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Case Studies for Honeybee Breeding Research: Beekeeping Status in Zimbabwe

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Abstract Beekeeping is an integral part of agriculture in Zimbabwe, providing income and employment opportunities for rural communities and contributing to the economic development of the country. The beekeeping industry has evolved from using traditional hives to modern hives, which are more efficient and productive. However, in Zimbabwe, 78% of the hives are still traditional because of their affordability and the availability of construction materials. The low adoption of modern hives, such as Langstroth and top bar hives, has resulted in low yields of honey and other bee products. This is why Zimbabwe imports 70% of its honey from South Africa and China, as the current local supply cannot meet the demand. Despite the widespread use of traditional hives, the benefits of the beekeeping industry are evident including crop pollination and bee products used as raw materials by several cosmetic and pharmaceutical industries in Zimbabwe. However, the industry faces several challenges, including pests and diseases, the use of agrochemicals toxic to the honey bee population, adulteration of honey, and limited availability of resources and financial support. It is therefore imperative that beekeepers, researchers, stakeholders, and the government work together to address these challenges and increase the productivity and efficiency of beekeeping in Zimbabwe. By harnessing the power of beekeeping, Zimbabwe can promote sustainable agriculture, preserve its natural biodiversity, and create opportunities for economic development.

Keywords Beekeeping industry, *Apis mellifera*, Honey bee products, Zimbabwe

INTRODUCTION

Apiculture or beekeeping involves the breeding, rearing, and management of bees in man-made hives. It is an important branch of agriculture with the potential to boost the economy and generate high income through honey bee products such as honey, beeswax, propolis, pollen and royal jelly. At the heart of beekeeping lies the honey bee, a key player in the pollination of many crops such as fruits, nuts, vegetables and wild flowers, thereby promoting biodiversity (Kumar *et al*., 2022). Beekeeping traces its roots back thousands of years, with evidence of honey gathering dating back as far as 10,000 years (Wachkoo *et al*., 2024). In ancient times, beekeeping was very basic and relied on simple natural resources to obtain honey from wild beehives. Humans used smokers to defend themselves and repel the bees, which unfortunately led to death of the bee colonies. This was done because the shape of the hive did not allow easy access to the honey unless it was broken. Overtime, beekeeping evolved from simple honey hunting to sophisticated hive management techniques with improved tools that increased honey bee productivity and enhanced bee manage-

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ment. Better hives made from wooden boxes, such as Langstroth and top bar hives were introduced. These hives have movable combs that allow regular disease inspection, monitoring of the bees, and easier honey collection. Using modern technology, some beekeepers are now practicing precision beekeeping which involves installation of cameras and electronic sensors in the hive for continuous and regular monitoring of hive temperature, humidity, weight, bee health, presence of the queen bee, and remote detection of parasite invasions (Wakjira *et al*., 2021; Alleri *et al*., 2023; Anuar *et al*., 2023; Wachkoo *et al*., 2024).

Beekeeping plays a vital role in the economy through honey bee products and services. Crop pollination is one key service offered by honey bees that is of great economic value. Honey bees can pollinate a wide range of crops, including cash crops such as almonds, coffee, cocoa and soybeans, thereby improving the quality and quantity of these crops (Degrandi-Hoffman *et al*., 2019; Khalifa *et al*., 2021). In the United States, the pollination contribution of the honey bee is valued at approximately USD 11.68 billion (Khalifa *et al*., 2021). Bee products such as honey, wax, propolis and royal jelly are also of great value to the economy. Beekeeping also contributes to the environment by promoting biodiversity as the bees pollinate various plant species allowing conservation of these species.

