

Dissemination of Stingless Bee Domestication Using Pot Hives in Ambo and Toke Kutaye districts of West Shewa Zone, Oromia Regional State, Ethiopia

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ABSTRACT

The purpose of this study was to raise awareness for domesticating stingless bees to generate revenue and promote sustainable species conservation. A farmer's research extension group that consists of 20 beekeepers per district, was directly involved in the project; 30 beekeepers in total took part in the technology's pre-scaling up. Potential representative kebele per district was chosen. Theory-practical training was given to beneficiaries, and bee experts. According to the study, stingless bee colonies yield an average of 2.53 liters of honey annually, ranging from 0.85 to 3 liters. The net income from *modern stingless bee* practice was US \$ 66.831, while the net income from traditional (hunting) practice was US \$ 12.875. The study shows that employing modern stingless bees yields a return that is US \$ 53.974 higher than honey hunting. Notable advancements have been made in the management of stingless bees, species conservation, and the amount and quality of honey produced.

INTRODUCTION

Stingless bees (Apidae, Meliponinae) are a group of eusocial insects with various genera known to live in tropical and sub-tropical regions of the world. Eusocial insects belonging to several species. A total of 20,000 distinct species of bees were discovered, with differences in size, shape, and way of life (Velthuis, H. H., 1997). According to Cortopassi-Laurino et al. (2006) and Eardley (2005), stingless bees are found in different parts of the world and belong to 58 genera, or 600 species. About six genera, or twenty species, of the numerous stingless bee species thought to exist worldwide (Michener 2007) are known to reside in Africa (Eardley 2005). Only five of these species have been discovered in Ethiopia to yet (Pauly and Hora 2013).

More *Meliponula beccarii*, sometimes called "Damuu," more are probably going to be introduced into Ethiopia since it is one of the most common species (Pauly and Hora 2013). The unique species *Meliponula beccarii* builds its nest in the subterranean soil, where the bees store and generate honey and pollen. It is a permanent colony. These bees use resins from a wide range of plant species for the building of their nests and chemical defenses against their diseases (Wilms et al. 1996; Leonhardt et al. 2009). *Meliponula beccarii* is a fairly docile species whose non-stinging habit makes it easy to maintain and adapt to household gardens for both pollination services and high-quality honey production. Because they play a major role in providing ecosystem support services that are essential to the survival of many forest plant species and crops through pollination, stingless bees are economically significant (Adler et al., 2023).

In Ethiopian rural communities, the production of honey from wild stingless bee (*M. beccarii*) colonies through honey hunting has a long history. In Ethiopia, traditional medical practices for wounds, respiratory conditions, surface infections, diarrhea, and other illnesses consider honey made by stingless bees to be crucial (Andualem, 2013). Because of this, stingless bee honey has a reputation for having a high market demand and fetching greater prices than honey made by *Apis* bees that are sold in various parts of Ethiopia.

These precious bee species, especially in Ethiopia, have received less attention despite their ecological significance and highly sought-after honey. Because of this, the traditional and damaging honey gathering method decreases the benchmark for honey quality and threatens the diversity of endangered species. At the Holeta bee research center apiary site in Ethiopia, this is the first successful phase of stingless bee domestication and management in pot bees' hives (Zewdu & Bayeta, 2021).

Therefore, it is crucial to teach small-scale farmers how to domesticate and maintain stingless bees in order to produce honey of higher quality, generate revenue, and preserve species. This study aimed to raise awareness of the benefits of domesticating stingless bees in order to support long-term species conservation and earn income.

THEORETICAL REVIEW

Stingless Bees (Meliponini)

The stingless bees represent one of the pinnacles of social organization among insects. Among their distinguishing features are very high species

diversity with extreme variation in body size, large, complex societies with strong queen-worker dimorphism, elaborate nest structures, diverse foraging behavior and diet, repeated evolution of obligatory cleptobiotic behavior, and a vestigial venom apparatus.

