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Research

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Survey of beekeeping systems, management practices, pests, and indigenous pest control strategies in Ghana

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Abstract

Introduction: *beekeeping is vital for pollinating crops and producing honey and other honey bee products. Pests, however, play a detrimental role in beekeeping, causing extensive colony losses and disrupting beekeeping operations. Despite their adverse effects, information on honey bee pests in Ghana is lacking.* ***Methods:*** *a cross-sectional snowball method was used in the absence of a beekeeper´s register to interview 51 consenting beekeepers from September 2023 to January 2024 in selected communities across three regions in Ghana to assess their beekeeping systems, management practices, pests, and indigenous pest control methods.* ***Results:*** *most of the beekeepers interviewed were from the Bono Region (49.0%), followed by the Bono East Region (47.1%), and the Eastern Region (3.9%). The average age of beekeepers was 46.9 years, predominantly male (88.2%), and had on average 3.4 apiaries and 9.5 years of experience in beekeeping. Most (94%) of the beekeepers used transitional hives, 14% used modern hives, and 2% used traditional hives. All the beekeepers reported encountering pests, and they ranked ants (35.1%) as being the most significant honey bee pest, followed by small hive beetles (20.1%), lizards (20.0%), wax moths (13.5%), and termites (6.2%). Their indigenous knowledge and practices included using magic chalk, fluids (water, oil, grease, dirty oil), insecticides, plastic polytene materials, or ash, among others to control honey bee pests in the area.* ***Conclusion:*** *this study has provided preliminary information on common honey bee pests in Ghana. Further investigation is needed to validate the indigenous pest control strategies and generate better alternatives for beekeepers.*

Introduction

Beekeeping, also called apiculture, refers to all activities that concern the practical management of social bee species [1]. This includes managing honey bee colonies for pollination of crops and the production of honey and other honey bee products [2]. Though once considered minimal within the animal sectors, beekeeping has become an activity of interest in recent years, providing jobs and income [3-5]. It is considered a suitable agricultural subsector for the rural poor since it can significantly contribute to income diversification and the improvement of the livelihoods of rural communities, thereby boosting the national economy [6]. The activity supplies valuable market goods (honey, pollen, royal jelly, propolis, wax, etc.) and livestock (artificial swarms, packed bees, queens) [7]. Honey bees also ensure food security by indirectly increasing crop productivity through their essential roles as pollinators and directly as honey producers [8,9]. Honeybees contribute to nearly 75% of the world´s food crop production [10].

In sub-Saharan Africa, and specifically in Ghana, there is substantial potential for honey production [11,12]. Ghana´s tropical climate, with its diverse agro-ecological conditions, ensures the year-round availability of flowers from numerous species of wild and cultivated plants, providing abundant forage for honey bees [13]. Beekeeping is reported to give up to 281.10% return on investment in Ghana [14], pointing to its local profitability. Despite this potential, beekeeping as a commercial venture remains underdeveloped in Ghana, with domestic honey demand largely met through imports from other countries [15]. Honey bee populations are facing numerous challenges due to globalisation, agrochemical pollution, environmental changes, and organisms that threaten their health, and it requires correct colony management that encompasses a wider One Health approach to protect the honey bees, humans, and the environment [16]. Beekeeping management practices are also fundamental to resilient and productive beekeeping operations [1]. A lack of knowledge and experience in specific beekeeping systems (tailored hive types) colony management and harvesting techniques can exacerbate the absconding rate or mortality of honey bees [17,18].

Pests play a particularly detrimental role, and they can cause extensive colony losses and disrupt beekeeping operations. Notable honey bee pests reported inflicting severe damage on honey bee colonies or beekeeping materials across different regions [19]. Apicultural pests such as wax moths, large hive beetles, and ants reportedly cause up to 50% loss of managed honey bee colonies in certain parts of Africa [18]. A study by Jeil *et al*. [20] that sought to understand the challenges to the sustainability of beekeepers' livelihoods in Ghana identified pests and predators as one of the top challenges. Despite the benefits of beekeeping and the reported significant threat by honey bee pests, there is limited knowledge on the specific pests impacting beekeeping in Ghana and how the beekeepers are locally managing these pests. Hence, this study focused on assessing the beekeeping systems, management practices of beekeepers, the kind of pests that are encountered in the beehives as well as the indigenous pest control strategies that are being used by bee farmers to control these pests in Ghana.

