Journal of Apiculture
2023.38(3) : 175-188
DOI: 10.17519/apiculture.2023.09.38.3.175

Original research article

A Review of Current Beekeeping Status in Uganda

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Abstract Beekeeping benefits agriculture across the globe due to the pollination services provided by honeybees. Therefore, the disappearance of honeybees may lead to the extinction of some important plant species. Most beekeepers in Uganda keep western honeybee (*Apis mellifera*) and are under the umbrella body called The Uganda National Apiculture Development Organization (TUNADO). TUNADO supports beekeepers with technology dissemination, bulking hives products, and ensures that the quality of hive products meets the specified standards of various markets. The beekeeping systems in Uganda comprise of traditional, transitional, and modern approaches, with 87% beekeepers practicing the traditional system. This preference for the traditional system is primarily due to its lower cost, the limited availability of materials for modern setups, and its ease of management. Uganda has the potentials for beekeeping due to its natural resources, the presence of wild colonies of honeybees, and government policies. Beekeeping has contributed to farmers' livelihoods both economically and ecologically. However, they are faced with challenges of agrochemicals, low colonization rate and absconding, climate change, parasites, pests, diseases, and unskilled labor. Beekeepers are undertaking extensive education in colony management to overcome the challenges. It is strongly recommended that a training center for queen breeding/rearing should be established to foster honey research in the country.

Keywords *Apis mellifera*, Beekeeping systems, Pollination, Pests, Breeding, Uganda

INTRODUCTION

Beekeeping is one of the farming systems that most living organisms depend on due to pollination services provided by honeybees. Honeybees pollinate most of the agricultural crops, fruit trees and many wild plants which are both beneficial to man and animals (Kasina *et al*., 2009; Mumoki *et al*., 2014; Hung *et al*., 2018; Kasangaki *et al*., 2018; Ogihara *et al*., 2020). They produce honey that is used by human as food, medicine, pharmaceuticals, confectionery, and in the bakery and cosmetic industries (Tarunika Jain, 2014). Honeybee products like bee venom (Babaei *et al*., 2016) and propolis are anti-inflammatories (Alanazi *et al*., 2020) that can help boost the body's immunity. This may help in fighting other diseases in the body including the corona virus pandemic which hit the world (Onlen *et al*., 2007; Caramalho *et al*., 2015; Anjum *et al*., 2019; Alanazi *et al*., 2020). In another study, honey added to water (22 g/L ad libitum) boosts the production of antibodies against the avian influenza virus H9N2 (Lima *et al*., 2020). In Uganda, honeybees are used to protect game parks, national, and forest reserves. In 2014, Gemeda reported that in Ethiopia, conservationists use beekeeping in watershed management including protected areas and for income generation (Gemeda,

Received 21 July 2023; Revised 9 August 2023; Accepted 9 August 2023
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Fig. 1. Value addition chain in honeybee products processing A. Automatic honey packaging machine, B. Packed honey ready for supply/marketing, C. Various Value added on bee products and D. Ugandan Honey exhibition in Dubai 2022. Sponsored by TUNADO.

2014).

The disappearance of honeybees would result in the loss of some plant species, crops, and potential ecosystems. According to Kasangaki *et al*. (2018), the common honeybee species reared in Uganda is western honeybee (*Apis mellifera*) with three different races (*A. mellifera mellifera*, *A. mellifera scutellate* and *A. mellifera adansonii*). *A. mellifera adansonii* are smaller in size, defensive, resistant to diseases and pests and are more productive compared to other races of *A. mellifera* (Petreanu, 2001). *A. mellifera* is referred to as Africanized honeybees because of its defensive behavior for their products and territory against any intruders (human and animals), disease and pests (Nouvian *et al*., 2016; Van Alphen *et al*., 2020; Düttmann *et al*., 2022). An understanding of the distribution of honeybee species is important in increasing our odds of successfully protecting such a critical player in most ecosystems. It also offers a source of employment to both elderly and youths, educated and uneducated (Makri *et al*., 2015).

To reduce the rural poverty in households, farming practices in both small and medium farmers need to be improved by embracing pollinators (Amulen *et al*., 2019). Improved technological practices in beekeeping being promoted in Uganda include modern hives, use of protective gears, smokers (Fig. 2A), honey processing, and packaging equipment (Tulu *et al*., 2020) (Fig. 1).

