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Factors affecting honey bee and honey production in Hidebu Abote Woreda, North Shoa, Oromia regional state, Ethiopia

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Factors affecting honey bee and honey production in Hidebu Abote Woreda, North Shoa, Oromia regional state, Ethiopia

A Thesis Submitted to the Department of Zoological Sciences, Addis Ababa University, in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology

By Getachew Bayissa

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THESIS APPROVAL SHEET

We certify that Getachew Bayissa's MSc thesis research entitled "Factors affecting honey bee and honey production in Hidebu Abote Woreda, North Shoa, Oromia regional state, Ethiopia" has been conducted under my direct supervision. Therefore, we kindly request the Department of Zoological Sciences, Addis Ababa University for the final approval and acceptance of the thesis.

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DEDICATION

This thesis research is dedicated to my wife Essey Dechasa and my children, who motivated me to learn and finish my thesis work.

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LIST OF ABBREVIATIONS/ACRONYMES

AGP	Agriculture Growth Program
Am	*Apis mellifera*
CSA	Central Statistical Agency
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
kg	kilogram
MOA	Ministry Of Agriculture
SNNPR	Southern Nations, Nationalities, Peoples Regional
SNP	Single Nucleotide Polymorphism
SPSS	Statistical Package for Social Science

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Department of Zoological Sciences, Addis Ababa University**,** February 2023

Abstract

This research was carried out in Hidebu Abote woreda, which is located in the North Shoa Zone of Oromia regional state, to examine the primary factors influencing honey production. We employed a descriptive study design technique. Data were gathered from 192 people via questionnaire, interview, and observation utilizing random and purposeful sampling procedures. Statistical software for the social sciences (SPSS, version 22) was used to analyze the data. The findings revealed that 60% of beekeepers used purely traditional, 7% used modern, and 2% used transitional beehives. In 2015 E.C., the average honey yield from a single traditional beehive was 7.52 ± 2.48 kg, transitional 17.08 ±1.63 kg, and modern 27.28 ± 3.72 kg. The number of honeybee colonies in Hidebu Abote woreda has fluctuated during the last five and three years. The majority of beekeepers (68.7%) managed their colonies by visiting and inspecting them daily, with 20% doing so weekly. The most significant pests or predators affecting honey bee output in the study locations were 60% ants, 36.7% birds, 34.0% spiders, 32.0% lizards, 29.3% hamagot, and 17.8% wax moth, ranked first to sixth. Furthermore, the widespread use of agrochemicals (98.7%), a lack of training (56%), and a lack of professional support (59.7%) on beekeeping all had an impact on honey output in the study areas. The utilization of traditional beehives was significant (0.001) and negatively linked (-0.144) with the beekeepers' educational level. The utilization of modern beehives and their corresponding gathered honey yields in kilogram had a positive (0.921) and highly significant (0.000) association.

Keywords: Beekeeping, Factors affecting, Honey, Honey bee, Modern hive, Traditional hive

1. INTRODUCTION

Beekeeping has a 1.3% GDP contribution to the agriculture of Ethiopia (Eskindir Amanuel and Yared Alemayehu, 2021). Ethiopia is the number one largest honey producer country in Africa, and the 10th honey (53782 tons) and 4th beeswax (5790 tons) producer country, respectively in the world (FAO-STAT, 2020). These large amounts of honey production was obtained by the presence of conducive natural resources and over 7000 flowering plant species in the country that provides the raw materials such as excess nectar and pollen for honeybees (Admassu *et al*., 2014).

Currently, beekeeping in Ethiopia is categorized into three systems based on the types of beehives used. These are traditional (fixed-comb), transitional (top-bar), and modern (frame). Among these, about 96%, 1%, and 3% of the total colony of the honey population are managed under traditional, transitional and modern systems, respectively. Furthermore, the total numbers of beehives found in Ethiopia are 6,958,004 (CSA, 2020). According to CSA (2021), the current number of honey bee colonies available in Ethiopia is about 7000.

According to (CSA, 2020), the major honey-producing regional states in Ethiopia with total annual production are Oromia (54.3%), Amhara (19.5%), and SNNPR (Southern Nations, Nationalities, Peoples Regional Government) 16.6%, respectively.

The majority of farmers in Ethiopia use beekeeping as a source of nutrition, brewing of locally known drinks called ‘'Tej’, and cash income (Haftey Sahle *et al*., 2018). Furthermore, the products of beekeeping such as bee wax, royal jelly, propolis, and bee venom are used in the medicine and cosmetics industry (Porto *et al*., 2020).

According to (MoA and ILRI, 2013), Ethiopia has a high potential for honey production due to its

natural endowment. However, the country is not producing honey with its full potential due to the various factors influencing the practices of beekeeping in the rural parts of Ethiopia.

Several research studies have been done on beekeeping regarding honey productions practices, marketing, constraints, and opportunities in different parts of Ethiopia including the Oromia regional state (South West Shoa (Taye Beyene, Marco Verschuur, 2014); Jimma and Illubabor (Welay Kiros, and Tekleberhan Tsegay, 2017); West Shoa (Segni Shimelis and Fufa Abunna, 2017), Amhara regional state (Gondar (Addis Getu and Malede Birhan, 2014), Hawi zone (Adino Andaregie *et al*., 2022), Southwest Ethiopia (Chala Kinati *et al*., 2013; Kassa Tarekegn *et al*., 2017; Dereje Tulu *et al*., 2020; Benyam Tadesse *et al*., 2021; Eskindir Amanuel and Yared Alemayehu, 2021), Tigray regional state (Gebrehiwot Nahusenay, 2015), and Somali regional State (Sisay Fikru *et al*., 2015).

However, to our knowledge, the North shoa of Oromia regional state has not been included in any beekeeping research studies. Furthermore, the factors affecting the honey bee and its production have not been known in Hidebu Abote Woreda. Therefore, this study was aimed to identify the major factors influencing honey bee and honey production in the Oromia regional state of North Shoa, Hidebu Abote Woreda.

1.1. Objective of the study

1.2. General objective of the study

- ✓ To analyze the major factors affecting honey bee and honey production in Hidebu Abote Woreda, North Shoa, Oromia regional state, Ethiopia.

1.3. Specific objectives of the study

- ✓ To identify factors hindering the honey production system in the Hidebu Abote Woreda.
- ✓ To assess the honey bee management practices of beekeepers in the Hidebu Abote Woreda.

2. LITERATURES REVIEW

2.1. Origin, Evolution and Distribution of Honey bee

Honey Bee probably evolved from ancient predatory wasp ancestors, contemporaneously with the flowering plants between 60 and 100 million years ago towards the end of the Cretaceous period (Martin, 1976). It is commonly believed that *Apis mellifera* originated in Asia and was distributed in Europe and Africa through natural ways. As a result, *Apis mellifera* was native to Europe, Africa, and Asia (Han *et al*., 2012). Furthermore, the molecular study using SNP on the origin of honey bee confirmed that the different species of honey bee were introduced into different continents including South America, North America, and Australia in the early century of 16th, 17th, and 19th, respectively through human migration (Whitfield *et al*., 2006).

2.2. The Species of Honey bee

According to Roubik (1989), about nine different species of honeybees have been known in the world since the late 1700s.These are *Apis mellifera*, *Apis florea*, *Apis andreniformis*, *Apis laboriosa*, *Apis vechti*, *Apis dorsata*, *Apis cerana*, *Apis dorsata* binghami, and *Apis cerana* indica. Among these, only five species of honey bees such as *Apis mellifera*, *Apis florea*, *Apis dorsata*, and *Apis indica* /cerana have economic importance in honey production and crop pollination. Among these honey species, *Apis mellifera* is the most common dominant honey bee in the world. These honey bee species' formation resulted from natural selection that enabled the honeybees to adapt to diverse geographical areas of the world for several years without the intervention of human beings. The effect of the environment on the physiology and anatomy of honeybees caused differentiation.