Methods

Study design: this study was a cross-sectional study conducted in specific areas of selected regions where beekeeping was a major occupation. Before the study, the literature was reviewed, and relevant information was collected through consultation at various levels with seasoned beekeepers and researchers in Ghana.

Study area: the study was conducted in three regions in Ghana, namely, Bono, Bono East, and Eastern as displayed in Figure 1. The first two selected regions are located in the forest-savanna transitional zone and the third region (Eastern region), is located in the forest belt of Ghana. The vegetation of the Eastern Region is tropical, and the rainfall pattern is the double maxima with dry and wet seasons [21]. The Bono and Bono East regions were originally part of the Brong Ahafo region before the reorganisation in 2018. All three regions had significant beekeeping history and potential for commercial expansion.

Sampling methods: a purposive sampling technique was used to select three regions, and a snowball method was used to reach individual beekeepers in the specific communities. The selected areas were based on their beekeeping experiences and potential for commercial beekeeping. Because there is no obligation to register as a beekeeper at any official establishment in Ghana [22] there was a lack of organised data on beekeepers or registries in the country. Hence, the snowball technique was used, as the researchers relied on individual beekeepers to refer them to other beekeepers they had contact with or could provide their addresses.

Data collection: data for this study were obtained from a structured questionnaire which was prepared by modifying a previously used questionnaire prepared by Shimelis [23] and subsequently pre-tested. The questionnaire instrument consisted of a section that collected beekeeper information, apiary information, beekeeping experience and production system, hive management, pests and predators, and local control methods for the identified pests. The questionnaires were administered to consenting beekeepers from September 2023 to January 2024. The questionnaire was self-administered to the identified beekeepers.

Data analysis: the collected data were entered into a Microsoft Excel spreadsheet version 19 for cleaning and coding before export to Statistical Package for the Social Sciences (SPSS) software version 27 for analysis. The results were reported using descriptive statistics (counts, percentages, means, and standard deviations) and presented in tables and figures. The ranking of the different types of honey bee pests obtained in the study was done using the rank index formula described by Musa *et al*. [24].

Results

Socio-demographic and beekeeping characteristics: the Bono region had 49.0% of the participants, followed by the Bono East Region (47.1%). The beekeepers were predominantly male (88.2%) and almost three-quarters (74.5%) were married. Regarding educational status, 39.2% had tertiary education, 25.5% had junior high or secondary education, and 5.9% were illiterate (Table 1). Participants indicated they learned beekeeping through a local master (experienced) beekeeper or got into the activity after being trained by an organization, for example, bee for Development Ghana. The study showed that all the participants were keeping bees (Table 2). Their average age was 46.9 (±14.7) years, and the age distribution showed that 27.7% were aged 31 to 40. They had, on average, 9.5 (±9.0) years of beekeeping experience, owning averagely 3.4 (±7.0) apiaries and 105.41 (±211.8) beehives per beekeeper. Only one participant had traditional hives (10 hives), and the average for transitional hives and modern hives were 105.7 (±212.7) and 33.6 (±37.5) respectively. The beekeepers had some bee hives empty, this included on average, 36.91 (±60.4) transitional hives and 11 (±9.7) modern hives (Table 2).

Out of the total beekeepers, 94% used transitional hives ("Top Bar or modified Kenyan top-bar"), 14% used modern hives (Langstroth), and 2% used traditional hives (Figure 2). Traditional beehives in the area were made from material items such as clay pots (Figure 3A), drum barrels, logs (i.e. from Borassus species (spp.) (Figure 3B), palm fronds and roofing sheets. The transitional and modern hives were made from wood. The hive woods were sourced mostly from locally available trees like Odum (*Chorophora excelsa*), Wawa (*Triplochiton scleroxylon*) *Gmelina spp*, Dahoma (*Piptadeniastrum africanum*), and Mahogany (*Kyaya ivorensis*); and some were imported western hive parts assembled locally (Langstroth). The installation of the hives at the apiaries was done by placing them on support structures such as hanging on trees (Figure 3A [25] and Figure 3B [26]), wood-erected sheds (Figure 3C), metal stands (Figure 3D), water filled gallons (Figure 3E) and car tyres (Figure 3E and Figure 3F).