Uganda is endowed with natural resources that help boost the potential of beekeeping industry due to the presence of evergreen vegetation, national reserves protected by the government and several plantations (Kasangaki *et al*., 2015). The abundant resources provide ambient environmental conditions including forages for the honeybees and subsequently, increased production and productivity (Otim *et al*., 2019). Most of the beekeepers installed their hives in different forests away from farmland and only wait for the harvesting season. approximately (75%) of beekeepers depends on natural honeybee swarms to colonize their hives (Chemurot *et al*., 2017). However, it has not limited the production of honey and other hive products for which there are enormous potential markets. This

Fig. 2. A. Training female beekeepers on lighting smoker and apiary management, B. Training beekeepers on how to make smoker using locally available materials. Sponserd by TUNADO.

is because honeybees are less affected by pathogenic micro-organisms (Masuku, 2013) and as a result, they produce a greater quantity of hive products that are beneficial to humans.

The beekeeping industry in Uganda was dominated by male (Fig. 2B) simply because in most African cultures, climbing trees by women was considered a taboo (UNECE, 2023) and yet hives were sited high on trees that require one to climb and harvest the products (Chemurot, 2011). Due to continuous education of women about the importance of beekeeping in households, there is an increase in the number of women participating in the development of the sector (Fig. 2A). This is due to the holistic approach in addressing rural poverty which involves promoting women's participation in the agricultural production process.

Beekeepers have formed themselves an umbrella body (Uganda National Apiculture Development Organization (TUNADO)) that deals with the welfare of beekeepers in the country. The organization started as a small association "Uganda honey beekeepers association (UHBA)" in 1995 (Petreanu, 2001) which was later transformed into TUNADO in 2009. Under the supervision of the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), TUNADO supports beekeepers with technology dissemination, bulking of hives products, and ensures that the quality of hive products meets the specified standards of various markets. The purpose of this review is to document the various beekeeping systems and beehive practices in Uganda, outlined challenges and give recommendations for action aiming at taking the industry to the next level.

Fig. 3. Map of Uganda showing location in Africa. Source; google.

1. Location and population of Uganda

Uganda is one of the smallest landlocked Country in East Africa. It is located at the line of zero-degree equator and bordered to the East by Kenya, to the West by Democratic Republic of Congo, to the South by Tanzania and Rwanda, and to the North by South Sudan (Fig. 3).

The country has Ten agro-ecological regions that include North-western savannah grasslands, North-eastern savannah grasslands, North-eastern dry lands, Southwestern farmlands, Pastoral rangelands, West savannah grasslands, Para savannah, Highland ranges,

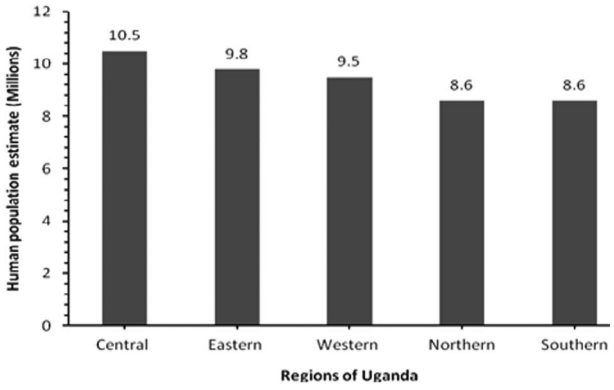

Fig. 4. Total regional distribution of population in Uganda. Source UNBS 2022.

Lake Victoria crescent, and Kiyoga plains (MAAIF, 2018). All these agro-ecological zones share the two seasonal rainfalls with variations in the amount of rain received, soil types, agricultural systems, and terrain (Wortmann and Eledu, 1999).

Uganda has a total population of forty-seven million, two hundred and sixty-five thousand and forty-one (47,265,041), which is made up of males (49.1%) and females (50.9%) (UNBS, 2022) (Fig. 4).

2. Bee forage plants

Uganda presents enormous potentials for beekeeping industry because of its natural resources that provides excellent forage and ambient climate for the honeybee colonies. The common bee forage plants in Uganda are; Coffee (*Coffee arabica* and *Coffee rubasta*), Combererirum (*Combererirum* spp), Calliandra (*Calliandra calothyrsus*), Albizia (*Albizia* spp), mango (*Mangifera indica*), Acacia (*Acacia* spp), Banana (*Musa* spp), Shea nut tree (*Vitellaria paradoxa*), including food and cash crops grown in open farm lands namely; maize (*Zea mays*), peas (*Pisum sativum*), sorghum (*Sorghum bicolor*), vegetables, cotton (*Gossypium* spp), sugar cane (*Saccharum officinarum*), and beans (*Phaseolus vulgaris*) (Otim *et al*., 2019) (Table 1).