Of the approximately 550 species of the pantropical tribe, 75% are located in the Neo-tropical zone. Meliponiculture, the practice of maintaining stingless bees in hives, has drawn more interest within their natural area since it allows them to produce honey and other colony products in addition to pollinating crops. Certain species can thrive in urban settings and even adapt to voids in man-made constructions (Gabriela, 2020).

Diversity and Habitat

The Meliponini tribe of stingless bees is a pantropical, monophyletic group. According to available data, stingless bees can be divided into two main monophyletic groups: the Old-World lineages and the New World fauna (Rasmussen & Cameron, 2010). Considering the size of their bodies, stingless bees need vast cavities. Another characteristic of stingless bee nests is that they are completely enclosed areas with just a tunnel for restricted access that leads to the outside through a somewhat small entrance hole. To restrict the amount of space the colony can occupy, the bees may build wall barriers, which are primarily composed of pure resin or resin combined with mud and/or inert organic debris, depending on the size of the cavity. Known as batumen, these walls usually include tiny gaps that let gases pass through. Certain species, primarily *Melipona*, have perforated batumen that closes the bottom of the nest chamber, allowing condensed water to drain. In species that nest in dirt cavities, drainage canals are often located near the bottom of the nest; they have also been observed in arboreal nests.

The size of the colony varies depending on the season and colony stage (Michener, 1974, Michener, 1974, Roubik, 2006). Smaller nest adversaries like ants, phorid flies, and other arthropods can also harm stingless bees. Stingless bees, like other social bees, are generalists in their pursuit of food, gathering pollen and nectar from a variety of plant species (Vit, et al., 2018).

Domestication of stingless bees

Ethiopian farming communities have a long history of using honey hunting to produce honey from wild stingless bee (*M. beccarii*) colonies. There have been reports of the widespread use of this traditional practice and the profusion of wild stingless bee nests from the country's central (Ebissa et al. 2012; Kinati 2020), northern (Lemma, 2018), and south-western (Shenkute et al. 2012) high- and mid-highlands. Similar to honeybee honey, a significant amount of stingless bee honey produced by local hunters is supplied to the local markets each year. As a new potential for sustainable honey production and for the protection of the local species, a successful attempt was made to domesticate and manage colonies of *M. beccarii* in specially built pot hives (made of clay soil) (Zewdu and Bayeta, 2021). Local potters built the pot hives in accordance with the natural nest structures of feral colonies, which include all of the components like the entrance tunnel, the chamber for honey and brood, and the hole for feces.

Using a disposable syringe, two seasons' worth of honey was extracted from pot hived colonies; the average production per colony per year was 1.10 ± 0.20 L, ranging from 90 ml to 3 L.

METHODOLOGY

Description of Study Areas

The Ambo and Toke kutaye districts of the West Shewa Zone of the Oromia Regional National State were the study's locations. Ambo is situated 110 km west of Addis Ababa at an elevation of 2,101 meters, with latitude and longitude of $8^{\circ}59'N$ $37^{\circ}51'E$. Ambo serves as the zone's capital, and there are 34 rural kebeles in the district. According to the CSA (2007), the district had a total population of 108,406 as of the national census, of which 54,186 (49.98%) were males and 54,220 (50.01%) were women. Conversely, Toke Kumatye is situated between $8^{\circ}59'N$ and $37^{\circ}46'E$ in terms of latitude and longitude. Gudar serves as the town's capital, and there are 34 rural kebeles in the district. There were 119,999 people living in this area as of the 2007 national census, with 59,798 (49.83%) males and 60,201 (50.71%) women (CSA, 2007).

