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PRODUCTION PRACTICES, TRENDS, CONSTRAINTS AND OPPORTUNITIES OF BEEKEEPING IN ARBA MINCH ZURIA DISTRICT, SOUTHERN ETHIOPIA

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ABSTRACT

The economic potential of beekeeping within rural communities is substantial. This research endeavors to explore the landscape of beekeeping practices, honey production trends and the associated challenges and opportunities within the Arba Minch Zuria District, Gamo Zone, Southern Ethiopia. Selected purposively for its beekeeping potential, the district was stratified into three agroecological zones. Seven representative kebeles were proportionally chosen based on their agroecological diversity, and 156 beekeepers were systematically sampled. Utilizing formal surveys, a cross-sectional analysis employing one-way ANOVA and cross-tabulations was conducted. Results underscored mixed crop-livestock farming as the prevailing livelihood strategy, accompanied by traditional beekeeping being the most practiced method, with 96.8 % of the beekeepers employing traditional techniques. The average honeybee stocks per household were 4.8 ± 1.78 and 5.2 ± 6.98 colonies for traditional and modern beehives, respectively. Correspondingly, the average honey yield was 5.8 ± 0.09 kg and 20.1 ± 0.31 kg per year for traditional and modern beehives, respectively. Over the last five years (2014 – 2018), there was a decreasing trend of total colony number and honey yield. While beekeepers face challenges such as a shortage of bee forage, absconding and honeybee enemies, there are ample opportunities such as numerous honeybee colonies, emphasis from the government and tourist attraction sites, all of which provide a lucrative market opportunity to sell honey at a premium price. To ensure the beekeeping industry thrives in the area and contributes to the growth and development of rural livelihoods, it is crucial to address the challenges faced by beekeepers.

Key words: agroecology; Arba Minch Zuria; beekeeping; constraints; honey yield

INTRODUCTION

Beekeeping plays a vital role in Ethiopia's agricultural landscape, with the potential to produce 500,000 tons of honey and 50,000 tons of beeswax annually. Currently, however, production levels fall short of this potential, with only over 207,000 tons of honey and approximately 13 tons of beeswax produced (MOA, 2024). Despite these figures, Ethiopia ranks among the top ten honey-producing countries globally and accounting for over 25 % of production in Africa (Apimondia, 2018).

Honey production is widespread across Ethiopia's regions, and the production potential varies depending on the region's suitability for beekeeping. Beehives come in three types: traditional, intermediate and frame hives, and the beekeeping system employed depends on the management practices, level and types of technology used (Solomon and Seid, 2015). According to Kenesa (2018) traditional honeybee production system is pre-dominant beekeeping technique exercised in two forms – traditional forest and traditional backyard practices.

Despite the long-standing tradition of beekeeping in Ethiopia, the knowledge and skills required for honey

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and beeswax production remain largely traditional (MoARD, 2010). Beekeeping is an income-generating venture for resource-poor farmers including women, youths and the unemployed population (Gezahegn, 2001). Honey production plays a critical role in job creation and maintaining livelihoods. However, current honey production levels account for only 8.6 % of Ethiopia's production potential (MoARD, 2010; Paulos, 2011). This sub-sector faces several constraints such as lack of beekeeping knowledge, shortage of trained manpower, shortage of beekeeping equipment, pests and predators, wild fire, pesticide threat and inadequate research works to support development programs (Askale *et al.*, 2017), but the government and other stakeholders are taking proactive measures to address them.

Beekeeping in Gamo Zone has been a long-standing practice. Gamo Zone is generally known by its great potential for honeybee resources and honey production (Nebiyu and Melesse, 2013). As being one of the beekeeping potential Districts in Gamo Zone, Arba Minch Zuria District is also known for its better natural vegetation coverage and honeybee colony number in comparison with other districts in Gamo Zone. Beekeeping is an integral part of livestock production in the district, contributing significantly to rural livelihoods. However, despite its importance, the lack of consolidated and reliable data poses a notable challenge. This study seeks to address this gap by offering comprehensive insights into beekeeping practices, honey production potential, trends, as well as the primary constraints and opportunities within the district. With the government and other stakeholders working together to address the challenges, we are confident that Ethiopia can achieve its full potential and become a leader in the global honey and beeswax market.