3. Honey production

In Uganda, due to the available natural resources providing bee forage plants, only few beekeepers (21%) provide supplementary feeds to the bees especially during dearth period. The bees depend entirely (79%)

Table 1. Common bee forage plants across all regions of Uganda

Common name	Scientific name	Plant form
Nile tolip	*Markhamia lutea*	Tree
Lantana	*Lantana camara,*	Shrub
Aleovera	*Aloe vera*	Herb
Grey bitter-apple	*Solanum incanum*	Herb
Camel's foot	*Bauhinia thonningii*	Tree
Coffee	*Coffee arabica*	Tree
Musase	*Albizia ferruginea*	Tree
Velvet bushwillow	*Combereritum molle*	Tree
Neem tree	*Azadirachta indica*	Tree
Albizia	*Albizia coriaria*	Tree
Calliandra	*Calliandra calothyrsus*	Tree
Phalsa or falsa	*Grewia mollis*	Shrub
Flamboyant	*Delonix regia*	Tree
Acacia	*Acacia polyacantha*	Tree
Large-leaved albizia	*Albizia grandibracteata*	Tree
Ficus	*Ficus natalensis*	Tree
Spider whisker	*Cleome gynandra*	Herb
Beef wood	*Bridelia micrantha*	Tree
Spike thorn	*Maytenus seneganalensis*	Tree/shrub
Adamant creeper	*Cissus quadrangularis*	Tree/shrub
Harrisonia	*Harrisonia abyssinica*	Shrub/tree
Tamarind	*Tamarindus indica*	Tree
Pigeon pen	*Cajanus cajan*	Shrub
Varriable bush-willow	*Combretum collinum*	Tree
Wild coffee	*Bridelia micrantha*	Tree
Flame tree	*Erythrina abyssinica*	Tree
Popcorn senna	*Cassia didymobotrya*	Tree
Lannea	*Lannea acida*	Shrub/tree
Bastard brandy bush	*Grewia bicolor*	Shrub
Acacia	*Acacia hockii*	Shrub
Eucalyptus	*Eucalyptus grandis*	Tree
Ocimum	*Ocimum tenuiflorum*	Herb
White berry-bush	*Flueggea virosa*	Shrub
Acacia	*Acacia brevispica*	Shrub
Black plums	*Vitex donianana*	Tree
Trema	*Tremas orientalis*	Tree
Bitter leaf	*Manihot esculenta*	Shrub
Coffee senna	*Cassia accidentalis*	Tree
Crotalaria	*Crotalaria cleomifalia*	Shrub
Bitter leaf	*Vernonia amygdalina*	Shrub
Red hot poker	*Erythrina abyssinica*	Tree
Mysore thorn	*Caesalpinia decapetala*	Shrub
Creeping foxglove	*Asystasia gangetica*	Herb
Mango	*Mangifera indica*	Tree
Bitter leaf	*Vernonia adoensis*	Shrub
Moringa	*Moringa oleifera*	Tree
Jacaranda	*Jacaranda mimosifolia*	Tree
African fan palm	*Borasus aethpicum*	Tree
Red thorn	*Acacia nilotica*	Shrub/tree

Table 2. Regional average honey production level in Uganda (TUNADO, 2022)

Regions	2017	2018	2019	2020	2021
Northern	17043	23129	17005	25294	28319
West Nile	15975	28204	23971	28197	30718
Central	6004	8586	11006	10432	9928
Western	9909	9101	11965	7224	11918
Eastern	19286	9839	14631	9829	6426
Southern	19086	11078	7805	8082	12010
Total	87303	74937	76383	59058	154319

