problem since they do not remove larvae and eggs of the pest before the infection is out of hand. Even though the farmers cleaned the ground and fumigate the hives before colonization of bees they still have issues with wax moth. I did not find any research on that cleaning the ground would prevent infestations so that would be something that requires more research. All the farmers consider an infected hive as a loss and cannot use any products from that hive. This shows the magnitude of the bee wax moth problem and the importance of finding an efficient and environmentally friendly control method. The best method, according to research, is hygiene and making sure the bees do not have too much space to clean. Since an extra income is important, scouting the hives a little bit more often would help preventing total losses (Charriére & Lmdorf, 2004).

## 4.2 The Bee Groups

There were no major difference comparing the different bee groups. Since the chairman from the biggest group is very popular in Embu he is active outside the group as well. He might influence some of the other groups that were interviewed when it comes to pest control. It also seemed like the beekeepers have learnt from each other or from their ancestors, for example cleaning the hives with smoke and branches.

Although the chairman helps the beekeepers to get extra money, and income was a major reason for keeping bees, they did not use much more products than the honey to sell. One reason for that is the lack of proper equipment. This might be something they can solve with the extractor machine and if they can learn how to use the wax for other products such as soap or cream. However, the lack of other equipment, as said above is bee suit, gloves etc., might also be a reason for not being able to use all material from the harvest. It is hard for the farmers to be as efficient as possible since they cannot actually inspect the hives themselves.

If they could purchase some bee suits and an extractor machine within the group, they might be able to optimize their beekeeping.

Money is not the only reason for keeping bees, pollination is very important and some of the farmers believed they had observed a decline in pollinators**.** A few farmers were concerned about the lack of interest from the younger generation and that it might affect the pollination of their crops and result in yield losses. This has also been shown in earlier research (Bradbear, 2009). Learning children and friends about something important is a good way to spread information and they can get extra money from the bees pollinating the trees. Some expressed a concern about the climate change and said it affected the bees in a negative way, but hopefully they will spread interest for bees and get deeper information about how to help the bees and the environment. The fact that they are aware of how the environments can affect the bees is a good sign and that will be beneficial in the future to optimize the beekeeping.

### 4.3 What About the Pests?

It is not only the wax moth that causes complications and all the other pests, ants, spiders, rodents etc., are something that should also be handled even if they are not as severe as the moth. All the farmers who had issues with ants knew that they can put grease on every way the ants may reach the hive. A suggestion is that different groups can meet and share experiences on what works the best, also searching for information about the different pests they could optimize the apiculture if they know which control methods to use. One challenge is how to spread information in the best possible way. The information needs to be easy to understand and have concrete solutions. Knowledge is power and it makes it easier to defeat a pest if the basic biology and ecology of the pest is known.

An interesting difference is between the farmers from the Mt Kenya forest and the farmlands. The beekeepers who had their beehives in the forest did not have the same problems as the others. In the forests there are a lot of wild animals including honey badgers and leopards and these animals are not found in farmlands. Spiders were more problematic in the forest than the farmlands and even though the beekeepers from the farmlands had spiders they did not express the same negative feelings about them. The biological diversity is higher in the forest and have more closed spaces while the farmlands are open and contain lesser food sources for spiders. Although spiderwebs and spiders of course can be found in a great amount in the farms there are probably a larger number in the forest. It would be interesting to do a further study to see if spiders could eat bee wax moth. The honey badger is a complication that can

occur in the farms as well but since the forest might offer more food and because the badger probably gets chased away by humans in the farms etc., the honey badger occurs more often there.

### 4.4 Are There any Common Factors?

Farmers from both the forest and farmlands stated that one of the common factors for higher frequency of the bee wax moth were the dry and rain seasons. Although the wax moth needs a higher temperature for an quick life cycle the adult prefers to fly at night when the temperature drops. The temperature in the hives when located in direct sun can get high and as the bees sometimes abscond because of this, the wax moth will probably also be uncomfortable. If the hives are located in the shadow the temperature will be lower and during the dry season it might be the ideal temperature for the development of the bee wax moth larvae. The temperature drops during the night so the adult wax moth will probably have the same nocturnal activity during both dry and rain seasons. It seems like humidity is not a major factor, as stated in an earlier study, in this case as the beekeepers had problem with the bee wax moth all around the year (Kwhada, 2017). Different animals, such as bats, that might eat the bee wax moth might also be more active during night-time. That might explain why the farmers had different opinions. Other factors mentioned were shadow and sun. If the hives are placed in direct sun it might get too hot both for the moth and the bees while the ideal temperature might occur when the sun is not shining on the hives the whole day.

It is hard to give an exact reason why and which factors that contributes most to the farmers' difficulties with the moth. However, one farmer said that the traditional hives do not get infested by the wax moth, which Sanna Bergqvist mentions in her study "Bee Wax Moth in Kenya, the Intruder in the Hives". It is shown in studies that the moth lays eggs in small crevices where the bees cannot reach to clean them out (Kwhada, 2017). A strong colony of bees will clean different pests out if they find them and will not have the same issues as a weak colony. The bees will remove both eggs and larvae from the wax moth, but if the colony is weak, they will not be able to get rid of the pest or leave the hive. It is hard to say which type of hive that have more suitable spaces for the moth but the traditional hive has less space for the bees. If the bees have too much area, they will not be able to clean it all, they need a smaller space first before one can expand. If a bee farmer put a new box on the colonized hive the bees will have to much area to clean. Instead the beekeepers should wait until the colonized hive is full of wax before putting on a new one. Either way, the traditional hives are harder to extract honey from and it takes longer time between harvests. The choice of type of

hive will depend on the farmer, some stated that the logs easier gets colonized by bees, and on how often they want to harvest honey since you can reuse the frames from Langstroth but not the traditional.