In Ethiopia, there are five different species of honey bee that are distributed in various geographical locations of the country. These are: 1) *Apis mellifera* has existed in eastern lowlands, 2) *A.m. litorea* was found in the extreme western lowlands, 3) *A.m. abyssinica* was available in the central plateau and

southwestern parts of the tropical forest), 4) *A.m. adansonii* was found in the southern mid-altitude areas and 5) *A.m. monticola* was available in the southern mountains of Ethiopia (Ayalew Kassaye, 1990). According to the report of Smith (1961), the first honey bee that existed in Ethiopia was *A.m monticola.*

2.3. The Colony of Honey bee (*Apis mellifera)*

The colony of honey bees (*Apis mellifera*) consists of diploid females of a queen, haploid drones, and workers with particular labor division and sophisticated behavior to finish numerous activities and roles that are adapted to local conditions under the control of environmental factors and genetics (Seeley, 2010; Behrends and Scheiner, 2012). According to Tarpy *et al*. (2015), a queen of *Apis mellifera* makes multiple mating of up to 20 drones in a drone congregation area by nature, which can be potentially collected from various colonies of the same subspecies, different subspecies, and levels of human intervention. Consequently, a colony may consist of hybrid workers of different or closely related honey bees as a reflection of the level of diversity.

2.4. Economic importance of beekeeping in Ethiopia

The honey bee is the insect that is most crucial to global agriculture. According to Jacobs *et al*. (2006), it is the second most economically beneficial livestock species. It has much importance, including the production of honey, royal jelly, and beeswax, the pollination of various crops and fruits, and the conservation of the ecosystem (Porto *et al*., 2020).

According to Haftey Sahle *et al*. (2018), the major contribution of beekeeping in Ethiopia includes the production of honey, bee wax, and queen and bee colonies. Additionally, products such as royal jelly, pollen, propolis, and bee venom are used in the medicine and cosmetics industries and contribute to the economy of the country by being exported abroad. Furthermore, about 85% of the local consumption of

honey is used for making a lovely local drink known as ‘Tej’ and only 15% of the produced honey is utilized by the beekeepers at their home (Edessa, 2005).

2.5. Honey production in Africa and the world

Ethiopia ranked first in the annual production of honey with 45,300 tons in Africa. Tanzania, Kenya, Uganda, and Rwanda came in second through fifth place in terms of annual honey production. Moreover, China (444,100 tons), Turkey (109,330 tons), Canada (80,345 tons), Argentina (78,927 tons), and Iran (75,463 tons) are the top five countries in the world by annual honey production, respectively (FAOSTAT, 2020).

2.6. Honey production in Ethiopia

According to CSA (2021), the numbers of traditional, intermediate, and modern beehives found in Ethiopia in the year 2020/2021 were 6,699,219, 102,957, and 183,924, respectively, for a total of 6986100. The honey production harvested in kilograms was 124,791,328, 920,058, and 3,589,692 from traditional, intermediate, and modern beehives, respectively, for a total production of 129,301,078. The largest honey production was harvested from traditional beehives, whereas the smallest was from intermediate beehives at the national level.

In the regional states of Ethiopia in the years 2020/2021, Oromia (3,770,056, 63.3 million), SNNP (1,003,737, 37.6 million), and Tigray (343,243, 7.4 million) had a total number of beehives and annual production of honey in kilograms, respectively. The smallest total annual honey production was observed in Dire Dawa (11,749 kilograms) from only traditional beehives (3,167) (CSA, 2021).

2.7. Honey bee Management Practices in Ethiopia

The management practices of the honey bee in Ethiopia vary from beekeeper to beekeeper and from region to region. The beekeepers in our country have poor honey bee management practices. For example, the majority of beekeepers (46.7%) in the Amhara region (Tessega Belie, 2009), about 53.8% in Southern Ethiopia (Haftu Kebede and Gezu Tadesse, 2014), and about 94% in the central Zone of Tigray (Haftu *et al*., 2015) checked their honey bees in the beehives rarely, sometimes, and daily, respectively, for bee enemies and diseases. Moreover, about 79.3% of beekeepers in the Hadiya zone checked their colonies only during honey harvesting time (Eskindir Amanuel and Yared Alemayehu, 2021). According to Haftu Kebede and Gezu Tadesse (2014), most of the beekeeper of Hadiya zone (60.2%) had been visiting their honey bees during the rainy season because the different pests and predators could use the beehives as a hiding place and affect the honey bee.

2.8. Factors Affecting Beekeeping in Ethiopia

Several studies have been done in different parts of Ethiopia to identify the major constraints that affect beekeeping in our country. The major constraints are:

2.8.1. Lack of Training and skilled manpower

Training and skilled manpower are essential in improving the various products of beekeeping for beekeepers. However, the lack of training and skilled manpower affected the honey bee and its honey production. Lack of awareness forced the beekeepers to use the traditional ways of honeybee and honey production, which resulted in low honey production (Edessa, 2005; Kerealem *et al*. 2009; Haftey Sahle *et al*., 2018). According to Benyam Tadesse *et al*. (2021), beekeeping practices in Southern Ethiopia were affected by poor extension services provided to the beekeepers.

2.8.2. Lack of modern technology

The traditional method has dominated beekeeping in Ethiopia. As a result, the production of honey was low due to the lack of modern technology that affected the production of honey (Benyam Tadesse *et al*., 2021; Dereje Tulu *et al*., 2021). Furthermore, improved beekeeping technologies were expensive and had no access to beekeepers compared to the traditional ones. As a result, beekeepers cannot afford to buy and use it (Eskindir Amanuel and Yared Alemayehu, 2021).

2.8.3. Application of agrochemicals

A different study conducted on the constraints of Beekeeping in various parts of Ethiopia confirmed that the improper application of agrochemicals such as pesticides and herbicides on the cereal crops affected beekeeping practices by killing the honey bee and destroying broad-leaved crop plants used as honey bee feed in Oromia in the South West Shewa Zone (Taye Beyene and Marco Verschuur, 2014), and in Southern Ethiopia in the Hadiya zone (Eskindir Amanuel and Yared Alemayehu, 2021).

2.8.4. Honey bee disease, bee pests and predators

The main enemies of honey bees are pests (mites, wax moths, and bee-louse) and predators (ants, wasps, spiders, hamagots, and birds) that affected beehives, killed honey bees, and influenced the production of honey in different parts of Ethiopia (Firisa Woyessa and Dejene Alemu, 2016 (Oromia Horro Guduru Wollega); Teklu Gebretsadik, 2016 (Southern Ethiopia in Sidama and Gedeo zones); Haftey Sahle *et al.*2018; Kenesa Teferi, 2018; Yibeletal Aynalem, 2020). Moreover, honey bee diseases such as amoeba diseases, chalkbrood diseases, and nosema diseases were the major diseases causing a significant economic loss to honey bees and their products (Sisay Fikru *et al*., 2015; Segni Shimelis, 2017; Eskindir Amanuel and Yared Alemayehu, 2021).

However, the factors affecting the honey bee and its production have not been studied in the Hidebu Abote Woreda of North Shoa, Oromia regional state.

3. MATERIALS AND METHODS

3.1. Description of the study area

The study was conducted in Hidebu Abote woreda, which is located in the North Shoa Zone of Oromia regional state. Geographically, Hidebu Abote woreda is found between 9°48'30" and 10°4'40" N Latitude and 37°24'00" and 38°40'12"E Longitude, about 150 km from Addis Ababa in the north direction and 42km from Fitche, the capital town of the zone (Figure 1). The woreda has a total of 20 kebeles, with 19 rural and 1 town. There are about 3020 beekeepers in Hidebu Abote woreda, with 111,589 and 2320 modern, transitional, and traditional hives, respectively. The total annual honey production of the woreda was 179,855 kg (Hidebu Abote woreda, Agricultural Office Report, 2021).