Beekeeping management practices: most (98.0%) of the beekeepers started by catching swarms, while 2.0% received their first bees as gifts from parents (Table 3). The beekeepers catch the swarm by setting boxes containing baiting materials (i.e. bee wax, honey, citrullina extract, cow dung) up on trees or support structures (Figure 4). Close to half (45.1%) of the beekeepers kept their hives on the farm, 41.2% in the forest, 9.8% both in the forest and on farms, and 3.9% in their backyard (within the boundaries of their residence) (Table 3). The survey results in Table 3 showed that 96.1% of the beekeepers usually visited their bee colonies to inspect (externally), and 90.2% usually cleared around their apiaries. Also, 56.9% of the beekeepers took measures like division of overcrowded colonies, provision of food and water, prevention of predator disturbances via clearing of apiary bushes, and controlling pests to control or prevent swarming or absconding, while 43.1% did not. Most of the beekeepers (94.1%) had empty beehives, and the bees were mostly said to have aggressive (80.4%) behaviour. The objective for beekeeping for most of the beekeepers (68.6%) was for commercial production of honey, the rest (31.4%) kept bees for both self-consumption of honey and commercial sale of the honey. Close to half of the beekeepers (49.0%) knew about queen rearing and colony multiplication (Table 3). All (100.0%) of the beekeepers produced honey, 94.1% produced crude beeswax, 13.7% produced propolis, and 3.9% produced pollen (bee bread) (Figure 5).

Honey bee pest and control methods: the ranking of the predominant honey bee pests as identified by the beekeepers is presented in Table 4. All the beekeepers reported encountering pests in their apiaries. Ants were ranked as the most significant honey bee pests in the area, followed by small hive beetles, lizards wax moths, termites, and spiders. Other pests in the area included wall

geckos (13.7%), rodents (9.8%), praying mantis (3.9%), wasps (3.9%), chameleons (2.0%), snakes (2.0%), and frogs (2.0%) (Table 4).

Local control methods for honey bee pests and predators: the local control methods for the honey bee pests by beekeepers were varied and specific to each pest. They are summarized in Table 5.

Discussion

This study examined beekeeping systems, management practices, pest challenges, and indigenous pest control strategies in the Bono and Bono East regions of Ghana, areas identified as significant centers for beekeeping due to their favorable ecological conditions [27]. The findings revealed that 88.2% of beekeepers were male, a pattern consistent with other studies in Ghana and across Africa, where gender roles, fear of bee stings, and limited access to land are cited as major barriers to female participation [6,20,28]. This male dominance in beekeeping may be further influenced by patriarchal structures that define traditional gender roles, limiting opportunities for women in agricultural ventures, including beekeeping. Addressing these barriers through gender-sensitive interventions could be crucial for promoting inclusivity and expanding the role of women in the beekeeping industry. The study also found that 74.5% of the beekeepers were married, which reinforces the perception of beekeeping as a supplementary income-generating activity that supports household livelihoods, as previously reported by Llorens-Picher *et al*. [23]. The higher literacy rate observed among beekeepers in this study compared to those in Kenya [6] and Ethiopia [22] suggests that better educational access in Ghana may positively influence beekeepers' ability to adopt modern practices and improve management techniques. This enhanced literacy could be a significant factor in the successful transition from traditional to more advanced beekeeping systems observed in this region.

The average age of beekeepers in this study was 46.8 years, indicating that beekeeping in the area is largely dominated by middle-aged individuals, with limited participation from younger generations. This is slightly higher than the 43.7 average years reported among beekeepers in a similar study in Kenya [22]. The significant participation of the aged/retirees in beekeeping shows the potential to exploit beekeeping to supplement their income during retirement. This also could be seen as an international trend, since the average age of beekeepers in developed regions like Europe, the United Kingdom, and North America range between 53-62 years [29]. This trend raises concerns about the future of beekeeping as a sustainable livelihood if youth engagement remains low. Targeted programs aimed at educating and attracting younger individuals to beekeeping could be essential for ensuring the long-term viability of the sector. Beekeepers in this study had an average of 9.5 years of experience, which is significantly higher than the average 4.69 years and 5-10 years reported in Kenya [22] and Ethiopia [6] respectively. This longer tenure in beekeeping suggests a greater accumulation of knowledge and skills, which would contribute to more effective hive management and higher productivity. Previous studies have shown that long-term engagement in beekeeping leads to improved colony management and increased yields [30], further supporting the importance of experience in successful beekeeping operations. In terms of beekeeping practices, the study found that beekeepers managed an average of 3.43 apiaries, suggesting relatively large-scale operations compared to 2.2 and 2.95 reported in Kenya [22]. However, the high number of empty hives points to potential challenges in colony establishment and maintenance. These challenges may be attributed to factors such as improper baiting techniques, inadequate swarm populations, or environmental limitations that hinder colony sustainability. Further research is needed to explore these issues and identify solutions to

improve hive occupancy rates and overall productivity.