In Zimbabwe, beekeeping started during the 18th century and has been practiced for centuries. Traditional beehives are the most commonly used hives in Zimbabwe because they are quite affordable and materials are readily available. However, traditional hives are less productive, do not allow regular disease inspection and they result in reduction of colony numbers (Nyatsande *et al*., 2014). This has resulted in low honey production in Zimbabwe (69.7 metric tons), which does not meet the country's demand. There is little beekeeping research done in Zimbabwe and recent data is very scarce. The little data that has been published shows that beekeeping has the potential of boosting the economy of Zimbabwe and improve rural livelihoods (Mwandifura *et al*., 2021). This review article provides an overview of the beekeeping industry in Zimbabwe, highlighting its history, current status, honey bee species and economic benefits. We also discuss the challenges being faced by the industry and potential recommendations to solve these challenges in order for Zimbabwe to fully benefit from the beekeeping industry.

1. Location, climate and agro-ecological zones of Zimbabwe

Zimbabwe is a landlocked country located in the southern part of Africa, between the Zambezi and Limpopo rivers (Fig. 1). It shares borders with four countries: South Africa, Zambia, Botswana and Mozambique. Zimbabwe has over 39 million hectares of land, with 33.3 million hectares used for agriculture. Agriculture is one of the most important sectors, contributing about 15~20% of the country's economy and providing a livelihood for about 70% of the population. The country has highly productive land, which makes agriculture a success by providing food, employment, and raw materials for other sectors of the economy (Runganga and Mhaka, 2023).

Zimbabwe is predominantly semi-arid and has high agro-ecological diversity, requiring proper scientific planning for agricultural land use and environmental management to maintain a healthy ecosystem (Manatsa *et al*., 2020). There are four seasons in Zimbabwe, with different temperatures and rainfall patterns. The summer season (wet season) ranges from November to March, with temperatures ranging from 22~30°C characterized by heavy rainfall and vast vegetation. This is the main farming season of Zimbabwe for major crops

Fig. 1. Location of Zimbabwe in Southern Africa (photos extracted from google images).

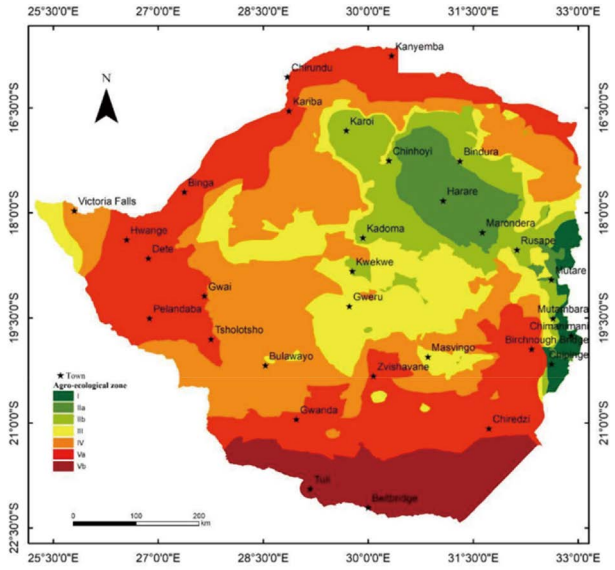

Fig. 2. Zoning according to the agro-ecological environment in Zimbabwe (Manatsa *et al*., 2020).

such as maize, sorghum and beans. Autumn season starts from March to early May, having milder temperatures (20~25°C) and low rainfall. Winter season is from late May to August and it marks the beginning of the dry season, with cool temperatures between 10-20°C, which may drop to 5°C at night. Spring season is the main flowering season which spans from September to October and has temperatures of 20~25°C (Bailey *et al*., 2021).