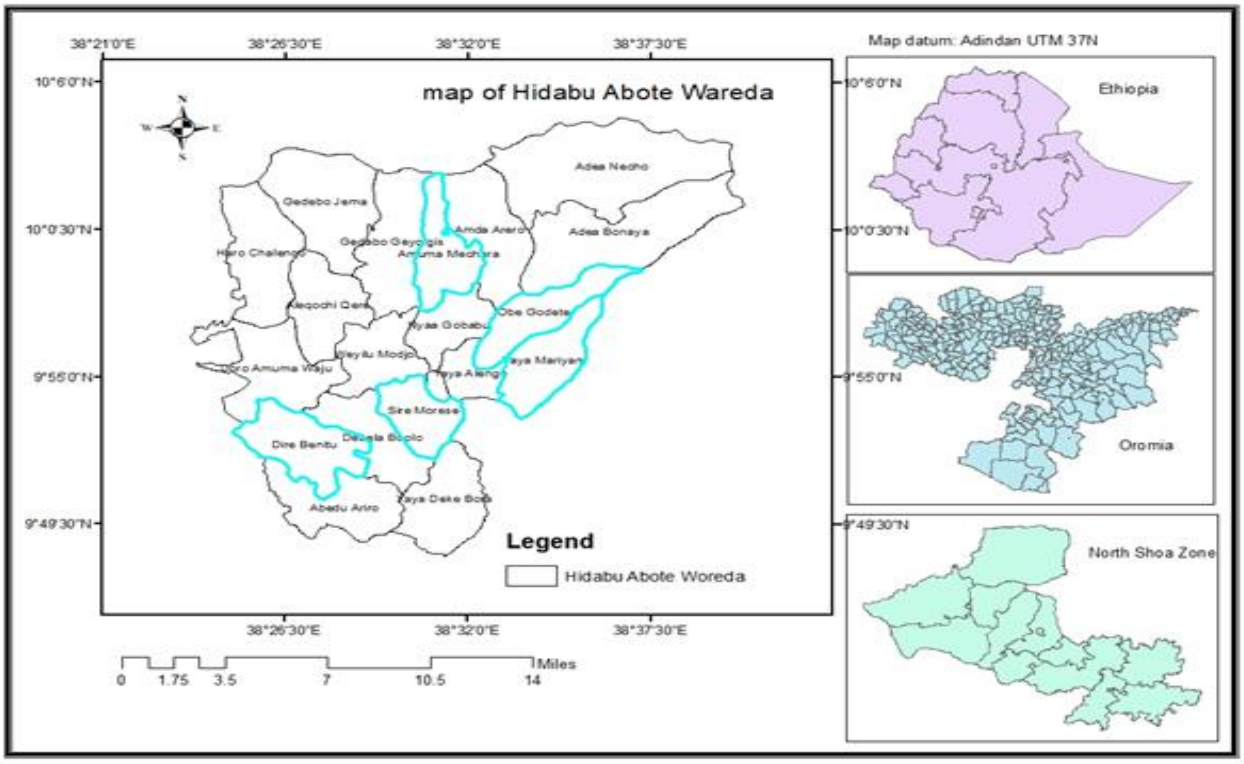

FIGURE 1. MAP OF THE STUDY AREAS

Source: Ethio-GIS, 2013

3.2. Research design, sampling techniques and sample Size

For this study, a descriptive research design approach was used. Both random and purposeful sampling methods were used to collect data. On the basis of the potential of their honeybee colonies, Hidebu Abote woreda and its five representative kebeles were specifically chosen. Accordingly, Kobe Godeti, Yaya Marami, Sire Morose, Dire Bantu, and Hamuma Machara were selected for data collection. The beekeepers were chosen randomly in order to collect data using questionnaire. However, a purposive sampling strategy was used for interview questions.

The sample size was calculated using Yamane's sample size determination formula at a 92% confidence level and a 7% precision level (Yamane 1967). In Hidebu Abote woreda, there are a total of 3020 beekeepers. As a result, 192 individuals participated in this study.

$$n = \frac{N}{1+N(e)^2} = \frac{3020}{1+3020(0.07)^2} = 192$$

Where n= number of participant, N= total number of honey producers, e= level of precision

3.3. Data Collection Method

Data were gathered from both primary and secondary sources. The primary data were collected randomly from the beekeepers using a semi-structured questionnaire. Data were collected from 160 beekeepers using questionnaires (32 beekeepers participated in each kebele). Furthermore, 32 participants participated in the interviews. Five model beekeepers and one livestock expert were involved in the interview process for each kebele. Two woreda agricultural supervisors participated in the interviews. Furthermore, observations were made to support the interpretation of the collected data.

The questionnaire and interview questions were prepared in English and translated into the local language, Afan Oromo, during data collection.

3.4. Data Analysis Method

Statistical software for social sciences (SPSS, version 22) was used to analyze the data that had been gathered. The use of descriptive statistics like mean, frequency, percentage, and standard deviation was also made.

4. RESULTS

4.1. Socio-economic background of the beekeepers

Table 1 and Figure 2 provide information about the socioeconomic background of the beekeepers, including their sex, age, education level, number of beehives, and "timad" (a unit of farmland). In Hidebu Abote, there were 90.7% male beekeepers and 9.3% female beekeepers who participated in the honey production process. Ages of beekeepers ranged from 41 to 50 and 20 to 30 years, respectively, with maximum (42%) and minimum (7.3%) participation in honey production. The education level ranges from uneducated to degree-level. According to Figure 2 below, the level of illiteracy had the highest percentage (31.3%). 42.7% of the beekeepers had less than five beehives, whereas 10% had more than 20. 42% of beekeepers owned 5-8 "timads" in relation to the farmland plot.

TABLE 1. SOCIO-ECONOMIC BACKGROUND OF THE BEEKEEPERS IN HIDEBU ABOTE WOREDA

Variables, Respondent type and Percentage														
Sex			Age			Education status			Beehives			Plot of Farmland		
	number	Percent	level	number	Percent	Level	Number	Percent	Beekeepers owned hive	number	Percent	Timad	number	Percent
Male	145	90.7	20-30	12	7.3	uneducated	50	31.3	<5	68	42.7	1-4	42	26
Female	15	9.3	31-40	17	10.7	Basic education	34	21.3	5-10	45	28	5-8	67	42
			41-50	67	42	Grade 1-4	19	12	11-15	11	6.6	9-12	37	23.3
			51-60	41	25.3	Grade 5-8	24	14.7	16-20	20	12.7	13-16	3	2
			≥ 61	23	14.7	Grade 9-12	20	12.7	21-30	16	10	17-20	11	6.7
						Diploma	5	3.3						
						Degree	8	4.7						