It was observed in this study that three types of hives namely traditional, transitional (Kenyan top bar), and modern (Langstroth) were used in keeping bees, with most beekeepers shifting towards transitional hives. This shift highlights the successful adoption of these hives in Ghana, likely due to the support from local institutions, such as the Technology Consultancy Centre of Kwame Nkrumah University of Science and Technology [27,31]. However, this differs from trends in Kenya, where traditional hives still dominate [22]. This contrast underscores the importance of local context and the role of technology transfer in shaping beekeeping practices. Future studies could investigate the specific motivations driving hive choice and adoption to understand better the factors that influence technology uptake in different regions. Swarm catching remained the primary method for acquiring colonies, highlighting a continued reliance on wild bee populations for apiary sustainability [18]. This dependence raises concerns about the long-term viability of beekeeping operations, especially in the face of environmental changes that could reduce wild bee populations and swarm availability. The prevalence of farm and forest-based beekeeping, as opposed to backyard beekeeping practiced by 58.9% of beekeepers) seen in Kenya [22], suggests that Ghanaian beekeepers prefer areas with abundant floral resources, which may also be influenced by the aggressive behaviour of local bee species [12,32]. This behaviour presents significant management challenges, and further training in nighttime hive management and careful handling practices is recommended to mitigate risks and improve beekeeper safety. Honey and wax were the primary products harvested by beekeepers in this study, with fewer beekeepers collecting propolis and pollen compared to previous report by Llorens-Picher *et al*. [23]. This limited diversification suggests a potential area for income growth, as other hive products, such as propolis and pollen, are increasingly gaining market value. Providing education and training on harvesting and marketing these additional products could enhance beekeepers' income streams and improve the profitability of their operations.

This study marks Ghana's first formal documentation of priority honey bee pests. The ranked pests of honey bees, as identified by the beekeepers´ showed ants, small hive beetles, lizards, wax moths, and termites as being the most significant in decreasing order. Other minor pests were encountered by beekeepers, which reflected local biodiversity and habitat overlap with apiaries. These minor pests, though typically less impactful, can cause localized disturbances. Snakes, for example, may not directly harm bees but can cause beekeepers to avoid certain areas, potentially leading to neglected hives [33]. The findings are similar to those of works done in Kenya, where ants followed by small hive beetles [22,34] were also the most important pests and predators affecting honey bee colonies. However, lizards and termites in those studies did not rank as highly as in this study. Also, studies in Ethiopia [6,17] found bee-eater birds, ants, wax moths, lizards, termites, and hive beetles to be the most harmful pests in decreasing order of importance. Ants were also ranked first in the work of Ayele *et al*. [35]. Earlier reports by Dieteman [36] indicated small hive beetle presence in sub-Sahara Africa did not represent any threat because they co-evolved with the local honey bee species; however, this study suggests they might have some adverse effects in Ghana. A previous investigation at some of the current study areas reported small hive beetle infestations that affected even strong colonies and led to absconding, spoilt combs, fermenting and contaminated honey [37]. This underscores the need for continuous monitoring and research to assess the impact of small hive beetles and other pests on beekeeping productivity.

Pest management was identified as a critical challenge for beekeepers, with ants, hive beetles,

lizards, wax moths, and termites reported as the most significant pests. The beekeepers employed various pest control methods, such as hive relocation, pruning, and the use of insecticides. However, the lack of focus on maintaining strong colonies and cleaning brood combs indicates gaps in pest management practices. Addressing these gaps through comprehensive training programs that integrate traditional knowledge and modern pest control techniques could significantly improve colony health and resilience. The collaboration between local beekeepers, researchers, and agricultural extension services will be vital for developing and disseminating pest management strategies tailored to the specific challenges beekeepers face in Ghana. The study's focus on systems, practices, and pests limited its ability to assess the productivity and economic impact of beekeeping. Additionally, the reliance on self-reported data and purposive sampling may have introduced some biases, although efforts were made to minimize these limitations.