on natural food (nectar and pollen) for producing hive products (Kugonza and Nabakabya, 2008) which, therefore, increase the value of its natural honey in various markets. As a result, the supply of honey in Uganda became low and could not meet the rapidly expanding market demands both domestically and regionally. Majority of beekeepers trade their honey informally in the local markets and across borders within East African countries. Baseline survey conducted by Kimani (2021), showed that the main honey producing areas in Uganda were the West Nile, Eastern, Northern, Western, Southern, and Central regions. There are lots of informal cross border trade of bee products between Uganda and its neighboring countries (Petreanu, 2001). The local and cross-border markets are fast growing and have less stringent requirements compared to Europe. This has made it exceedingly difficult to quantify and produce accurate data about the actual production of hive products produced by beekeepers. However, the production of honey in the country is estimated at 500,000 metric tons annually but the actual data collected showed that the production of honey amidst all the potential is far less than estimated (Table 2). This is due to the demands in both local and cross border business and poor culture of record keeping (TUNADO, 2022).

4. Number of beekeepers

Beekeepers in Uganda have organized themselves into smaller groups in different villages, but the management of hives/apiaries is done individually. According to TUNADO (2021), the total number of beekeepers are one million two hundred and seventy thousand, five hundred and forty-four (1,270,544) with the total number of six million three hundred and fifty-two thousand seven hundred and twenty (6,352,720) beehives, 77% of which are colonized and 23% uncolonized in all the beehive types (local, transitional, and modern).

BEEKEEPING SYSTEMS

Beekeeping is the maintenance of honeybees in colonies together in the hives. It started about ten thousand years ago and dominated by men as they used to go for hunting of wild animals. Honeybee colonies were quite common in anthills, cavity of trees and clustering on tree branches in the forest (Roberts, 1969). This was before man invented the idea of beehives and bee rearing for both ecological and economic reasons.

1. Traditional beekeeping

The first system invented was the traditional system which is still in practice to date by most beekeepers in Uganda to keep and maintain honeybee colonies (Otim *et al*., 2019). An un-published annual report of the United Nation Development Program (UNDP) (2017), Uganda chapter estimated that there are about three million (3 m) hives in Uganda, 87% of which were traditional log hives with 76% colonization rate. Although the traditional beehives had the least reported yield in terms of production, they were the most used and owned types of hives by most beekeepers to date (Al-Ghamdi *et al*., 2017). This was attributed to their low cost, availability of construction materials within the locality, and little technical skills required in making and management of these hives (Amulen *et al*., 2019; ChiEmela *et al*., 2022).

In traditional beehives, the production of honey ranges between 20-25 kg annually during flowering and honey flow seasons (Shimelis, 2017). Traditional beehives are of different types invented based on regions which were divided along different ethnic groups and availability of construction materials within a particular locality. The common types were the palm tree, log, woven, bamboo tree, twigs smeared with cow dung and tree bark (Fig. 5). However traditional beekeeping is associated with many problems such

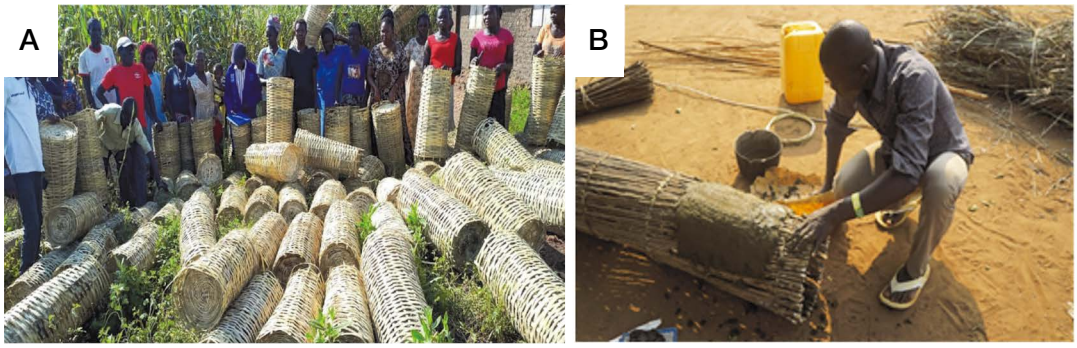

Fig. 5. A. Beekeepers training on making local hivesfrom Bamboo tree ans B. Beekeeper smearing local hives made of twigs with cow dung. Sponsored by TUNADO.

Fig. 6. A. transitional hives sited in the forest and B. Demonstration on the best way to handle transitional hives to Beekeepers. Sponsored by Makerere University in Uganda.

as fixed space and combs, vulnerable to pests, colony cannot be divided, and easily affected by weather and it is difficult to check for queen's performance and other colony management practices (Amulen *et al*., 2019; ChiEmela *et al*., 2022).