Zimbabwe has seven agro-ecological zones named I, IIa, IIb, III, IV, Va, and Vb (Fig. 2) and are divided based on the rainfall and temperatures in the different regions of the country. Transitioning from zones I to Vb, the average annual rainfall decreases significantly as well as the probability of receiving at least 500 mm of rainfall. Zone I, which receives the highest amount of rainfall, occupies only 1.5% of the country, and receives an average of 1,250 mm per year. This region is suitable for farming maize, soy beans, macadamia nuts, tea, coffee and fruit trees such as apples and bananas. Zone II has an average rainfall of about 975 mm and commonly grown crops are maize, tobacco, groundnuts, cotton, barley and sorghum (Manatsa *et al*., 2020). Zone III has lower annual rainfall between 650~800 mm and crops such as soybean, groundnuts, cotton, sunflower and certain maize varieties can be grown in this region, although supplementary irrigation may be necessary in some cases. Annual rainfall of Zone IV is between 450 to 650 mm and drought resistant crops such as sorghum, finger millet, pearl millet, water melons and cowpeas are common in the region. Zone V (both Va and Vb) is the driest, with an average below 450 mm and only drought resistant crops can be grown although farming activity is very low. Zones IV and V hold the largest part in the country, occupying 29.1% and 38.2% respectively (Manatsa *et al*., 2020). The varying weather conditions in the different zones result in different kinds of plants flourishing in each zone, which also affects the beekeeping industry. The agriculture sector in Zimbabwe has been heavily affected over the past few years by sudden climate changes, which have resulted in droughts and cyclones in the country (Runganga and Mhaka, 2023). Since honey bees are also excellent pollinators, intensive beekeeping may boost the agronomy and horticulture branches in Zimbabwe.

2. The history of beekeeping in Zimbabwe

Beekeeping in Zimbabwe dates back to the 18th century and has been practiced for centuries, with evidence shown in rock paintings in Matopo hills. Traditional methods were used, where honey was harvested from caves, cliffs, hollow trees, and logs (Nyatsande *et al*., 2014). Smoke from poisonous trees was used to kill the bee colonies and harvest the honey. Since this method resulted in fewer colonies each time honey was harvested, the quantity of honey decreased. This led to the introduction of newer methods of beekeeping, such as modifying the African drum, using bark hives, making holes in tree logs (Fig. 3A), and using clay pots (Fig. 3B) and buckets. However, these methods made it difficult to inspect the colonies because once the comb was removed, it could not be returned into the hive. Furthermore, it was difficult to prevent swarming or replace the queen using this method, which led to low productivity and poor quality honey.

Modern methods of beekeeping were introduced in the early 1960s and proved to be very productive and sustainable. The first recognized apiculturist in Zimbabwe was Mrs. Papadopoulo, who was appointed on the 11th of July in 1962. She then trained one thousand farmers, who produced 650 tonnes of honey per year. The Greek basket-hive was also introduced in 1962,