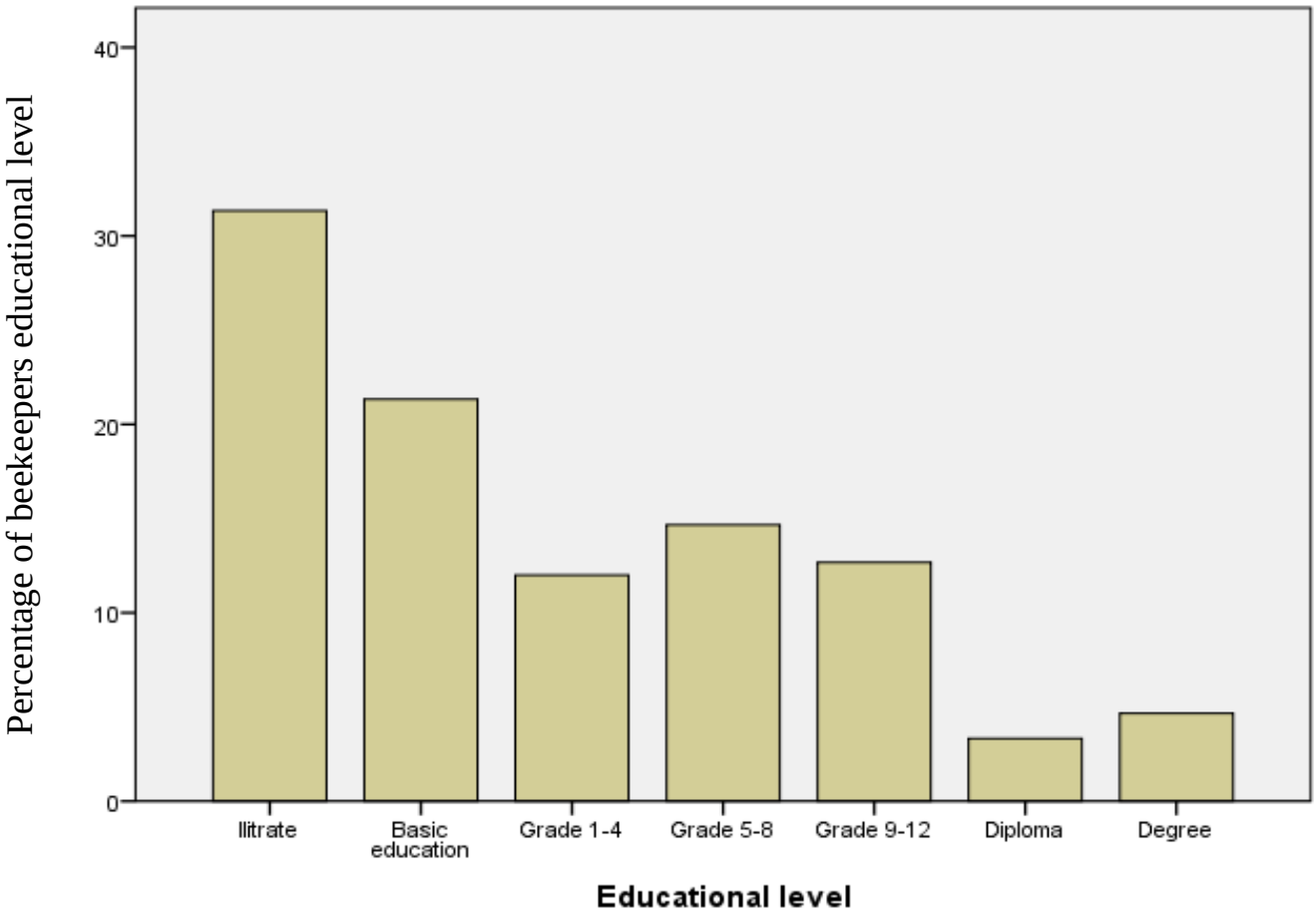

FIGURE 2. EDUCATIONAL LEVELS OF BEEKEEPERS

4.2. Types of beehives used, source, and its price

In Hidebu Abote woreda, beekeepers produced honey using conventional, modern, and transitional beehives. Only traditional, modern, and transitional beehives were used by 60%, 7%, and 2% of beekeepers, respectively. Beekeepers also employed a mixed type of beehive, including traditional and transitional (6%), traditional and modern (20%), and all three types (5%) (Figure3). About 48% of beekeepers prepared their own hives, compared to 59.3% who purchased them from the market. An NGO called World Vision Ethiopia gave modern hives to 26% of the beekeepers. Surprisingly, the government did not provide the beekeepers with any modern hives.

The minimum prices of traditional, transitional, and modern beehives were 50, 250, and 4000 Eth birr, respectively, whereas the maximum prices of traditional, transitional, and modern beehives were 200, 800, and 4900, with an average of 103.5, 433.3, and 4438.5 Eth birr, respectively as shown in table 3 below. Beekeepers kept their bee colonies in the backyard (98.7%) and under the house (1.3%).

TABLE 2. BELOW SHOWS THE TYPES OF BEEHIVES USED, THEIR SOURCE, AND PLACE OF KEEPING BEE COLONIES.

Variables	Respondent response (%)
Types of beehives	
Only traditional	60
Only transitional	2
Only modern	7
Traditional and transitional	6
Traditional and modern	20
Transitional and modern	0.0
All three types	5
Sources of beehive	
Prepared by myself	48
Bought from market	59.3
Granted from government	0
Granted from NGO	26
Keeping bee colonies	%
Backyard	98.7
Under the house	1.3

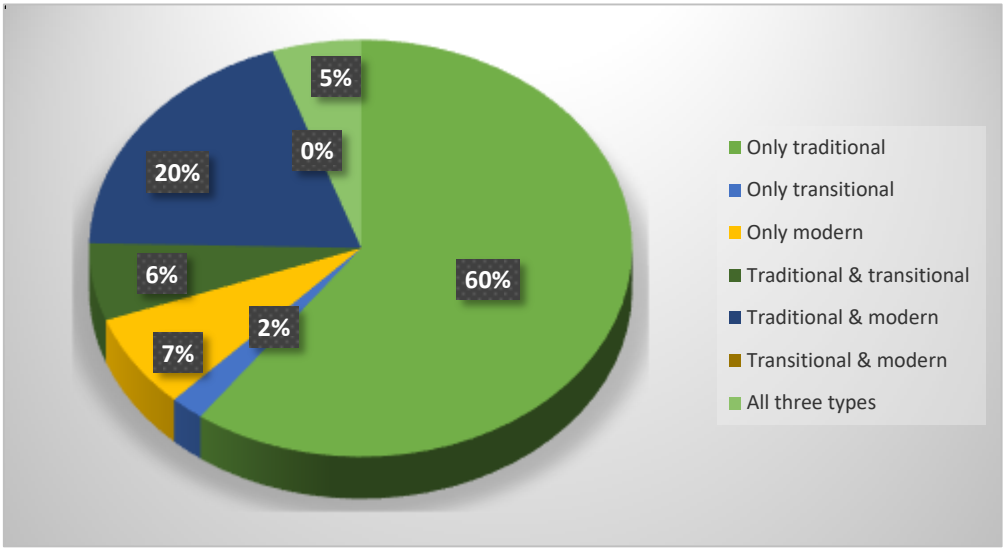

FIGURE 3. TYPES OF BEEHIVES USED FOR HONEY PRODUCTION IN HIDEBU ABOTE WOREDA

TABLE 3. THE PRICES OF BEEHIVES IN ETHIOPIAN BIRR

Types of beehives	Price of beehive in Ethiopian birr		
	Minimum	Maximum	Average
Traditional	50	200	103.5
Transitional	250	800	433.3
Modern	4000	4900	4438.5

4.3. Honey Production, its selling price and places in Hidebu Abote

Table 4 lists the categories of beehives, the annual honey production of honey from a single bee hive, and the common price of honey per kilogram in 2015 E.C. in Ethiopian Birr. Table 5 shows the places where honey is sold, and the frequency of honey collection annually. The average annual yields of honey from modern and traditional beehives were, respectively, 27.28 ± 3.72 kg and 7.52 ± 2.48 kg. Furthermore, the average annual yield of honey from transitional beehives was 17.08 ± 1.63 kg as

showed in table 4. Honey was harvested by beekeepers twice (97.3%) and three times (2.7%) per year, respectively. Beekeepers sold their honey at a variety of locations, including the local market (85.3%), the village (56%), and the bazaar (2%), respectively. At farmers' cooperatives and local "Tej" houses, they did not sell as shown in table 5. They sold it for a mean price of 417.9 birr, with a minimum price of 300 and a maximum price of 600 as indicated in table 3 below.