2. Transitional beekeeping

Transitional beekeeping is the second most popular system commonly practiced. Top bar hives like Kenya Top-Bar hives (KTB) and Tanzania top-bars are used (Roberts, 1971). Adjare (1990), Amulen *et al*. (2019), and Abro *et al*. (2022) suggested that the early and serious beekeepers were not for the poor and for this reason, most African countries were capable of adopting beekeeping technologies only up to this level as would represents there satisfactory compromise. KTB hives (Fig. 6) were mostly used because they are less costly to manage in terms of skills and easy to construct as opposed to modern Langstroth hives. Also, Abro *et al*. (2022) reported that transitional hives yield more honey (50 kg or above) annually compared to the traditional hives.

3. Modern beekeeping

The fact that modern beekeeping (Langstroth hives) is environmentally friendly and easy to manage, produces more honey (Al-Ghamdi *et al*., 2017) which diversifies the farmers' income (Amulen *et al*., 2019), the rate of adoption has remained exceptionally low (Amulen *et al*., 2019; Kaudjhis *et al*., 2020). Low adoption of Langstroth hive (Fig. 7) was attributed to high cost of production and management skills (Kaudjhis *et al*., 2020; Tulu *et al*., 2020; Mulatu *et al*., 2021).

OPPORTUNITIES OF BEEKEEPERS

Among all challenges faced by beekeepers in Uganda, they have lots of opportunities such as government policies which include recruitment of entomologists

Fig. 7. A. modern hives (Langstroth) installed in beehouse and B. demonstrating how to work with Langstroth hives. Sponsored by Makerere University.

in all the districts of Uganda to carry on beekeeping activities, the Uganda National Bureau of Statistics (UNBS) that design, regulate and ensure quality and standard of honeybee products and equipment. Also, beekeepers benefit from apiculture policy and other environmentally related policies like National Environment Management Authority (NEMA), National Forestry Authority (NFA), and the Uganda Wildlife Authority (UWA) (UWA, 2019). These policies have given leeway for beekeepers to access and install their hives in such protected areas.

CONTRIBUTIONS OF THE BEEKEEPING INDUSTRY

1. Ecological contributions

1) Pollination

Honeybees are considered the best insect pollinators (Breeze *et al*., 2011) and play a vital role in the economy of Uganda. This has led to increase in agricultural production and productivity while reducing food insecurity (Hanley *et al*., 2015; Aryal *et al*., 2020). For instance, honeybees were regarded as the main pollinators of coffee plants because farmers experienced an increase in coffee production when colonies were placed in coffee farms (UCDA, 2023). Uganda is ranked seventh globally in coffee production and export countries, second in Africa after Ethiopia and first in East Africa (UCDA, 2023). It has also improved the household income of Ugandan and the country's gross domestic products (GDP) by 1.5% (UNBS, 2022) in 2021/2022 financial year (Table 3).

Table 3. Variation in coffee production versus export value in the economy (UCDA, 2023)

Year	Quantity of coffee (KG)	Growth rate (%)	Value exported ($)
2021	374760	4	303555.6
2020	360103	15	291683.4
2019	313933	10	108485.7
2018	284225	−6	230222.25
2017	302063	24	244671.03
2016	243061	6	196879.41
Total	1878145	53	1375497.39

Honeybee carryout cross pollination thus reducing the chances of inbreeding depression, causing reduction in genetic diversity which could results into negative traits in the population (Partap, 2011). However, the untapped opportunity by beekeepers in Uganda is the sale or hire of honeybee colonies for pollination services to commercial farmers. This could be linked to the abundance of wild colonies which are able to carry out pollination at a wider range. However, this would help improve livelihood of the beekeepers by providing a source of income (Garratt *et al*., 2014; Hanley *et al*., 2015; Picanço *et al*., 2017).

2) Conservation of the environment

Honeybees are an integral part of the intricate web of life that exists in fields and pastureland. They interact with many organisms like birds, bats, and other insects in performing their cardinal role of pollination.

Beekeeping practices play a vital role in environmental conservation. Beekeepers through collaborative forest management (CFM) initiated by government agencies such as NFA and UWA, participate communally in protecting gazetted areas (Mackenzie *et al*., 2012). The purpose of beekeepers' engagement was to reduce the number of timber dealers, poachers and charcoal activities in protected forests/games of Uganda thus supporting the ecosystems (Petreanu, 2001; Otim *et al*., 2019).