Conclusion

This current study found beekeeping in Ghana to be male-dominated, with the traditional, transitional, and modern methods of keeping being used of which the transitional system is the most employed. Most beekeepers inspected hives externally and cleared around their apiaries but did not actively manage swarming or absconding. Key honey bee pests encountered included ants, small hive beetles, lizards, wax moths, and termites, with minor threats from rodents, geckos, and other small animals. Chalk, water, oil, insecticides, and other local materials comprised the indigenous bee pest control methods. Targeted training for women in beekeeping, along with providing protective gear, is recommended to boost confidence and encourage female participation, promoting income diversification and gender inclusivity. Training should focus on hygienic apiary management, colony strength, and swarming control. Comprehensive pest management education must be included for new beekeepers, and indigenous pest control methods should be scientifically validated or improved. The Veterinary Services Directorate of Ghana should expand its role to offer bee health services and collaborate with academic institutions on research. Further studies should explore the motivations, productivity, and pest prevalence in different beekeeping systems.

What is known about this topic

- *Beekeeping is an important agricultural activity for pollination and honey production, particularly in rural communities where it provides a supplementary source of income;*
- *Beekeeping serves as a potential economic advantage for the country in the area of honey production due to the favourable ecological conditions in the country;*
- *Honey bee pests, such as wax moths, hive beetles, and ants, are known to cause significant losses to managed honey bee colonies in Africa, with up to 50% of colonies affected in some regions.*

What this study adds

- *This study identifies ants, small hive beetles, lizards, wax moths, and termites as the most significant honey bee pests in Ghana, marking the first formal documentation of honey bee pests in the country;*
- *The study highlights the prevalent use of transitional hives among Ghanaian beekeepers and the reliance on indigenous pest control methods such as the use of magic chalk, fluids, and insecticides;*
- *This study underscores the need for further research to validate these indigenous methods, explore more effective pest control strategies, and focus on improving colony management practices to prevent swarming and absconding.*

Competing interests

The authors declare no competing interests.

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Authors' contributions

The authors of this study contributed to the research in the following manner: Benjamin Obukowho Emikpe was responsible for conceptualizing the study and designing the methodology, supervision, and review of the final manuscript. Emmanuel Dongbataazie Piiru did the investigation, data collection, curation, data analysis, writing of the original manuscript, and reviewing the final manuscript. Vitus Burimuah, Flavie Vial, and Tasiame Williams were responsible for supervising and reviewing the final manuscript. Derrick Adu Asare contributed to writing the original draft, and reviewing and editing the final manuscript. All the authors have read and agreed to the final version of this manuscript.

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Tables and figures

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Table 3: source of honey bee colonies, hives placement, and management practices

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Table 5: indigenous control methods for major honey bee pests and predators in Ghana

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Figure 2: proportion of beekeepers in relation to the type of beehive they used

Figure 3: (A-F) traditional beehives and materials used in making them

Figure 4: swarm-catching boxes hang on trees to catch new bee colonies

Figure 5: bee products harvested by beekeepers

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Table 1: socio-demographic and educational characteristics			
Variable	**Categories**	**Frequency (N)**	**Percentage (%)**
Region	Bono East	24	47.1
	Bono	25	49.0
	Eastern	2	3.9
Gender	Female	6	11.8
	Male	45	88.2
Marital status	Married	38	74.5
	Single	13	25.5
Educational status	Can read and write	1	2.0
	Illiterate	3	5.9
	Junior high education	13	25.5
	Primary education	1	2.0
	Secondary education	13	25.5
	Tertiary	20	39.2

Table 2: age distribution and beekeeping information				
Variable	**Frequency (n)**	**Percentage (%)**	**Mean**	**SD**
Age (years)			46.9	14.7
Age category				
20 - 30 years	7	14.9		
31 - 40 years	13	27.7		
41 - 50 years	10	21.3		
51 - 60 years	6	12.8		
≥61 years	11	23.4		
Number of years of keeping bees (years)	50		9.5	9.0
Number of Apiaries	51		3.4	7.0
Number of hives	51		105.4	211.8
Types of bee hives owned				
Traditional	1	0.2	10	
Transitional	48	95.4	106.9	212.5
Modern	7	4.4	33.6	37.5
Presence of empty bee hives				
Traditional	0	0.0		
Transitional	43	29.5	36.9	60.4
Modern	6	1.2	11	9.7
SD = Standard Deviation				

Table 3: source of honey bee colonies, hives placement, and management practices			
Variable	**Categories**	**Frequency (n)**	**Percentage (%)**
How did you start beekeeping?	By catching the swarm	50	98.0
	Gift from parents	1	2.0
Where do you keep your bee colonies?	Backyard	2	3.9
	Both farm and forest	5	9.8
	In the farm	23	45.1
	In the forest	21	41.2
Do you visit and inspect your beehives and colonies?	No	2	3.9
	Yes	49	96.1
Do you clean your apiary?	No	5	9.8
	Yes	46	90.2
Do you control/prevent swarming/absconding?	No	22	43.1
	Yes	29	56.9
Do you have empty beehives	No	3	5.9
	Yes	48	94.1
Characteristic feature/behaviour of your honey bees?	Aggressive	41	80.4
	Docile	1	2.0
	Very aggressive	9	17.6
Production (beekeeping) objective	Both (self-consumption and commercial)	16	31.4
	Commercial	35	68.6
Do you know queen rearing and colony multiplication?	No	26	51.0
	Yes	25	49.0