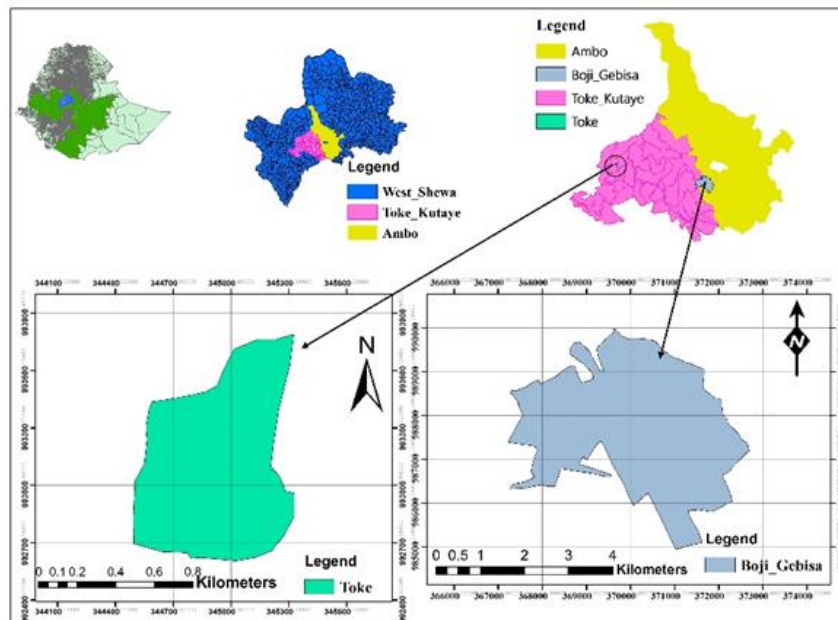


Figure 1. Map of the study areas

Source: ArcGIS software (version 10.4), 2024.

Target Areas and Beekeepers' Selection

Based on the availability of abundant stingless bees with traditional (hunting) practice, as well as an indication of declining stingless bee nests (population), the dissemination of stingless bee (*M. baccarii*) honey production using pot hives was carried out in Ambo and Toke kutaye districts of West Shewa Zone. Additionally, the area receives priority intervention as a valuable lesson because to the large number of beekeepers and demand from beekeepers to the new practice. Based on the facilities and resources that were available, one representative kebele per district was chosen. Then, based on their desire to take part in the initiative and share the knowledge they had acquired with the local

community in order to further promote best practices, interested beekeepers were established.

A farmer's research extension group (FREG) participant strategy that consists of 15 beekeepers per district, was directly involved in the project. Thirty beekeepers in total took part in the technology's pre-scaling up. All gender groups were taken into account in the selection criteria for participation, with a focus on low-income households and women. The appropriate district bureau of agriculture office was closely consulted with the selection of the location and beekeepers.

Research Approach to Technology Uptake Pathway

Through this effort, connections were made with all pertinent parties. Beekeepers, researchers, government officials, and honey traders were all actively involved in the project's coordination. To establish a shared understanding of the project's goals and anticipated outputs, a memorandum of agreement was first formed with the Bureau of Agriculture office before to activity implementation. Three farmer's research extension groups, or FREGs, were typically established, with one FREG made up of ten beekeepers at each suitable site.

Subsequently, extension agents and beekeepers received theory-cum-practical training as a future resource for people. Training covered hunting, excavating, transferring into pot hives, feeding, and collecting honey for stingless bees (*M. baccarii*). Then, as a learning center (experience sharing) each site per district, apiary sites were developed where stingless nests with pot hives to be set at model beekeepers' backyard. The stingless bee nests were carefully excavated, moved into pot hives, and had their lids sealed with mud (Figure 2a-d). In order to sustain robust colonies, queen right colonies including broods, pollen, and honey were put inside the pot hive. Ultimately, three model beekeepers established 21 stingless bees (*M. baccarii*) and implemented all management procedures, including supplemental feeding and pest control.



Figure 2. Stingless bees nest excavation (a), transferring into pot hives (b), smear pot with mud (c), and ready for bury (d)

Every FREG has group standards that promotes the growth of fellowships, harnesses the power of synergy, and assigns tasks and obligations to members for mutual benefit (Lalisa, 2021). In addition, democratic votes were cast for the Chairperson, Secretary, Cashier, and Controlling Committee to oversee the FREG. In addition, practical instruction in record keeping, entrepreneurship, problem-solving techniques, and women's empowerment was given.