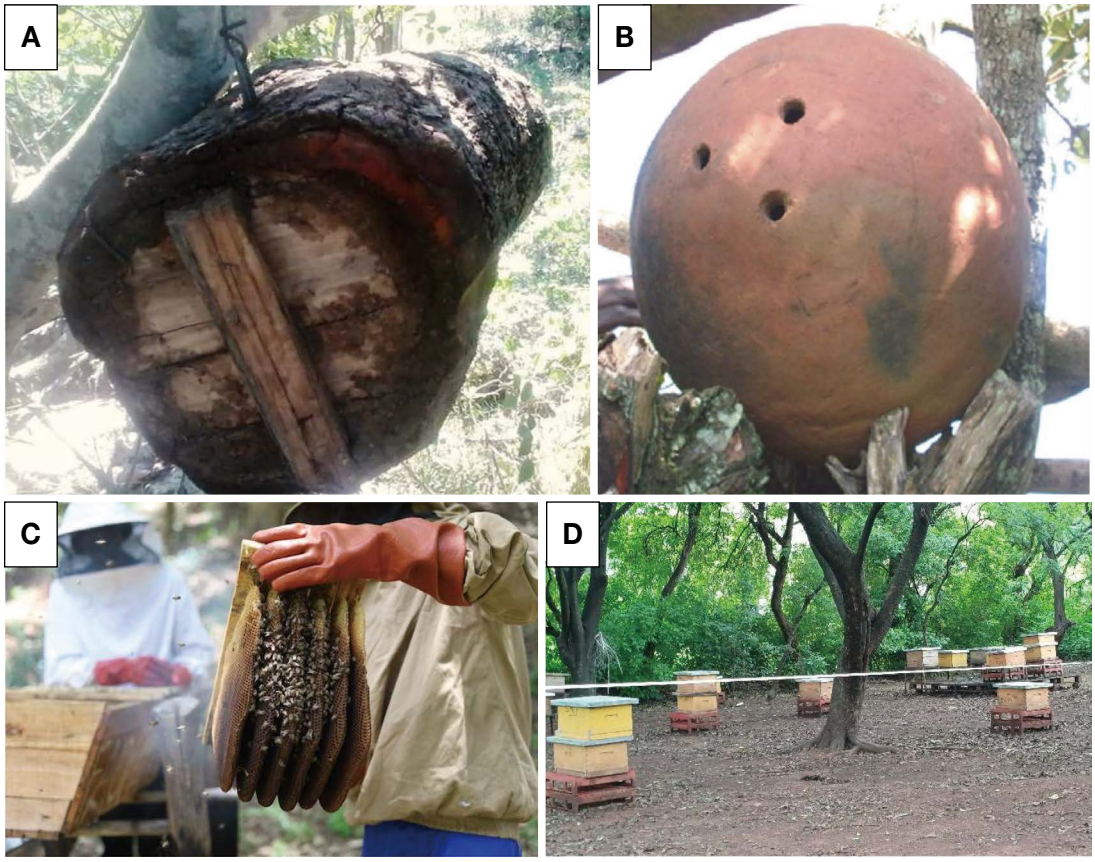

Fig. 3. Different types of hives used in Zimbabwe. (A) Log hive (Mambondiyani, 2023); (B) Clay pot hive (Kasangaki *et al*., 2014); (C) Frames extracted from the Kenyan Top Bar hive (Matiashe, 2024); (D) Langstroth hives (by Bianza Mbavha at an apiary in Harare, Zimbabwe).

resulting in increased honey productivity as it allowed for inspection of the colonies. The government later introduced other beehives such as the Kenyan Top Bar (Fig. 3C) and Langstroth hives (Fig. 3D). Since then, Zimbabwe has witnessed a steady adoption of modern beehives, although most beekeepers still use traditional hives (Nyatsande *et al*., 2014).

3. Current status of beekeeping in Zimbabwe

Beekeeping in Zimbabwe is practiced by both men and women, including the youth. Women have been integral to the sectors of production and economic activity in Zimbabwe, making valuable contributions in several agricultural sectors, including apiculture (Mwandifura *et al*., 2023). There are three common types of beehives currently used in Zimbabwe which are the Traditional, Kenyan Top Bar and the Langstroth hives. The majority of beekeepers in Zimbabwe still use traditional hives (78%), which include tree bark, log, clay pot and bucket hives (Nyatsande *et al*., 2014). This is due to their low cost, availability of construction materials, and the minimal technical skills needed to manage the hives. However, traditional hives come with challenges such as monitoring the bee colonies and low productivity (Nyatsande *et al*., 2014).

In 2023, about 50,000 beekeepers were reported to be established in Zimbabwe (Mambondiyani, 2023). However, there is no available data on the distribution of these beekeepers. The Agritex report of 2014, showed that there are 15,966 beekeepers in Zimbabwe and a total of 85,794 beehives (Mwandifura *et al*., 2021). Fig. 4 shows the distribution of beekeepers for each of the provinces, except Harare and Bulawayo whose information was not recorded. The majority of beekeepers are in the Midlands province (47%), likely because this is where beekeeping extension started in Zimbabwe. Matabeleland South has the fewest beekeepers (only 24),