Table 4: rank index and distribution for major and minor honey bee pests and predators										
Constraints	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**Index**	**Rank**
Ants	38	8	2	1	1	0	0	0	0.351	1
Hive beetles	6	14	10	2	0	1	0	0	0.201	2
Lizards	1	17	8	7	0	1	2	0	0.200	3
Wax moth	4	6	8	5	0	0	0	0	0.135	4
Termites	1	2	5	1	1	2	0	0	0.062	5
Spiders	0	0	1	2	4	2	0	0	0.035	6
Bee eating birds	0	0	1	0	1	0	0	2	0.011	7
Honey badger	0	0	0	0	0	0	2	2	0.006	8
(Relative importance index (RII) = sum of (8*ranked 1st +7*ranked 2nd + 6* ranked 3rd +5* ranked 4th +4* ranked 5th +3* ranked 6th +2*ranked 7th +1* ranked 8th) for individual and predators divided by the sum of (8*ranked 1st +7*ranked 2nd + 6* ranked 3rd +5* ranked 4th +4* ranked 5th +3* ranked 6th +2*ranked 7th +1* ranked 8th) for overall pests and predators.)										
Minor pests and predators					**Frequency (n)**				**Percentage (%)**	
Rodents					5				9.8	
Wall geckos					7				13.7	
Praying mantis					2				3.9	
Chameleon					1				2.0	
Snake					1				2.0	
Wasps					2				3.9	
Frog					1				2.0	

Table 5: indigenous control methods for major honey bee pests and predators in Ghana	
Pest and predators	**Local control methods**
Ants	Relocation of hives to prevent ants. Clearing and pruning tree branches over hives that harbor ants. Placing hive stands in containers with fluid (water, oil, grease, dirty oil, etc) to kill and prevent access of ants. Open the hive covering to allow the direct sun heat to drive away ants. Use magic chalk to circle hive stands to prevent ants from moving across to infest the hive. Direct killing of ants or nests by burning with fire. Use of insecticides (spraying with liquid and spreading powder) when the ants are a distance away from the hives, poisoning the ants' nest with chemicals. Use plastic polytene materials to tie around nearby trees and hive stands to prevent ants from climbing across them and use ash on the ground to disrupt ant trails.
Wax moth	No treatment for wax moths, wax moths are difficult to treat, clean or clear wax moths in hives after bees have left.
Small hive beetles	No available control method yet for small hive beetles, cleaning to prevent small hive beetles, driving away small hive beetles by the sun, and sweeping or clearing away (with a broom) the beetles when found in hives.
Spiders	Kill spiders directly, spraying with chemicals to prevent spiders, and destroy the homes of spiders.
Termites	Use of chemicals (termiticide), putting hive stands inside containers with fluid to trap termites attempting to climb onto hives, using metal hive stands instead of wood, using salt and wood dust to deter termites, putting fire, or hot water on the termitaria.
Lizard	Use repellents for lizards and other reptiles, cover the hives with zinc roofing sheets to prevent lizards' entry, and directly kill lizards with a catapult.
Wall geckos	Directly kill or chase wall geckos away.
Honey badger	No treatment.
Bee eating birds	No treatment.
All other pests and predators	Remove or change the location of hives, clear bushes and clean around the hive, and clean colony boxes.