TABLE 4. HONEY HARVESTED IN KILOGRAMS FROM A SINGLE BEEHIVE PER YEAR AND ITS COMMON SELLING PRICES IN 2015 E.C

Types of beehives	Average of harvested honey Per year in kg from a single beehive	Common Price of one Kg honey harvested from the three types of honey beehives in 2015 E.C in Eth birr		
		Minimum	Maximum	Average
Traditional	7.52 ± 2.48 kg			
Transitional	17.08 ± 1.63 kg	300 birr	600 birr	417.9 birr
Modern	27.28 ± 3.72 kg			

TABLE 5. THE FREQUENCY OF HONEY COLLECTION PER YEAR, IT'S SELLING PLACES

Frequency of honey collection/ year		Honey selling places	
Times	%	Places	%
Once	0	Village	56
		Local market	85.3
Twice	97.3		
		Tej houses	0.0
Thrice	2.7	Farmers' cooperatives	0.0
		Bazaar	2

4.4. Status of honey colonies in Hidebu Abote woreda

The comparison of the number of honey colonies in Hidebu Abote over the last ten, five, three, two, and this year is shown in Table 6. In the last ten and five years, the comparative status of honey bee colonies in Hidebu Abote increased from 41.3% to 46.1%. Contrarily, it decreased over the previous three, two, and this year, with respective decreases of 38.3%, 37.2%, and 36.3%.

TABLE 6. COMPARATIVE NUMBERS OF HONEY COLONIES FROM ALL THE THREE TYPES OF BEEHIVES IN LAST TEN, FIVE, THREE, TWO AND THIS YEAR

Status bee colonies	Last ten years %	Last five years %	Last three years %	Last two years %	This year %
Increased	41.3	46.1	38.3	37.2	36.3
Decreased	38	31.2	41.6	50.3	56
No change	20.7	22.7	20.1	12.5	7.7

4.5. Management of honey bee colonies, and swarming in Hidebu Abote Woreda

Most beekeepers (68.7%) managed their bee colonies by visiting and inspecting their colonies daily, 20% weekly, 6.7% every two weeks, and 4.7% monthly, as shown below in Figure 4. During the honey bee colony visit, most of the time 100% of the beekeepers checked the presence or absence of colonies and insect problems externally, while 19.3% checked the status of honey production, as indicated in Table 6 below. About 98.7% of beekeepers responded that there were occurrences of swarming. Beekeepers managed swarming by transferring to empty beehives (80.2%), harvesting honeycomb (12.5%), and removing queen cells (7.3%), as shown below in Table 5.

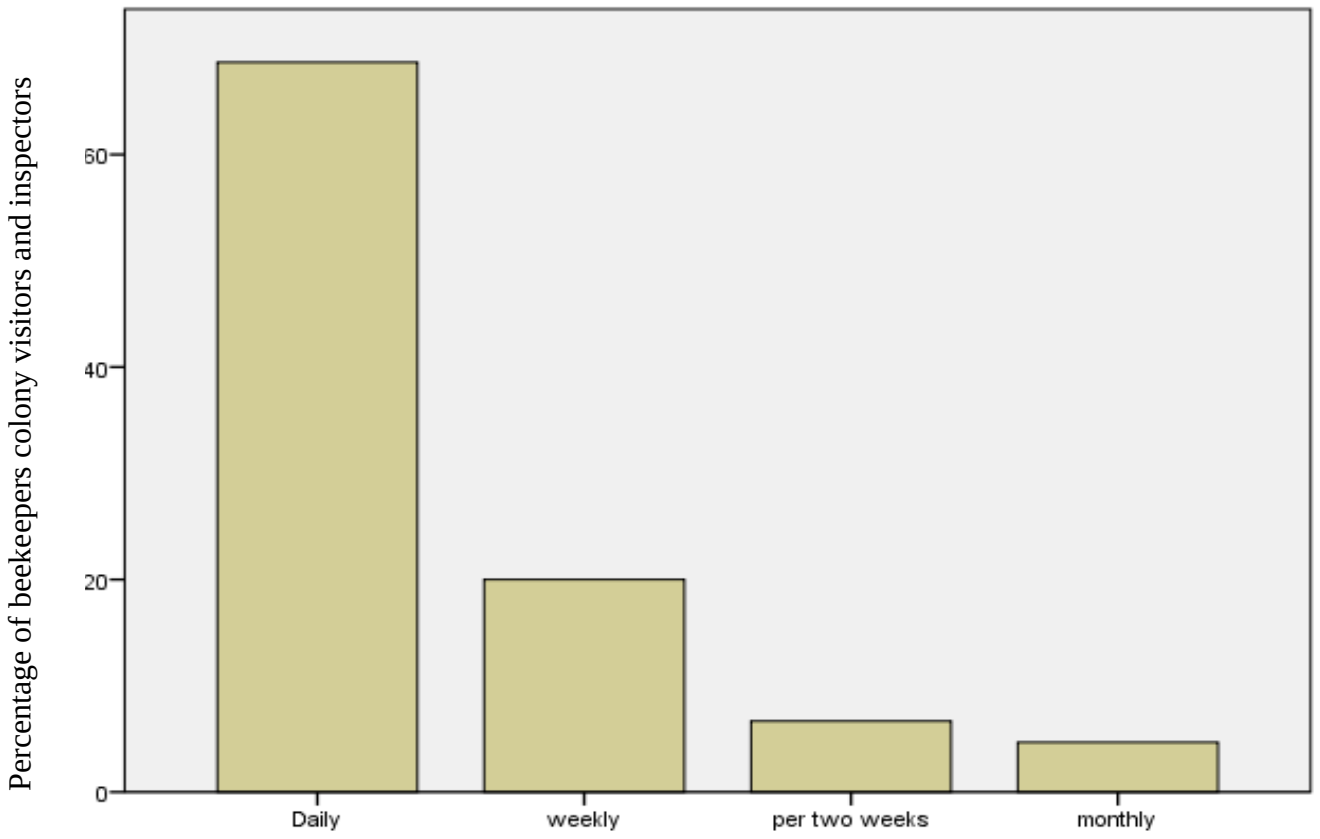

Figure 4. Time of visit and inspection of honey bee colonies

TABLE 6. HONEY BEE COLONY VISITS AND MANAGEMENT METHODS OF SWARMING

S/N	Variable	Response in percentage
1	**Honey colonies visit**	
	Presence or absence of colonies	100
	Insect problem	100
	Status of honey production	19.3
2	**Management methods of swarming**	
	Transferring to empty beehives	80.2
	Harvesting honey comb	12.5
	Removal of queen cells	7.3

4.6. Major factors affecting honey bee production in Hidebu Abote woreda

There are different major factors that affected honey bee production in Hidebu Abote woreda. The major pests or predators that affect honey bee production in the study areas were 60% ants, 36.7% birds, 34% spiders, 32% lizards, 29.3% hamagot, and 17.8% wax moth, respectively ranked 1st to 6th (Table 7).

Furthermore, 98.7% of beekeepers used different agrochemicals to protect their crops from weeds, insect and pests, whereas 56% and 59.7% didn't receive any training and professional support in beekeeping, respectively. Only 44% of beekeepers get training, and 40.3% get professional support in beekeeping. There was 100% colony absconding in the studied areas. As the beekeepers responded, the presence of water during the dry season was 100%, and the honey bees got water from streams (2%), rivers (7.3%), and from home (90.7%). Furthermore, the honey bees get their food from the forest or field (100%) and food prepared at home (17.3%), as shown in Table 8.