MATERIALS AND METHODS

Description of the study area

The research was carried out in the Arba Minch Zuria District, one of twenty districts in Gamo Zone of Southern Ethiopia (Figure 1). The district has a general elevation ranging from 1150 to 3300 m.a.s.l. The district's

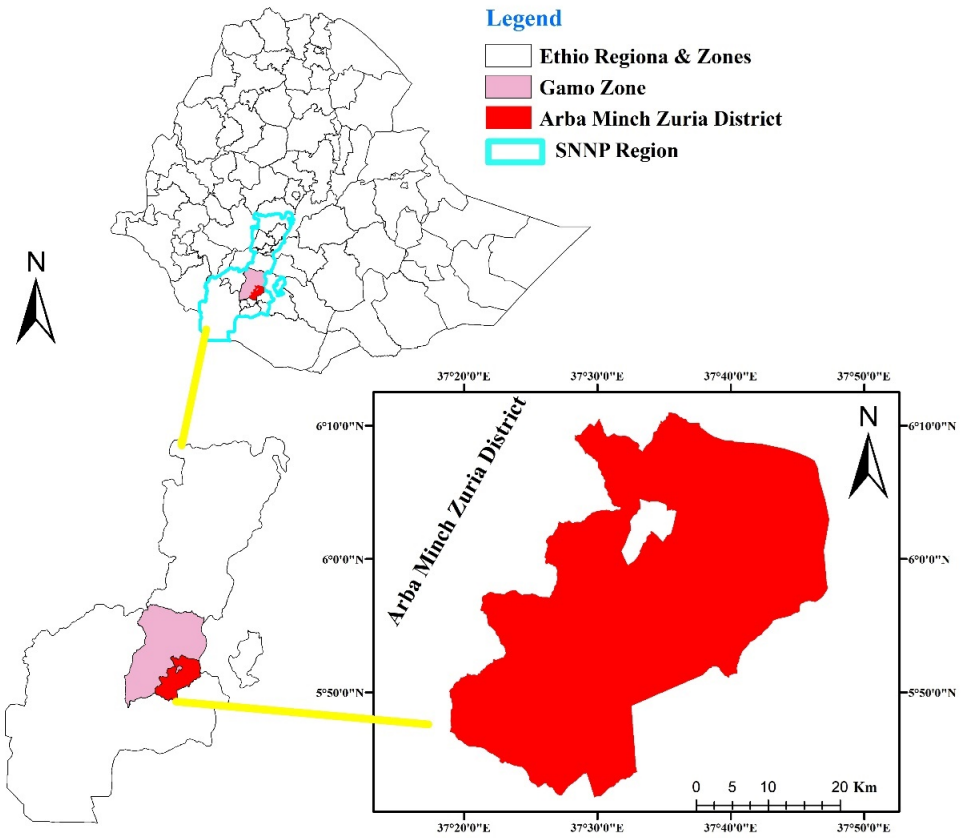

Figure 1. Map of the study area

annual rainfall ranges between 800 and 1500 mm, and the average annual temperature falls between 16.3 °C and 37 °C. The district's climate is characterized as 14 % highland, 53 % midland and 33 % lowland.

Sampling procedure and sample size determination

The study employed a multi-stage sampling procedure at three distinct levels. Firstly, the study district was stratified into three different agroecologies or agricultural ecosystems, namely lowland (< 1500 m.a.s.l), midland (1500 – 2300 m.a.s.l) and highland (> 2300 m.a.s.l) (MoARD, 2007). Secondly, seven representative "Kebeles", the smallest administrative units within the district, were selected proportionally to their agro-ecological variation utilizing a purposive sampling technique based on the beekeeping potential of the Kebeles. Finally, individual household heads with honeybee colonies were identified and selected through a systematic random sampling technique from a list of households in each Kebele. In this study, the beekeepers in the district were used to represent the study population, and the sampling units were households keeping honeybee colonies. The sample size required for the study was determined by the formula recommended by Arsham (2005) for survey studies:

$$N = \frac{0.25}{SE^2}$$

where, N – sample size and SE – the standard error.

With the assumption of 4 % standard error, a total of 156 households were sampled. The sample sizes from each agro-ecology were selected based on proportion to the total sample size. Thus, 22, 83 and 51 beekeepers were selected from highland, midland and lowland, respectively.

Methods of data collection

Cross-sectional study was conducted to collect primary data from formal survey, focus group discussions, key informants' interview and field observations. Relevant information was further collected through discussions with the district honeybee experts, development agents (DAs), NGOs and other relevant institutions that play significant role in beekeeping activities of the district. Secondary data, which are used to supplement the primary data, were obtained from Gamo Zone Livestock and Fishery Resource Department (GZLFRD), Arba Minch Zuria District Livestock and Fishery Resource Development Offices (AMZDLFRDO) and each *Kebele* farmer training centres (*FTC*). Besides, the reports of previous research findings, guidelines, manuals and other published and unpublished documents were also reviewed.

Data management and statistical analysis

The collected data were checked, coded and entered into SPSS software version 24 every day after administering questionnaire to prevent loss of data. The means of quantitative data among agro-ecologies were compared by employing one-way ANOVA. The means were separated using the Tukey HSD test whenever they were statistically significant at $P < 0.05$. Statistical differences among qualitative variables were analyzed in a cross-tabulation. The analysed data were presented using tables, graphs, charts, frequencies, percentages, means and standards.

RESULTS

Socio-economic characteristics of the respondents

The sex category revealed that all interviewed beekeepers were male headed households. The overall mean age of the interviewed beekeepers was 42.90 ± 0.56 years, with a range of 26 – 68 years (Table 1).