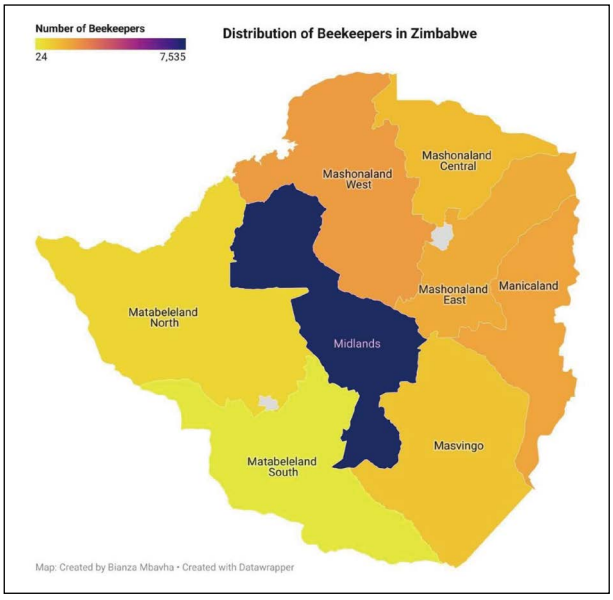

Fig. 4. Distribution of Zimbabwe beekeepers per province by the year 2014. Map created by Bianza Mbavha, using data extracted from Nyatsande *et al.* (2014).

Table 1. Composition of the types (Traditional, Kenya top bar and Langstroth hives) and number of beehives according to provinces in Zimbabwe (Mwandifura *et al.*, 2021).

Province	Traditional hives	Kenya TBH	Langstroth hives	Provincial total
Manicaland	10098	1324	135	11557
Mashonaland East	1539	1337	10	2877
Mashonaland Central	5054	274	15	5343
Masvingo	2160	435	23	2718
Matabeleland North	64	11	954	1029
Matabeleland South	38	130	15	183
Mashonaland West	16793	3531	1100	21424
Midlands	33586	7062	15	40663
National total	67172	14124	2215	85794

which is just 0.2% of total beekeepers in the country. The beekeeping industry is not very favorable in this province since it falls in agro-ecological zone V, where there is very little rainfall, reducing the availability of bee forage (Nyatsande *et al.*, 2014).

The distribution of beehives across different provinces in Zimbabwe is shown in Table 1, adapted from Mwandifura *et al.* (2021) based on Agritex records from 2014. The highest number of beehives are in the Midlands Province (47%), although the majority are traditional hives due to the high prevalence of the big indigenous tree *Brachystegia* spp. Matabeleland South, which has the lowest number of beekeepers consequently has the fewest beehives, with only 183 hives (Mwandifura *et al.*, 2021). Traditional beehives are the most commonly used hives in Zimbabwe (78%). Of all the beehives present in Zimbabwe, only 2.6% are Langstroth hives, making them the least used hives in the country, despite their high productivity and superior honey quality. This is due to the high cost associated with its acquisition and materials needed for it, as well as the very limited financial support available to fund beekeepers (Nyatsande *et al.*, 2014).

BEE PRODUCTS AND SERVICES

1. Honey

Honey is one of the main products of honey bees and is highly sought after by beekeepers. There are over 300 types of honey in the world, differing in appearance, taste, and composition depending on their botanical and geographical origins. The global honey production is 1.72 million metric tons per year, with China being the largest honey-producing country, contributing 29% of the total honey production (Oravecz *et al.*, 2020; Puranik, *et al.*, 2023). In Zimbabwe, honey production is low due to the widespread use of traditional hives that produce low quantities of honey (Nyatsande *et al.*, 2014; Mwandifura *et al.*, 2021). Approximately 69,730 kg of honey is produced per year, and the distribution across provinces is shown in Fig. 5. The highest amounts of honey are produced in Mashonaland West province, likely due to its high number of Langstroth hives, which produce large quantities of honey. Matabeleland South, which has the fewest beehives, is also the smallest producer of honey. The honey produced in Zimbabwe is mainly used by the cosmetics industry in hair and beauty products, in the confectionary industry (e.g. Willards Foods and Crystals Sweets), and the pharmaceutical industry such as the Zimbabwe Pharmaceuticals (Mwandifura *et al.*, 2021). Zimbabwe's honey production cannot meet the country's demand, leading to the importation of 70% of the honey from South Africa and China. Annual honey production in Zimbabwe