TABLE 7. MAJOR PESTS AND PREDATORS THAT AFFECT HONEY PRODUCTION IN HIDEBU ABOTE WOREDA

S/N	Variable	Response in percentage	Rank
1	Ants	60	1
2	Spiders	34	3
3	Hamagot	29.3	5
4	Lizards	32	4
5	Birds	36.7	2
6	Wax moth	17.8	6

TABLE 8. USES OF AGROCHEMICALS, CAPACITY BUILDING, AND OTHER RELATED FACTORS AFFECTING HONEY BEE PRODUCTION

	Response in percentage	
Studied Variable	Yes	No
Possession of empty beehives	90.7	9.3
Training on beekeeping	44	56
Professional support on beekeeping	40.7	59.3
Uses of agrochemical	98.7	1.3
Colony absconding	100	0.0
Occurrence of swarming	98.7	1.3
Availability of water during dry season	100	0
Sources of water for honey bee		
Streams	2	
Rivers	7.3	
Provide by myself	90.7	
Sources of feeding for honey bee		
From forest/field	100	
From home (prepared at home)	17.3	

4.7. Correlations

The correlation between educational level and the types of beehives used in Hidebu Abote is shown below in Table 9 The use of traditional beehives was significant (0.001) and negatively correlated (-0.144) with the educational level of the beekeepers. However, the use of transitional and modern beehives was highly significant (0.002, 0.000) and positively correlated (0.247, 0.535), respectively, with the educational level of the beekeepers. Moreover, the relationships between the types of beehives used and harvested honey yield in kilograms (kg) were also calculated using Pearson correlations, as indicated in Table 10. The relationship between the use of traditional beehives and harvested honey

yield in kg was highly significant (0.000) and negatively correlated (-0.791). There was a positive and highly significant correlation between the use of transitional (0.915, 0.000) and modern (0.921, 0.000) beehives and their respective harvested honey yields in kilograms, respectively.

TABLE 9. THE 2-TAILED PEARSON CORRELATIONS BETWEEN THE INFLUENCE OF EDUCATIONAL LEVEL AND THE OWNERSHIP OF BEEHIVES TYPE USED IN HIDEBU ABOTE WOREDA (BELOW THE DIAGONAL SHOWS CORRELATION, AND ABOVE THE DIAGONAL IS SIGNIFICANCE)

Variables	Influence of Educational level	Ownership of Traditional beehive	Ownership of Transitional beehive	Ownership of Modern beehive
Influence of Educational level	1	.001	.002	.000
Ownership of Traditional beehive	-.144	1	.052	.000
Ownership of Transitional beehive	.247**	-.159	1	.007
Ownership of Modern beehive	.535**	-.320**	.219**	1

Key= ** shows the correlation is significant at the 0.01 level (2-tailed), (This means the value will be considered significant if it is between 0.001 to 0.010).

TABLE 10. THE 2-TAILED PEARSON CORRELATIONS BETWEEN THE TYPES OF BEEHIVES USED AND MEAN OF HARVESTED HONEY YIELD FROM IT IN HIDEBU ABOTE WOREDA

Variables	Correlation and significance	harvested mean of honey yield in kg from traditional beehives	harvested mean of honey yield in kg from transitional beehives	harvested mean of honey yield in kg from modern beehives
Traditional beehive	Correlation	-.791**	-.135	-.338**
	Sig.	.000	.098	.000
Transitional beehive	Correlation	-.152	.915**	.249**
	Sig.	.063	.000	.002
Modern beehive	Correlation	-.145	.247**	.921**
	Sig.	.076	.002	.000

Key: **. Correlation is significant at the 0.01 level (2-tailed)

5. DISCUSSIONS

The participation of males (90.7%) was much higher than that of females (9.3%) in the beekeeping activities in Hidebu Abote woreda. These findings showed that males dominated honey production in the study areas. Haftu Kebede and Gezu Tadesse (2014) reported that 93% of the participants in Southern Ethiopia were males and 7% were females, while Segni Shimelis and Fufa Abunna (2017) found that 91.1% of the participants in West Shoa were males and 8.9% were females in honey production. Fewer women may participate in beekeeping due to cultural norms that view it as a male job (Addis Getu and Malede Birhan, 2015; Teklu Gebretsadik, 2016).

The current study confirmed that 42% of the beekeepers who were productive ages (41–50) were participating in the honey production in the study areas. This finding is in line with the result reported by Taye Beyene and Marco Verschuur (2014) that beekeepers had a mean age of 49 years in the South West Shewa Zone and 40.2 years in Jimma and Illubabor (Welay Kiros and Tekleberhan Tsegay, 2017).

Most of the beekeepers (31.3%) and (21.3%) who were engaging in beekeeping activities had illiterate and basic education levels, respectively. This result indicated that the low education level was highly affecting the activities of beekeeping and the use of modern technologies in the study areas. Relatively similar and much higher finding were reported that 18.33% and 60% of the beekeepers had basic education and illiterate status of education levels, respectively in the West Guji zone (Hussen Abduku, 2023). Furthermore, Eskindir Amanuel and Yared Alemayehu (2021) reported that 39.3% of the beekeepers who participating in the honey production were illiterate which is similar finding with our current observation. Less than five beehives were utilized by many beekeepers (42.7%) in the study areas to produce honey, showing that beekeeping was done to generate extra income. Beekeeping was

used for household consumption and generating additional income in Jigjiga zone (Sisay Fikru *et al*., 2015), and in Arsi Negelle woreda (Tariku Olana and Zerihun Demrew, 2018).

The current study confirmed that most of the beekeepers (60%) were using only traditional beehives for honey production. On the other hand, a few of them (7%) used only modern beehives. This result is in line with the findings of Benyam Tadesse *et al*. (2021) that 65% and 0% of the beekeepers used traditional and modern beehives for honey production in Southwest Ethiopia. Higher results were also reported by Tariku Olana and Zerihun Demrew (2018) in their study that 81.7% and 6.01% of the beekeepers in the Arsi Negelle district produced honey using traditional and modern beehives, respectively.

Furthermore, traditional beehives were very cheap, while modern beehives were expensive in the study areas. Therefore, beekeepers widely use traditional beehives because they are cheap and can be easily made from locally available materials. In contrast, the higher costs of modern beehives and a lack of knowledge limited their usage. Our findings were in agreement with the results of (Sisay Fikru *et al*., 2015; Firisa Woyessa and Dejene Alemu, 2016; Welay Kiros, and Tekleberhan Tsegay, 2017) who reported that most beekeepers employed traditional beehives than modern beehives.

The current study showed that the government did not play any role in granting modern beehives to the beekeepers in the study areas. Furthermore, it didn't employ an expert for functioning the farmers' cooperative which was built and fulfilled with modern materials by Agriculture Growth program (AGP). On the other hand, different NGOs made better contributions by granting modern beehives and providing some training for beekeepers.

In Hidebu Abote woreda, beekeepers employed traditional, transitional, and modern beehives to produce honey. The majority of beekeepers (97.3%) gathered honey twice a year. The average honey production harvested per year from a single traditional beehive was 7.52 ± 2.48 kg, transitional 17.08 ±

1.63 kg, and modern 27.28 ± 3.72 kg. The highest honey yields were collected from a single modern beehive per year, while traditional beehives produced the lowest yields. These findings demonstrated that the employment of modern beehive produces a higher yield of honey, whereas the traditional of beekeeping produces poor results. The current results were higher than the previous findings reported by Addis Getu and Malede Birhan (2015), who found that the mean honey yield harvested from a single beehive of modern, transitional, and traditional beehive per year was 23.38 ± 0.73, 14.70 ± 0.62, and 7.20 ± 0.23 kg for respectively. Similarly, Welay Kiros, and Tekleberhan Tsegay (2017) found that an average of 22 ± 4.56, 16.2 ± 4.12, and 6.97 ± 1.58 kg of honey yield were harvested per year from a single beehive of modern, transitional, and traditional respectively.