Data Types and Methods of Data Collection

Data were gathered from primary and secondary sources in both qualitative and quantitative formats. Both qualitative and quantitative data were collected using a variety of methods, including in-depth key informant interviews, focus groups, and observations for qualitative data; and semi-structured questionnaire for household interviews for quantitative data. Documents that were both published and unpublished provided the secondary data.

Statistical Data Analysis

The narrative of response and content analysis methodologies were used to examine the qualitative data that was gathered through focus group discussions, direct observation, and key informant interviews. Nonetheless, statistical tools for descriptive (frequency percentage) and inferential analysis (mean, and partial budgeting) were employed to examine the gathered quantitative data. The economics of pot hive technology was examined using partial budgeting.

RESULTS AND DISCUSSION

Stingless bee (M. baccarii) Honey Production Practice and its Uses

Brief meetings were scheduled for this study with local elders, including women, to talk about the stingless honey producing method in the areas. The discussion was held with the consent of all participants. Information about the stingless bee honey production system, such as honey harvesting, management techniques, and marketing strategies, was gathered using a checklist. The participants in the focus group noted that traditional practices are widespread, harmful, and have an adverse effect on the quality of honey as well as the loss of species diversity. When collecting honey, it results in honey loosing. This could be the outcome of less focus being placed on these priceless natural riches that God has given us. Another issue is a lack of knowledge and information necessary for the preservation and benefit of the species.

The stingless bee (*M. baccarii*), in response, is said to make its underground nests around farmlands, muddy places, forested regions, and riverbanks by the indigenous people. Nearly all honey is used locally for income-generating purposes. Elders are aware that honey and pollen have traditional medical uses, including the treatment of severe coughs, the alleviation of stomach aches, and the healing of wounds and fungus-infected skin in people. Since a few years ago, the spread of farms (which disturbs ecosystems), the removal of

forests, the use of pesticides, and recurrent climate change have all contributed to a sharp decline in the stingless bee population. Furthermore, according to key informant interviews, honey is produced twice a year to keep pollen and nectar available during the rainy season. A honey yield would occur if there is a sufficient and regular amount of rainfall; otherwise, none. This suggests that, similar to honeybees (*Apis mellifera*), stingless bees are highly vulnerable to ongoing climate change.

Training on Modern Stingless Bees Management

For the target farmers and study sites, employing pot hives to raise stingless bees (*M. baccarii*) was a novel approach. As a result, training is essential to help farmers advance their knowledge and abilities so they can absorb new information. Subsequently, theory-practical training was given to farmers, development agents, and bee experts. The training was reinforced by PowerPoint, flip charts, posters, and video shows (Table 1).

Table 1. Training participants by sex composition prior to actual activity implementation

No	District	kebele	Training participants						Total
			Farmers		Development agents		Bee experts		
			Male	Female	Male	Female	Male	Female	
1	Ambo	Bojigebis	11	4	8	1	4	2	30
2	Tokekuta	Toke	6	9	6	2	4	2	29
Total			17	13	14	3	8	4	59

Source: Own data 2024

Stingless bees (*M. baccarii*) Modern Management Techniques

Farmer’s research extension group established after receiving formal training in order to promote the exchange of information regarding stingless bees kept in pot hives. By getting extension agents and assisting in the creation of favorable conditions for cooperation and the sharing of knowledge and skills among FREG members, FREG would be able to reduce transaction costs. In both areas, a total of 21 queen right stingless bee (*M. baccarii*) colonies were established (Figure 2). Every colony within the pot hive was positioned correctly in the ground by having its entrance left open in a vertical orientation (Figure 3a). Strong bee colonies were achieved using management techniques including shade, supplementing nutrition, and guarding against pests. However, inadequate fencing and shade in apiary at Ambo district resulted in the loss of a relatively small percentage of stingless bee colonies. It suggests that the likelihood of stingless bee colonies absconding is lower. Unlike honey bees (*Apis mellifera*), stingless bees don't sting, thus anyone who is productive – including women – can operate them. Women's engagement in the beekeeping enterprise

is impacted by the stinging behavior of honeybees (*Apis mellifera*) (Qaiser, et al., 2013; Chemurot, 2011). It demonstrates how women can have the opportunity to profit from stingless bee techniques in the present era.