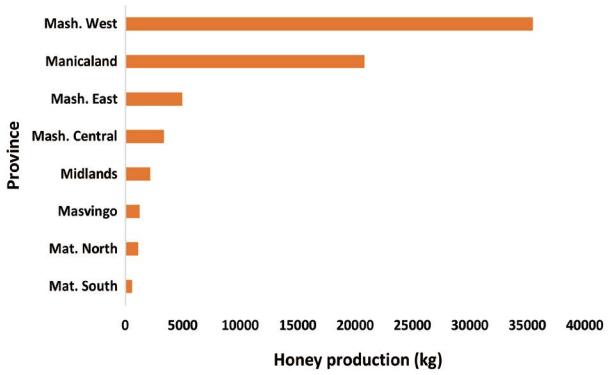

Fig. 5. Zimbabwe's annual honey production by province, reported in 2014 (Nyatsande *et al*., 2014).

has the potential to reach 427 metric tons (Nyatsande *et al*., 2014), given the highly diversified natural flora in Zimbabwe which is favorable for apiculture (Mwandifura *et al*., 2022a). If more beekeepers are trained and the number of bee colonies in the country increases, honey production levels will rise and the honey shortfall will be met (Mwandifura *et al*., 2021). Honey can also be value added; for example, it can be infused with ginger or cinnamon to increase its health benefits. In the Chipinge district, honey is infused with ginger and sold at a higher price (Mwandifura *et al*., 2021). The Sweet Maungwe company in Zimbabwe also infuses honey with ginger and cinnamon, resulting in higher economic value than ordinary honey.

2. Other honey bee products

Other products produced by honey bees include wax, propolis, venom, honeycomb and royal jelly. Royal jelly is highly nutritious and is used as a dietary supplement, as well as in skin and hair care. Beeswax is commonly used in the candle making industry and cosmetics. It has also been shown to have antimicrobial, antifungal and antioxidant properties (Papa *et al*., 2022). Bee propolis, also called bee glue, is known for its antimicrobial properties and is a common ingredient in some dental care products. Bee venom contains peptides with anti-inflammatory and pain-relieving properties and can be used to treat arthritis and other joint-related diseases. The diverse use of honey bee products facilitates the expansion of manufacturing industries in Zimbabwe and can increase income generation for many smallholder farmers. Exporting these products can also generate foreign currency for Zimbabwe and boost the country's economy. However, there is no available published or reported data on quantities of these honey bee products being produced in Zimbabwe.

3. Crop pollination

Honey bees make a crucial contribution to the economy of Zimbabwe through their pollination services. They are capable of pollinating a wide range of crops such as almonds, coffee, cocoa and soybeans, thereby improving the quality and quantity of these crops (Degrandi-Hoffman *et al*., 2019; Khalifa *et al*., 2021). The *Apis mellifera*, which is the common honey bee in Zimbabwe has been shown to have the highest contribution to crop pollination (Hung *et al*., 2018b; Sillman *et al*., 2021). In the United States, the pollination contribution of the honey bee is valued at approximately USD 11.68 billion (Khalifa *et al*., 2021). Since Zimbabwe heavily depends on agriculture to boost its economy, honey bees can significantly benefit the country by increasing agricultural yields. With the expanding human population in Zimbabwe and the ever-increasing demand for food security, beekeeping could serve as the perfect opportunity to enhance food security. Research conducted in the Chipinge district of Zimbabwe (Mwandifura *et al*., 2021) showed that farmers engaged in macadamia nut production who have beehives in their plots had a 30% higher yield compared to farmers without beehives. The same study also showed that honey bees could increase the yield of maize by 24%, sorghum 28%, mangoes 18% and peaches by 23%. These results indicate that beekeeping can promote food security if honey bee pollination services are fully utilized in Zimbabwe.