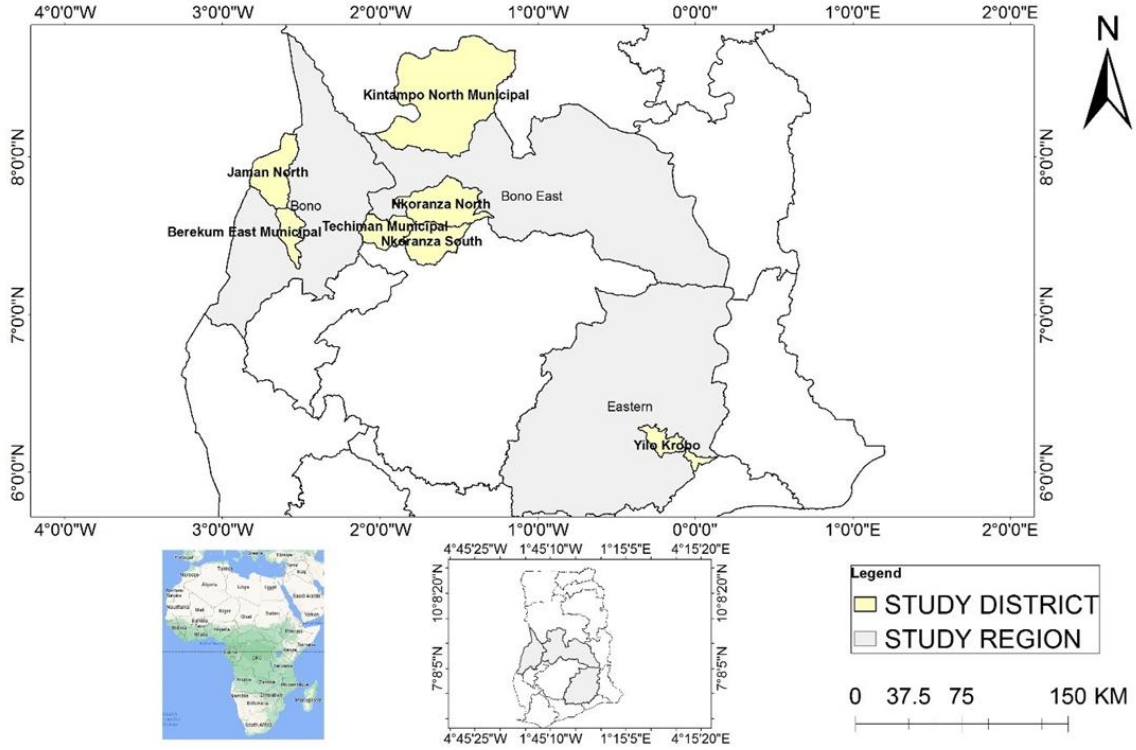

Figure 1: map of study area showing the study region and study district

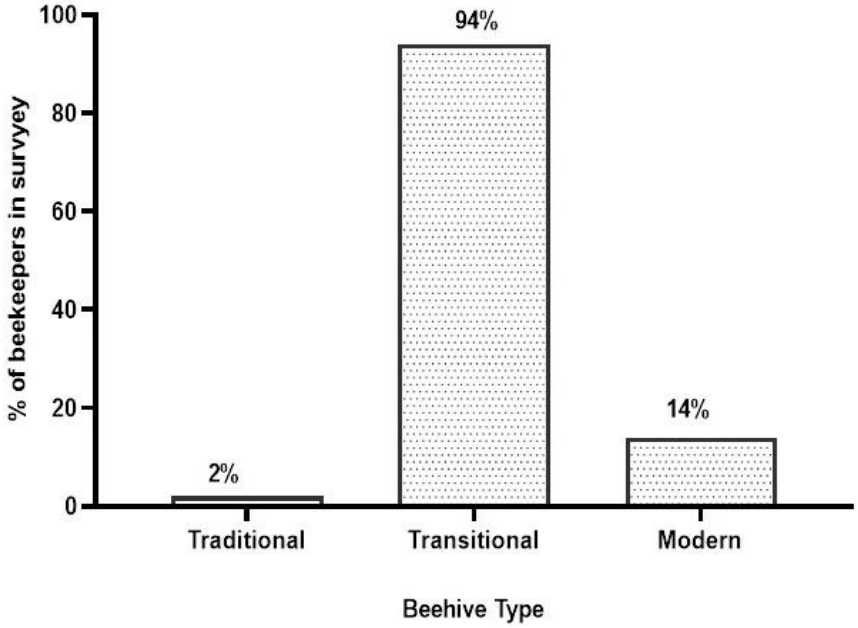

Figure 2: proportion of beekeepers in relation to the type of beehive they used