An interesting question is why traditional hives are colonized by bees in the forest while other types of hives are not. This has been shown in a previous study, but the reason behind is unclear (Mwangi, 1985). If the height is the deciding factor other types of hives at the same height should be colonized. One reason might be the preference by the bees, the log hive might be more similar to a natural nest than a Langstroth hive. Another reason might be that the Langstroth, that is normally painted bright yellow, is not camouflaged well enough, even though the top-bar has natural wood colour. It is unclear how long and to what extent the farmers have tried with the other hives and if the conditions were the same. This would be very interesting to study further. The farmers' claim that the way the entrance of the hive is facing is also something that is a factor of colonization of the bees. One reason the beekeepers gave was that it is too cold in the shadow and that the bees prefer the sun at the entrance. However, those hives that were also located at a small hill and the sun came from above, so the shadowed part of the hives, where the entrance were, faced downhill. Another reason could be that the bees prefer an entrance facing uphill, so it does not get blocked by vegetation as easily.

## 4.5 Conclusion

In conclusion the bee wax moth is a major issue in Kenya, the beekeepers are aware of this problem and sweep the ground as a method of control. The pest is spread throughout Embu and is widely known by the beekeepers. Knowledge about this moth is not widespread and more information about the different control methods would help prevent infestations. The lack of proper equipment, both bee suits and the extractor machine, makes it difficult for every farmer to be a part of the beekeeping. Many beekeepers are therefore dependent on the help from ones who have suitable equipment.

With more knowledge about the biology of the moth, the farmers might find more solutions to this dilemma. I suggest that more information about the pest and what options the farmers have would be a start of a solution. Maybe arranging meetings locally or handing out brochures or something similar to help spread information. More research on this topic as stated above is recommended to find the best and most efficient control method for the bee wax moth.

## 5 Sources of Error

When searching for information about African bees you find that there is a lot of mixing between the African bees and the Africanized bees. This gave me some trouble in the beginning since it was hard to find information about the species that should occur naturally (*Apis mellifera scutellate*). If the species identification in the literature sources were not correct the information might be misleading. However, there should not be that large difference in biology and behaviour between the African honeybee and the Africanized honeybee so I did not consider it a problem.

When interviewing the farmers they were not sure what species of bees they had in their hives. The possibility that the species and sub-species would be other than the African honeybee, *A. mellifera ssp scutellate*, is low since the African honeybee should occur naturally in the region and Africanized bees occur more in Brazil and south America.

The majority of beekeepers, that is 13 of 20, I talked to were a part of the same group. In that group the chairman did most of the work and were the one to provide information about the different pests and pest control. This might lead to that the answers I got during the interviews were more or less influenced by the chairman or were similar because the chairman did the same work at all the farms.

If this or a similar study were to be repeated, I would recommend that more work would be designated on formulating the questions. Try to find more and deeper questions and after interviewing the farmers changing or adding something if needed. Further, try to capture a few bees to make sure that the species is what you want. I would also recommend to find beekeepers that are part of different bee groups or independent since that might have affected the results I got.

## Acknowledgements

I would like to thank all the people who made this study and journey possible for me. My supervisors, Helena Bylund and Jamleck Muturi, helped and encouraged me along the way and were always available to help me find solutions when needed. I also appreciate all the help I got from my guide, Nelson, who helped me find all the beekeepers and my driver Martin, who drove me every day. A big thank you to my friend Sanna Bergqvist who I did this journey with, without you it would have been much harder! And of course, I would like to say thank you to all the beekeepers who volunteered getting interviewed, I am so happy I met them and got to see their farms. I am joyful that I got to meet the bees as well! Finally I am grateful for SIDA for getting the scholarship that made all of this a possibility!

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**Pictures:**

All pictures. Johansson, I. (2019)

## Appendix

The questions asked during the interviews:

1) What is your name and age?
2) Who works with your hives?
3) Where do you sell your honey?
4) Why do you keep bees?
5) What do you use the honey for?
6) Do you have a group that you operate with or is it an individual activity?
7) If there is a group, how do you benefit from it?
8) How long have you been keeping bees?
9) Which pests do you consider to be a problem? Which one is the main problem?
10) Do you know if you have bee wax moth in your hives?
11) How do you maintain cleanliness/hygiene in and around your hives?
12) How does the bee wax moth affect the quality and quantity of honey?
13) Do you know if other beekeepers close to you have this problem?
14) Do you see a common factor for the infected hives; location, shadow or sun, high or low, weak or strong colony?
15) Which method of control works the best?
16) What type of hives do you have?
17) When is the wax moth most severe throughout the year?
18) For how long have you had a problem with the wax moth?
19) Do you keep the ground under your hives clean?
20) How many hives do you have?
21) How many of your hives are colonized?