4. Honey bee species

Globally, bee species (Hymenoptera: *Apoidea*) are estimated to total 20,000 (Zattara and Aizen, 2021). *Apidae* is the largest family within the superfamily *Apoidea*, containing many species of bees including honey bees of *Apis* genus. *A. mellifera* and *A. cerana* are the most important and most domesticated honey bee species in the world due to their high honey production and highly effective pollination (Li *et al*., 2019). *A. cerana* is an Asian bee that is approximately 10~11 mm, has better hygiene awareness and is generally docile

and gentle (Katuwal *et al*., 2023). On the other hand, *A. mellifera* produces larger quantities of honey but is less disease resistant compared to *A. cerana* (Wang and Tan, 2014; Park *et al*., 2015; Katuwal *et al*., 2023). Since the 1700s, several honey bee species have been identified in Zimbabwe such as *A. andreniformis*, *A. cerana*, *A. dorsata*, *A. florea*, *A. laboriosa*, *A. vechti* and *A. mellifera*, with the most common species being *A. mellifera*. The subspecies of *A. mellifera* that are geographically distributed in Zimbabwe are *A. mellifera scutellata* and *A. mellifera adansonii* (Chakuya *et al*., 2022a). These species are common in the Eastern, Western and Southern parts of Africa. Due to the close similarities among honey bees, differentiating each race is critical and requires molecular characterization. *A. mellifera scutellata*, also known as the East African bee, has a small and slender body with an intense yellow color, while *A. mellifera adansonii* has a medium sized body with yellow markings. Both subtypes are strongly aggressive and have a great urge to swarm and abscond but *A. mellifera scutellata* is more commonly used due to its ability to produce more honey (Chakuya *et al*., 2022a). These two subspecies have stings that have the potential to kill animals (Djoko *et al*., 2023), such as humans (Fletcher, 1978), waterbucks (Barnes *et al*., 2005), and goats (Karidozo and Osborn, 2005). Therefore, proper care and appropriate protective clothing should be used when handling these bee subspecies.

CHALLENGES IN THE BEEKEEPING INDUSTRY

1. Pests and diseases

Pests and diseases are among the greatest threats to the beekeeping industry, resulting in the destruction of bee colonies. Several pests and diseases affect bee colonies, such as Varroa mites (*Varroa destructor*), wax moths (*Galleria mellonella* and *Achroia grisella*), small hive beetles (*Aethina tumida*), American foulbrood, European foulbrood, and chalkbrood (Ebeling *et al*., 2022). Varroa mites are among the most damaging honey bee pests in the world, causing malfunction and weakening of bee colonies. They were first discovered in Cape Town, South Africa in 1997 (Allsopp, 1997), and in 2002 they were found close to the borders of Botswana, Swaziland and Mozambique, and were already reported in Zimbabwe (Allsopp, 2004; Dietemann *et al*., 2009).

Controlling these pests and diseases within the hive is essential to maintain healthy and productive colonies. In Zimbabwe, information on honey bee pests and diseases is very scant due to inadequate recording and publishing. However, some confirmed cases of Varroa mites were recorded in 2006 in areas such as Chiredzi, Beitbridge, Chipinge, Masvingo, Bulawayo, Nyanga, Shangani and Gweru. Other diseases of huge economic significance such as the American foulbrood and European foulbrood have not yet been reported in Zimbabwe (Nyatsande *et al*., 2014). Another study conducted in the Manicaland Province reported the presence of ants, honey beetles, honey badgers, spiders and birds feeding on bees and bee products (Mwandifura *et al*., 2023). It is important to conduct research and surveillance on pests and diseases in Zimbabwe as well as collect and publish information that can be easily accessed by other beekeepers, thereby adding to the knowledge of the beekeeping industry within the country. One of the best ways to avoid or minimize pests and diseases in the hive is to maintain good hygiene, keeping all the equipment and the apiary clean. It is also important to regularly inspect and monitor the hives to identify any diseases and pests at an early stage before they spread throughout the colonies.