Stingless Bee Honey Yield and Marketing

One of the most significant activities of stingless bees in the study areas is the production of honey, which they use as a medicinal source and a means of income. According to Quezada-Euán et al. (2018), stingless bees' economic worth is the most significant factor overall. In both Ambo and Tokekutaye districts, it was discovered that stingless bees can produce between 0.85 and 3 liters of honey per colony annually, with an average production of 2.53 liters (Table 2). This suggests that the areas have the potential to support stingless bee populations. This study found no significant differences in stingless bee honey yield between locations at a significant level of $p < 0.05$ in this study.

Table 2. Honey yield from modern stingless bees across locations

S/N	Districts	Liter			t-test
		Minimum	Maximum	Mean	
1	Ambo	0.85	1.25	2.21	
2	T/kutaye	1.65	3	2.85	-0.42
Total				2.53	

Source: Own data 2024

Nevertheless, the conventional procedure yielded 0.5-1 liters of stingless bee honey, which is dirty and distracting. The typical amount of honey harvested using conventional stingless methods was 0.6 liters per colony. A sharp stick was used to puncture honey storage chambers during the honey harvest, resulting in the flow of honey (Figure 3b). The flip-over method was used very carefully to filter the ripened honey, keeping debris, fallen branches, and dead bees out of the honey (Figure 3b). The production of stingless honey typically occurs twice a year on average. There have been improvements noted in the quantity and quality of honey produced, as well as in the conservation of species and stingless bee management. Unlike stingless bee's honey hunting, technology adopters (beekeepers) leave some honey for the continuation of the colony. Recipients stated that throughout our time in the area, they had never seen such a large quantity and high-quality honey.



Figure 3. Buried pot hive (a) stingless honey extraction (b), processed honey (c)

The technology's use offers the chance to preserve bee colonies' availability while also increasing income. According to the study, beekeepers in the area had no trouble selling their honey. Actually, the roadside market in the village is where most of the honey produced in the area is sold. In the research locations, pot hive honey was sold for an average of US \$ 28.571 per liter. The average gain of stingless bee honey from pot hives (liter) is significantly more than cost of honey from honeybees, US \$ 10.714/kg (2023). This research supports the findings of Hsien et al. (2016) and de Oliveira Alves (2013), who reported that stingless bee honey price is more than honey derived from *A. mellifera*. This paper demonstrates how the worth of stingless bees cannot be compared to the money made from their products. This is so because stingless bees' products and services are unique and cannot be found anywhere else. Stingless bees are widely valued for their essential role in pollination, food production, medicine, and cultural practices. Their benefits transcend financial gains. For example, money cannot cure disease; honey can.

Profitability of Pot Hive Technology

A basic financial analysis was conducted to determine the pot-hive technology's potential profitability. Assuming other costs are identical for both modern stingless bees' management and stingless bee honey hunts, pot hive cost, supplemental feed cost, and honey yield were recorded and compared to determine the profitability of modern stingless techniques vs. traditional stingless operations. To calculate the net return from both approaches, an analysis was conducted. Table 3 lists the additional feed costs and pot hive purchasing costs for modern stingless bee management under column one, category of cost. The average cost of purchasing supplemental feed and pot hives was US \$ 1.852 and US \$ 3.703, respectively (2023).

On the other hand, the benefit of both stingless bee management practices was the honey yield, which fell under column two, return. The entire revenue from each kind of stingless practice was calculated by multiplying the honey yield from stingless bees by the selling price. For current stingless bees and stingless bee honey hunters, the average annual honey yield in the research area was 2.53 and 0.6, respectively. During the study period, the average cost of one liter of honey produced by modern stingless bee practices and stingless bee honey hunting was US \$ 28.571 and US \$ 21.429, respectively (2023).