2. Economical contribution

1) Income generation

Beekeeping provides farmers with both direct and indirect capital. Beekeepers earn money directly from the sales of products harvested from the beehives crudely or processed, purified, and packaged. Statistics shows that there are 1.2 million beekeepers in Uganda and the confirmed quantity of honey produced is 316,940 metric tonnes and a kilogram of honey cost $5.5 in local markets. The common products sold includes honey, propolis, beeswax, and bee venom (Amulen *et al*., 2019). Youths earn their living from beekeeping by making Langstroth beehives which cost $70, KTB hives at $50, local hives $10 each and sale of other beekeeping equipment (Drost *et al*., 2014). However, the sale of colonies of raised queen with desirable traits (Vinícius-Silva *et al*., 2017; Patel *et al*., 2021) and medicinal products of honeybees (Hegazi, 2012) are still unexploited by most beekeepers in the country.

2) Medicines (Apitherapy)

Honeybees are social insects that produce honey and other hive products used as medicines by consuming the products directly or used in pharmaceutical industries. All the hive products are believed to have medicinal values (apitherapy) because of the several plants visited by bees (Zekarias *et al*., 2020). The common products include; honey, propolis, beeswax, royal jelly, pollen and bee venom (Akullu and Mwesigwa, 2021).

Honey is a natural sweetener collected by bees from the nectar of plants' blossom or other sweet substances, stored and left to ripe in the comb's cells. As a dietary supplement, honey can treat gastric ulcers and due to its anti-bactericidal activities, it can act against enteropathogenic organisms such as *Salmonella*, *shigella* and *E. coli* (Petreanu, 1979; Cortés *et al*., 2011; Roberts *et al*., 2015; Matzen *et al*., 2018) also treat cold and mouth, throat or bronchial irritations and infections (Emsen, 2007). Honey is non-irritative, non-toxic, self-sterile and has anti-bactericidal properties and its nutritive abilities used for treating septic wounds in its raw state (Armon, 1980). In addition, honey also contains twenty-two amino acids (Adebiyi *et al*., 2004) and the variation in the quantity depends on the source of pollen and nectar collected (Ogwal *et al*., 2021). Propolis have shown positive results in the control of fungal, bacterial, viruses and other microorganisms due to its antimicrobial properties (Zekarias *et al*., 2020).

CHALLENGES FACED BY BEEKEEPERS

1. Agrochemical application

Honeybees just like any other insects, are vulnerable to chemicals or pollutions from the environment (Amulen *et al*., 2017). Commercial farmers in Uganda (85%) spray their crops, fruit trees and domestic animals against several pests and fungal infections using different chemicals in attempt to reduce the level of damage with little or no consideration to pollinators (honeybees). Application of these chemicals are on the rise with increase in human population, and commercialization of agricultural products. A study conducted by Amulen *et al*. (2019) revealed the presence of minute traces of chemical residues in honey and beeswax. These chemicals, when taken by honeybees, lower their body immunity, strength to collect food, and resistance to pests and disease in the colony. It is estimated that over 40% of the global honeybee species are declining by more than a third (DeGrandi-Hoffman *et al*., 2013; Fikadu, 2020) due to the use of different chemicals in the environment.

2. Low colonization and absconding of colonies

In Uganda, beekeepers pay very little attention to the factors leading to colonization such as hive hygiene, baiting, and planting forages because there are lots of wild trees providing forages (Chemurot, 2011; Otim *et al*., 2019). It is important for beekeepers to understand

where and when to install the hives (swarming period). However, due to inadequate knowledge about colony management, many hives were sited and abandoned in the forests. This is because they believed that there were many swarm colonies in the wild to colonize the hives in the forests. It was also proven that colonization is high when hives were sited high on trees than workable heights (Acai and Okullo, 2010). Therefore, many beekeepers were unable to climb the tree since it is a taboo for women in some cultures in Uganda. The commonly used baits included beeswax, propolis, *Ocimum*, lemon grass, honey, and smearing local hives with cow dung (Ande *et al*., 2008; Acai and Okullo, 2010).