The honeybee colony had a fluctuating status in Hidebu Abote woreda. The current results showed that the status of honey bee colonies in the past ten, and five years showed an increment. The increment may have been caused by the assignment of a livestock expert to each kebeles to monitor and support beekeepers, the provision of modern beehives, and some training given to beekeepers by an NGO called World Vision Ethiopia. However, the increment was not sustainable. It became decreasing in the past three, two and this year due to the variable natural conditions, an increment uses of agro-chemical, predators, absconding, pests, lack of using modern beehives, lack of training on beekeeping. The decreasing of honey colonies were reported by Haftey Sahle *et al*. (2018), Alemayehu Anza *et al*. (2021), and Alemayehu Tolera *et al*. (2022).

Most of the beekeepers in the study areas externally managed the presence/ absence of colonies and swarming through daily inspection and transferring the colonies into the prepared empty beehives, respectively. However, the majority of the beekeepers had not inspected the insect problems while they were visiting their colonies. These results confirmed that the beekeepers had not checked the colonies internally due to the placement of traditional beehives, which made it difficult for internal inspection.

A similar result was reported by Haftu Kebede and Gezu Tadesse (2014) in Hadiya zone and Alemayehu Tolera *et al*. (2022) in Horo Guduru that beekeepers did not practice internal inspection for their colony management.

The major pests and predators that affected honey production in the study areas were ants, birds, spiders, lizards, hamagot, and wax moths, ranking 1st to 6th in the current findings. Our findings were consistent with those of numerous researchers who reported from various parts of Ethiopia that the main pests and predators that affected honey production with varying ranks at various study areas included ants, wax moths, birds, spiders, lizards, and Hamagot in the Tigray region (Teklu Gebretsadik, 2016), spiders, lizards, and birds in the West Shewa zone (Segni Shimelis and Fufa Abunna (2017), ants, wax moth, lizard in Arsi Negelle (Tariku Olana and Zerihun Demrew, 2018), ant and wax moth in Guji zone (Hussen Abduku, 2023).

Furthermore, the extensive use of agrochemicals like pesticides and herbicides (98.7%), lack of training (59.7%), absconding (100%), and failure to use modern beehives (92.7%) were the main factors affecting beekeeping activities in the study areas. The majority of beekeepers utilized various agrochemicals to keep pests and weeds out of their crops. These agrochemicals had the potential to wipe out honey bee colonies, which reduced the amount of honey produced. The findings of Benyam Tadesse *et al*., 2021; Gratzer *et al*., 2021; and Hussen Abduku, 2023 were in agreement with our findings. In contrast, honey bees in the study locations had access to plenty of water and food during the dry seasons. The current findings conflicted with those reported by (Haftey Sahle *et al*., 2018) and Yibeletal Aynalem (2020), who claimed that a lack of water and bee fodder were factors that had an impact on honey production in their study regions.

The relationship between beekeeper education and the use of traditional beehives was negative and significant. This means that as the level of education decreased, the use of traditional beehives

increased. This demonstrated that illiterate beekeepers relied on traditional beehives. Adino Andaregie *et al*. (2022) reported a similar finding, indicating that being illiterate reduces the likelihood of utilizing modern beekeeping beehives due to a lack of awareness.

On the other hand, there was a positive and highly significant correlation between educational level and the uses of transitional and modern beehives. This result indicated that as the level of education increased, the uses of transitional and modern beehives were increased respectively. Education raises beekeepers' awareness of new technology and their applications. This result was consistent with the findings of (Kassa Tarekegn *et al*., 2017; Dereje Tulu *et al*., 2020), who found that beekeepers' awareness about modern technology increased their adoption and its applications in their beekeeping activities.

The association between the use of modern beehives and honey yield was positive and significant, whereas the relationship between the usages of traditional beehives was negative and significant. This finding revealed that using modern beehives boosted honey yield whereas traditional beehives reduced the honey yield. Our findings were consistent with those of Affognon *et al.* (2015) from Kenya and Kuboja *et al*. (2017) from Tanzania, who found that the implementation of modern beehive technologies has a significant and positive impact on honey yield.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The major constraints that hindered beekeeping activities in Hidebu Abote were the lack of use of modern beehives (due to their high cost and lack of awareness), lack of internal inspection of colonies, lack of training, presence of absconding, extensive use of agrochemicals such as pesticides and herbicides, pests, and predators such as ants, birds, spiders, lizards, hamagots, and wax moths. These factors resulted in a decrease in honey colonies, which in turn reduced honey production, finally affecting the income of the beekeepers to support their livelihood. Furthermore, the beekeeping activities of the woreda were mainly dominated by the traditional system, which resulted in low honey yield. The local government paid less attention to the honey production activities of woreda. The beekeeping farmers' cooperatives did not function in the study areas because of the lack of skilled manpower that forced beekeepers to sell their honey at cheap prices in villages and local markets. There was a positive correlation between the use of modern beehives and honey yield, while traditional beehives had a negative correlation.

6.2. Recommendations

Based on the findings, the following recommendations are presented.

- ✓ Beekeepers should replace the traditional beekeeping system with the modern beekeeping system, use less agrochemicals, and combine external and internal colony checks in order to overcome the constraints of honey production and boost honey yield.

To improve the factors affecting honey production, the Woreda Agricultural Office should consider the following:

- ✓ Give attention to beekeeping activities, organize beekeepers at the cooperative level, and employ experts to function in modern technology prepared for beekeepers' cooperatives at the Woreda level.
- ✓ Intervention measures should be taken to improve the traditional beekeeping system through training, encouraging beekeepers to use modern technologies, and granting and providing modern beehives at affordable prices.
- ✓ Create market networking for beekeepers to sell their honey products at reasonable prices.
- ✓ Livestock experts should provide professional support and follow up beekeepers appropriately.

Agricultural Research centers and universities are key stakeholders in improving the constraints of honey production. Therefore, we recommend the following.

- ✓ Regarding beekeeping activities, appropriate training should be provided to beekeepers and livestock experts at regional, zonal, and Wereda levels.
- ✓ Perform problem-solving research at the community level and develop appropriate intervention methods.
- ✓ Provide community services on the beekeeping activities.

Due to budget and time constraints, we did not cover more kebeles and all factors affecting honey production in the Hidebu Abote Woreda. Therefore, we recommend that future researchers include more kebeles, beekeeping marketing systems, and cultural practices to overcome these constraints are needed.

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APPENDEXES

1 APPENDEX 1. QUESITIONNAIRE PREPARED FOR DATA COLLECTION FROM BEEKEEPERS - 2023

Addis Ababa University, Department of Biology

My name is Getachew Bayisa. I am an MSc student at Addis Ababa University, department of biology. I am going to study the Factors affecting honey bee and honey production in Hidebu Abote Woreda, North Shoa zone of Oromia regional state, Ethiopia. Therefore, I would like to ask you to give me genuine information about your beekeeping practices. Thank you in advance.

The main objective of this study is to analyze the major factors affecting honey bee and honey production by smallholder beekeepers.

Instruction: Please try to give me the correct responses from the options provided for you.