2. Agrochemicals

Agricultural chemicals such as pesticides and herbicides have a significant impact on the beekeeping industry. These chemicals can drift into beehives, contaminating the nectar, pollen and also water sources for the bees and may also contaminate the honey and wax. Some chemicals are highly toxic and can affect bee health and development, potentially leading to colony loss. Bees may ingest contaminants orally during foraging, and the pollutants can end up in stored foods, such as honey, pollen, royal jelly or propolis. A study conducted in Nyamakate Communal Area, the northern part of Zimbabwe showed that beekeeping in this area is greatly affected by the use of toxic agrochemicals, resulting in the mortality of bee populations (Chakuya

et al., 2022b).

3. Limited access to resources and support

Another challenge in Zimbabwe is the limited access to modern beekeeping hives and equipment due to high cost. Most beekeepers in Zimbabwe are still using the old traditional hives because they are affordable. However, traditional beehives are less efficient, produce low quantities of honey and do not allow regular inspection of the hives. Honey quality is also poor due to the old and outdated equipment used for honey extraction (Mwandifura *et al*., 2021). The Langstroth hive costs approximately USD 200 (without start-up kit), which explains why its adoption in the country has remained very low (Mwandifura *et al*., 2023). Another challenge is the lack of financial support for beekeepers, making it difficult for them to invest and grow their businesses. There is very little support from the government to increase honey production in the country and very few organizations provide financial support to the beekeeping industry. There is also insufficient and inconsistent training and extension services to equip beekeepers with the necessary skills and modern beekeeping practices used in developed countries. Without the relevant and improved skills, honey quality and quantity will remain low and Zimbabwe will not be able to meet the honey demands of its growing population. Since 70% of the honey consumed in Zimbabwe is imported (Mwandifura *et al*., 2021), there is need to improve beekeeping management practices within the country to increase honey production.

4. Adulteration

Adulteration is the intentional or fraudulent replacement or addition of a substance to increase the apparent value of a product or reduce its cost of production (Chirsanova *et al*., 2021). Honey adulteration is a major cause of concern worldwide, especially in developing countries which do not have strict polices and regulations. Honey adulteration involves adding sugar or corn syrup to the honey, diluting it with water, or mixing it with other sweeteners such as glucose and fructose. This affects the aroma, flavor and texture of the honey, thereby reducing its nutritional value and health benefits. It can even pose health risks since the adulteration may affect the shelf life of the honey. Over the past few years, the number of street vendors selling honey in Zimbabwe has increased, despite the number of beehives remaining stagnant in the country. Most of the honey sold on the streets is of unknown origin and it has been shown that much of it is adulterated (Mwandifura *et al*., 2022b). Therefore, there is a great need to educate beekeepers, traders, and consumers about the risks of honey adulteration and methods to identify adulterated honey. The government should also enforce strict regulations and quality control measures to make it difficult for adulterated honey to enter the market.

CONCLUSION AND RECOMMENDATIONS

Apiculture in Zimbabwe remains underdeveloped, with low productivity due to the high prevalence of traditional beehives compared to modern hives. There is little research done and very scarce information available online on current beekeeping practices in Zimbabwe. There is a need to implement apiculture research and intensive surveillance to establish the occurrence and patterns of endemic colony problems since the industry has a high potential to boost the economy of Zimbabwe. Disease and pest surveillance participation by beekeepers is also important through prompt reporting of any diseases and pests attacking their colonies and any colony collapses (Nyatsande *et al*., 2014). It is also important to report the number of colonies to the national authorities so that there is up to date information on the number of bee colonies and bee keepers in Zimbabwe. There is also need to increase extension support to beekeepers through field training of both old and new beekeepers, so as to promote maximum productivity of the beehives available in Zimbabwe. Financial support from the government and other supporting organizations is also crucial to promote use of modern hives such as the Langstroth hive with increased quantity and quality of honey. With more funding and consistent training and extension services, the Zimbabwe bee industry can grow and better equipment and tools can be used. This will result in increased colony population, improved productivity and increased exports of the bee products, thereby unlocking the full potential of economic sustainable development in Zimbabwe.

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