Absconding is when honeybees abandon the hive and move to another location leaving uncapped and or capped brood and pollen in the hive. This could be attributed to inadequate forage plants within the vicinity, deforestation, pests, disease, predators, leaking hives or other human activities in the environment (Masuku, 2013; Kasangaki *et al*., 2015; Kajobe *et al*., 2016), and poor colony management (Amulen *et al*., 2019; Njukang *et al*., 2021).

3. Climate changes

Human activities on the environment such as cutting of trees for poles, timbers and curing bricks has led to deforestation which is depriving honeybees from suitable habitats and forages (Forneri *et al*., 2006; Aggrey *et al*., 2010) and because of these, colonies of honeybees are seen colonizing ceiling board of houses occupied by human being. A similar study was conducted in Nigeria by Mustafa *et al*. (2015) where man was labeled as the worst enemy to honeybees and its environment. Abnormal changes in air, shift in temperatures, increased frequency and intensity of droughts have contributed to the high mortality of honeybees. A situation that has progressively reduced the population of honeybees over time and pollination services hence reducing agricultural production and productivity. This is because there were no bloom and flower synchrony, some plants were able to emerge earlier than the normal time (Kimani, 2021). The effects have led to direct influence in the behavioral and physiological characteristics of honeybees and floral environment (Büchler *et al*., 2014).

The fall in the population of worker bees reduces the yield of agricultural crops and other wild plants, thus resulting in food insecurity. This has also affected the ecological functioning of honeybees in their ecosystems (Safe *et al*., 2020; Rahimi *et al*., 2021). In some instances, the beekeepers have abandoned their hives as it was recorded in Benin (Paraïso *et al*., 2012). The change may also favor the growth of honeybee pathogens with haplotypes of varying virulent on different honeybee populations leading to absconding (Reddy *et al*., 2012). The effect of climate change is a global problem. In Uganda, there are two rainy seasons and ten agro-ecological zones with varied weather. This causes prolonged drought, rise in temperature, floods, and wildfires (Josephat, 2018) which are a threat to beekeeping environments and survival. It has affected the seasonal pollination services, bee habitats, foraging cycle (Reddy *et al*., 2012; Kalanzi *et al*., 2015) because of short season or no flowers, and compromising their body immunity leading to high mortality rate (Markandya *et al*., 2015).

4. Pests, diseases, and predators

Common honeybee pests, parasites and diseases of economic importance to beekeepers includes; Little black ants (*Monomorium minimum*), small hive beetles (*Aethina tumida*), Greater wax moths (*Galleria mellonella*) (Fig. 8), Oriental hornrts (*Vespa orientalis*), black rats (*Rattus rattus*), Honey badger (*Mellivora capensis*), Birds (*Indicator indicator*) and varroa mites (*Varroa destructor*) (Kajobe *et al*., 2016; Chemurot, 2017). *V. destructor* and black queen cell virus (BQCV) were first detected by Kajobe *et al*. (2010) while studying the viral infection of honeybees and later deformed wing virus (DWV) and American foul brood (AFB) disease (Chemurot *et al*., 2016), Nosema, chronic bee paralysis virus (CBPV), acute bee paralysis virus (ABPV) and Sacbrood virus (SBV) were also confirmed in Uganda by Otim *et al*. (2020). Apart from the known species of Nosema (*Nosema apis* and *Nosema ceranae*), Otim *et al*. (2020) also identified a new species of Nosema (*N. neumanni*). However, the fact about its effect is not yet known though it seems less virulent than *N. ceranae* and *N. apis* (Stainton, 2018).