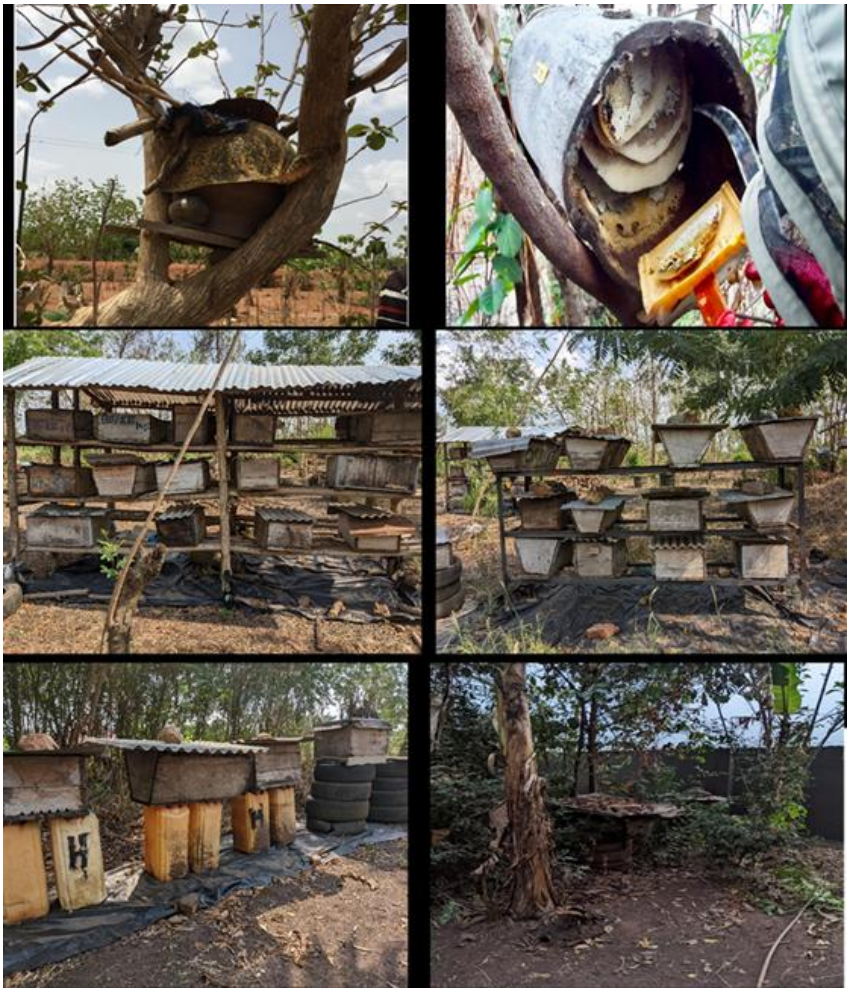

Figure 3: (A-F) traditional beehives and materials used in making them

Figure 4: swarm-catching boxes hang on trees to catch new bee colonies

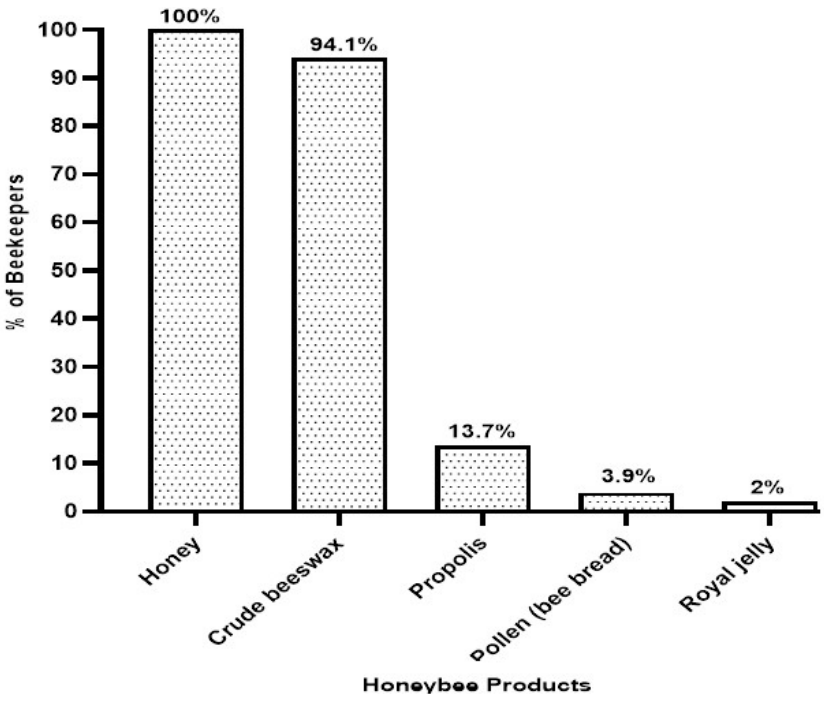

Figure 5: bee products harvested by beekeepers