The net benefit was calculated using the honey yield from one of the model farmers' contemporary stingless bees and the honey taken at random from nearby farmers who engage in stingless bee honey hunting. According to the study, a single model farmer in the Toke kutaye district harvested fifteen liters of honey from seven pot hives. On the other hand, the computation was done using 0.6 liter of honey production from honey hunting.

Table 3. Analysis of profitability of pot hive technology

	Column 1	Column 2			
Added cost	Modern stingless management	Stingless bee honey hunting	Additional return	Modern stingless management	Traditional stingless practice
Pot hive	3.636	0.00	Honey yield	2.53	0.6
Supplementary feed	1.818	0.00	Total added return	72.285	12.857
Total costs of production	5.454	0.00	Total return from sells of honey	66.831	12.857

Source: own data computation, 2024

The net revenue from modern stingless bee management technique was US \$ 66.831, according to Table 3, whereas the net revenue from stingless bee honey hunting (traditional) was US \$ 12.857. According to the study, using contemporary stingless bee results in a US \$ 53.974 increase in return over using stingless bee honey seeking.

Exit strategies for ensuring project sustainability

The benefits of pot hive technology were preventing the destruction of stingless bee colonies, saving time and work, and producing honey of a high caliber and quantity. Therefore, it is vitally important to guarantee the continuous success of technology across broader domains and more beneficiaries. Farmers, non-governmental groups, and pertinent government entities, for example, who operate in potential regions where technology might be further extended, received training. In addition, producers of stingless bee honey were urged to keep up their high-quality, high-volume honey production. Targeted farmers were also provided with information about where to sell their extra honey. In addition, Field Day was planned to raise awareness and spark interest in the technology. This strategy might make development intervention more successful over the long run.

CONCLUSIONS AND RECOMMENDATIONS

In Ethiopia in general and study regions in particular, the dissemination and domestication of stingless bees using pot hives for honey production and income is still in its infancy. Due to intervention, there have been advances in the amount and quality of honey produced as well as in the management of stingless bees and species conservation. For example, powerful stingless bee colonies were established with novel methods of management. There was reduced chance of stingless bee colonies going missing. If there was enough consistent rainfall, there would be a honey yield; if not, none. This phenomenon increases people's susceptibility to the effects of climate change.

The use of pot hive technology resulted in the production of high-quality, abundant honey, time and labor savings, and the prevention of the destruction of stingless bee colonies. Furthermore, stingless bee colonies produce 2.53 liters of honey on average per year, as opposed to 0.6 liters per year from traditional methods. Therefore, employing modern stingless bees (in pot hives) yields a return that is US \$ 53.974 per colony more than that of using conventional stingless bee practices.

In general, encouraging the domestication of stingless bees in suitable locations will give pro-poor farmers, especially women and young people without access to technology, land, or income, a new source of revenue. The care of stingless bees requires the least amount of capital and does not compete for labor, time, or land. Thus, it is crucially important to scale up even further for large farmers and in locations where stingless bees are found. Furthermore, the nation's stingless bee population needs to receive the proper attention from non-governmental organizations, governmental authorities, and the commercial sector involved in development projects.

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FURTHER STUDY

Future research should explore the genetic diversity, adaptability, and resilience of stingless bee species in different ecological zones of Ethiopia to enhance colony productivity and climate resilience. Investigating the impact of environmental variables, such as rainfall patterns, floral resource availability, and land-use changes, on honey yield and colony survival would provide valuable insights for sustainable beekeeping practices. Additionally, economic assessments should be expanded to evaluate the long-term profitability and scalability of pot hive technology for smallholder farmers, particularly in different socio-economic contexts. Comparative studies on the nutritional and medicinal properties of stingless bee honey versus conventional honey could further highlight its market potential and health benefits. Research should also focus on policy development, exploring ways to integrate stingless beekeeping into national agricultural and rural development programs. Lastly, studying the effectiveness of training and knowledge dissemination strategies among farmers, especially women and youth, would be essential for scaling up adoption and maximizing the socio-economic benefits of stingless beekeeping.

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