5. Unskilled beekeepers

Burning of bushes, use of direct fire instead of smok-

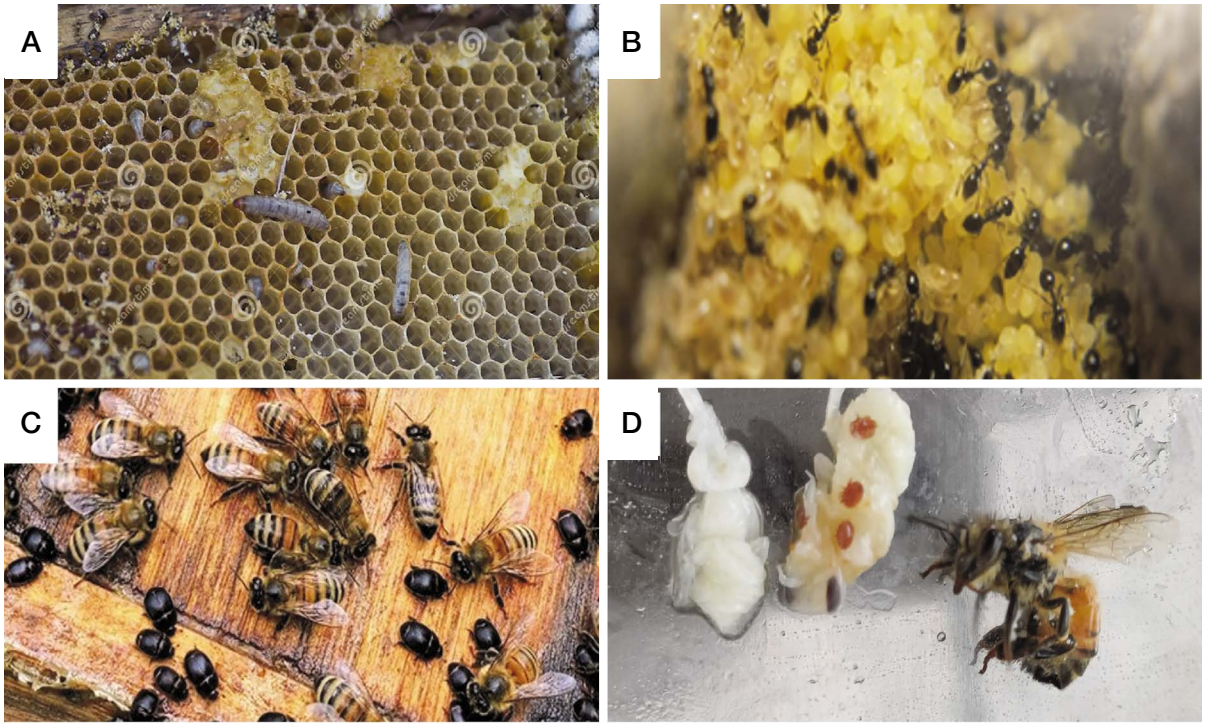

Fig. 8. Common honeybee pests and parasite in Uganda A. Greater wax moths (*Galleria mellonella*), B. Small black ants (*Monomorium minimum*), C. Small hive beetles (*Aethina tumida*), and D. Varroa mites (*Varroa destructor*),

er for hive inspection and harvesting of hive products, and poor handling colonies are some of human activities which are problematic to beekeeping as a result of poor skills (Amulen *et al*., 2017).

CONCLUSION AND RECOMMENDATIONS

The environmental conditions of Uganda coupled with its many agro-ecological zones have promoted beekeeping in the country. This activity has provided a source of income to both the youth and elderly people through the sale of hive products and equipment. Thus, reducing unemployment rate and crime wave in some localities. Beekeeping in Uganda is motivated by the government, TUNADO and other non-governmental organizations. However, beekeepers are still being faced with many challenges including poor colony management, pests and diseases, climate, the use of agrochemicals, and high cost of beekeeping equipment. Honey production and quality is influenced by different beekeeping systems and practices, irrespective of these challenges, Uganda still have high potentials of producing quality honey in the continent if proper measures are taken to addressed some of the challenges.

Some of the strategic measures include collaboration between MAAIF and the ministry of water and environment to do environmental education and protection against deforestation, agrochemicals, bush fires, and pollution. This would help protect pollinators from getting exposed to toxic environments and reduce the mortality rate of honeybees.

MAAIF should build the capacity of entomologists across the country with technical skills in colony multiplication to address the problem of low colonization and production of honeybee products.

Research as a guiding tool for development should be embraced and funded so gaps are identified and addressed.

ACKNOWLEDGEMENTS

This study is part of the “2023 Korean-Africa Food and Agriculture Cooperation Initiative (KAFACI)

Long-term Training Program" of Rural Development Administration (RDA), Republic of Korea.

I am grateful to the KAFACI Secretariat and RDA for the financial support. Department of Agricultural Biology, National Institute of Agricultural Science (Division of Apiculture) for all the guidance given in different forms. I also thank the government of Uganda through the Department of Entomology at the MAAIF and Apac District Local Government for granting me permission to attend this training. Lastly, I thank Mr. Kagenda Gabriel A, Ebuu Martin Odwong, and Acola Judith for their input in writing this paper.

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