1. Background of the beekeeper:
   Name**:**_____
   Sex: 1. M 2. F
   Age: 1. <20 2. 20-30 3. 31-40 4. 41-50 5. 51-60 6. ≥61
   Educational level: 1. Illiterate 2. Basic education 3. Grade1- 4 4. Grade 5-8
   5. Grade 9-12 6. Diploma 7. Degree
   Household head: 1. Male 2. Female
   Number of beehives: 1. < 5 2. 5-10 3. 11-15 4. 16-20 5. ≥21
   Plot of farmland in Timad: 1. 1-4 2. 5-8 3. 9-12 4. 13-16 5. 17-20 6. ≥21
2. What type of beehive do you use for honey production (multiple answers are possible)?
   1. Traditional 2. Transitional 3. Modern
3. Where did you get the beehives you use for honey production (multiple answers are possible)?
   1. Prepared by myself 2. Bought from market 3. Grant given from government 4. Grant given by NGO
4. If you bought it from the market, for how much Ethiopian birr did you buy?
   1.Traditional_____ 2.Transitional_____ 3.Modern_____
5. Where did you keep your bee colonies? 1. Backyard 2. In the house 3. Hanging in the forest
   4. Others (please specify):_____

6. How many bee colonies did you have in 2014 E.C? 1. Below 5 2. 5-10 3. 11-15 4. 16-20 5. 21 and above.
7. How many bee colonies do you have this year (2015 E.C)? 1. Below 5 2. 5-10 3. 11-15 4. 16-20 5. 21 and above.
8. How do you compare the number of bee colonies with the last 10 years, 5 years, 3 years, 2 years and now? Is the trend down ward or upward or no change? 1. Down ward 2. Upward 3. No change

   If there is a change what do you think brought the change? ----------
9. How many times do you collect honey per year? 1. Once 2. Twice 3. Three times 4. Four times
10. Do you have an empty beehive? 1. Yes 2. No
11. If your answer for question number 10 is yes, how many empty beehives do you have? _____
12. Did you take any training on beekeeping? 1. Yes 2. No
13. Do you get any professional support on beekeeping from agricultural extension workers? 1. Yes 2. No
14. Do you use agrochemicals for crop production?

    1. Yes ____ 2. No_____
15. If your answer for question number 14 is Yes, what kinds of agrochemicals do you use (multiple answers are possible)? 1. Insecticides 2. Herbicides 3. Fungicides
16. Do you think that usage of agrochemicals affect the honey bee?

    1. Yes 2. No 3. I do not know
17. Is water available for your honey bees during dry season? 1. Yes_____ 2. No_____
18. If yes, where do your honeybees get water? 1. Streams 2. River 3. Provide by myself 4. I don't know.
19. Where do your honey bees get its feeding most of the time (multiple answers are possible)? 1. from forest/ field 2. I prepare and provide it from my home

    3. Others (please specify)_____
20. How frequent do you visit and inspect your honey bee colonies? 1. Daily 2. Weekly

    3. Per two weeks, 4. Monthly, 5. During honey harvesting time, 6. during rainy time.

    7. I do not visit my honey bee colonies

21. If you visit your honey bee colonies, what do you check most of the time (multiple answers are possible)? 1. Condition of beehives 2. Presence or absence of bee colonies
    3. Insect problem 4. Honey production status 5. Others (please specify)_____
22. Have you encountered colony absconding in your beekeeping practice? 1. Yes 2. No
23. What are the major pests or predators that affect the bee production in your area? Please identify them by ranking from highest to smallest.
    1. Ants (rank__) 2. Spiders (rank__) 3. Hamagot (rank__) 4. Birds (rank__)
    5. Lizard (rank__) 6. Others (specify) rank___
24. Does swarming (bee colonies reproduce to form new colonies) occur in your colonies?
    1. Yes 2. No
25. How do you manage swarming (multiple answers are possible)? 1. Transferring into empty beehives, 2. Harvesting honey combs 3. Removal of queen cells 4. Others (specify)____
26. How many kilograms of honey do you harvest from one beehive per year on average?
    Traditional_____
    Transitional_____
    Modern_____
    Other than honey what other products you get as a bee keeper? Beewax, etc.
27. Where do you sale your honey products (multiple answers are possible)? 1. in the village, 2. Local market, 3. Tej houses, 4. At farmers cooperatives 5. Others (please specify) _____
28. On average, at what price did you sell a one kilogram of honey in this year (2015 E.C.) in Ethiopia Birr? _____

Thank you very much for your cooperation

2APPENDIX 2. INTERVIEW QUESTIONS PREPARED FOR DATA COLLECTION FROM MODEL BEEKEEPERS 2023, ADDIS ABABA UNIVERSITY, DEPARTMENT OF BIOLOGY

My name is Getachew Bayisa. I am an MSc student at Addis Ababa University, department of biology. I am going to study the Factors affecting honey bee and honey production in Hidebu Abote Woreda, North Shoa zone of Oromia regional state, Ethiopia. Therefore, I would like to ask you to give me genuine information about your beekeeping practices. Thank you in advance.

The main objective of this study is to analyze the major factors affecting honey bee and honey production by smallholder beekeepers.

Instruction: Please try to give me the correct information.

Background of the model beekeeper:
Name:_____

Sex: 1. M 2. F

Age: 1. <20 2. 20-30 3. 31-40 4. 41-50 5. 51-60 6. ≥ 61

Educational level: 1. Illiterate 2. Basic education 3. Grade1- 4 4. Grade 5-8

5. Grade 9-12 6. Diploma 7. Degree

Household head: 1. Male 2. Female

Number of beehives: 1. < 5 2. 5-10 3. 11-15 4. 16-20 5. ≥21

Plot of farmland in Timad**:** 1. 1-4 2. 5-8 3. 9-12 4. 13-16 5. 17-20 6. ≥21

1. What are the major factors that affect your honey production? Please describe them in ranks. How do you overcome the effects of these factors?
2. What is the status of your honey production in 2015 E.C? Does it increase, decrease or no change compared to 2014 E.C? What about in the past three years? Why?
3. Does the government facilitate the market for selling your honey in the woreda? Why?
4. Which types of beehives do you use mostly? Why?
5. What kinds of support do you want from gov't that you did not get it before to improve your honey production more? Please list them down.

Thank you very much for your cooperation

3APPENDIX 3. INTERVIEW QUESTIONS PREPARED FOR DATA COLLECTION FROM HIDEBU ABOTE LIVESTOCK EXPERT AND AGRICULTURAL SUPERVISORS -2023 ADDIS ABABA UNIVERSITY DEPARTMENT OF BIOLOG**Y**

My name is Getachew Bayisa. I am an MSc student at Addis Ababa University, department of biology. I am going to study the Factors affecting honey bee and honey production in Hidebu Abote Woreda, North Shoa zone of Oromia regional state, Ethiopia. Therefore, I would like to ask you to give me genuine information about your beekeeping practices. Thank you in advance.

The main objective of this study is to analyze the major factors affecting honey bee and honey production by smallholder beekeepers.

Instruction: Please try to give me the correct information.

Background of the Livestock expert and agricultural supervisors

Name:_____

Sex: 1. M 2. F

Age: 1. <20 2. 20-30 3. 31-40 4. 41-50 5. 51-60 6. ≥ 61

Educational level: 1. Illiterate 2. Basic education 3. Grade1- 4 4. Grade 5-8 5. Grade 9-12, 6. Diploma 7. Degree

6. What are the major factors that affect honey production in the kebele you are supporting? What did you support farmers to overcome these challenging factors?
7. Have you deliver training on beekeeping for farmers yet? Please list down the topics of training.
8. Does the Woreda establish farmers' cooperative on beekeeping that facilitates the marketing network for beekeepers?
9. Which types of beehives beekeepers use most of the time for honey production in the kebele you are working? Why?
10. What is the status of the honey production of the kebeles you were assigned to support it professionally in 2015 E.C? Does it increase, decrease or no change compared to 2014 E.C? What about in the past three years? Why?

Thank you very much for your cooperation

4 APPENDIX 4.PHOTOS INDICATING TYPES OF BEEHIVES USED BY BEEKEEPERS IN HIDEBU ABOTE WOREDA

Traditional hive

Transitional hive