The overall beekeeping experience was 14.85 ± 0.68 years, with a minimum of 3 years and a maximum of 42 years. The average farmland landholding of the respondents was found to be highly significant ($P < 0.001$) across agroecologies. The highest landholding was recorded in lowland, whereas the lowest farmland size was recorded in highland agroecology.

Major farming activities and source of income for households

The primary means of livelihood in the study areas was mixed crop-livestock farming system. Crop production was ranked the first farming activity with an index value of 0.460 (Table 2). Accordingly, *enset*, barley, wheat, *teff*, sorghum, maize, haricot bean, common bean, pea, potato, sweet potato, tomato, pepper, cotton, onion, banana, avocado, papaya, mango and lemon were major crops produced in the study area. Among these mango, avocado, papaya, banana, bean, pea and potato were major honeybee plants that provide nectar and pollen to bees. Livestock production (index = 0.272) plays a substantial role in the household food security in the study area. Livestock species kept

Table 1. Socio-economic characteristics of the respondents (N = 156)

Variables	Agro-ecology (Mean ± SD)				*P*-value
	Overall	HL (N = 22)	ML (N = 83)	LL (N = 51)	
Average age (years)	42.90 ± 2.56	43.36 ± 2.22	42.58 ± 3.80	43.22 ± 4.59	0.849
Beekeeping experience (years)	14.85 ± 2.68	14.73 ± 2.36	14.08 ± 1.92	16.16 ± 3.08	0.400
Av. family size	7.01 ± 3.17	6.86 ± 3.74	7.05 ± 5.24	7.02 ± 4.31	0.940
Av. land holding (ha)	1.27 ± 0.56	0.68 ± 0.37^{c}	1.12 ± 0.26^{b}	1.78 ± 0.74^{a}	0.000
Educational level (%)					
Illiterate/uneducated	19.2	50.0	12.0	17.6	
Read and write	28.8	18.2	25.3	39.2	
Primary school	38.5	31.8	48.2	25.5	0.001
High school	11.5	0	13.3	13.7	
College and above	1.9	0	1.2	3.9	

ns – not significant; HL – highland; ML – midland; LL – lowland; N – number of interviewed beekeepers; SD – standard deviations; ^{a,b,c}means followed by different superscript letters in a row are significantly different.

Table 2. Farming activities of the respondents in the study area

Activity	1st	2nd	3rd	Index*	Rank
Crop production	91	59	40	0.460	1st
Livestock production	32	42	75	0.272	2nd
Beekeeping	13	19	34	0.119	3rd
Trade	14	31	5	0.116	4th
Others	6	5	2	0.032	5th

*Index – sum of 3 × number of responses for the first rank + 2 × number of responses for the second rank + 1 × number of responses for the third rank for each farming activity divided by the sum of 3 × total responses for the first rank + 2 × total responses for the second rank + 1 × total responses for the third rank for overall activities.

include cattle, sheep, goat, donkey, horse, mule, poultry and honeybees. Beekeeping (index = 0.119) ranked as third source of income next to crop and livestock production.

Beehive ownership and sources of foundation beehive

Traditional hives are typically made from locally available materials, making them inexpensive and simple to construct without the need for special skills. The type of hive varies from area to area, depending on the materials readily available such as clay, straw, bamboo, bark and logs. In contrast, modern hives feature standardized dimensions and movable frames, which allow for easier inspection, maintenance and harvesting. However, these modern hives generally require a higher initial investment. Majority of the interviewed beekeepers in highland and midland location owned only traditional hive, whereas higher adoption rate of modern hives was in lowland location ($P < 0.001$), as indicated in Table 3.

Source of foundation colony and means of stock increment

The majority (85.3 %) of the beekeepers obtained their foundation stock by swarm catching. Once the honeybee colony is established, beekeepers initiated to increase their colony number. In this regard, almost all beekeepers (98.7 %) increase their colony number through catching swarms, as revealed in Table 4.

Honeybee keeping practices

Beekeeping in the study area was practiced as a side line to other agricultural activities (Figure 2). Except

Table 3. Beehive distribution and source of foundation beehive in the study area

Variables		Agro-ecology (Mean ± SD)				X^2	*P*-value
		HL (N = 22)	ML (N = 83)	LL (N = 51)	Overall (N = 156)		
Beehive Type (%)	Traditional beehive only	77.3	55.4	31.4	50.6	21.92	0.000 **
	Both beehives	22.7	44.6	58.8	46.2		
	Modern beehive only	0	0	9.8	3.2		
Source of trad.) hive (%)	Constructed by the beekeeper himself	18.2	19.3	4.3	14.6	5.57	0.062
	Purchased from local market	81.8	80.7	95.7	85.4		
Source of mod. hive	Supplied by district livestock office	0	40	31.4	33.3	3.26	0.196
	Donated by NGO's	100	60	62.9	64		
	Purchased	0	0	5.7	2.7		

**Significant at $P < 0.001$; HL – highland, ML – midland, LL – lowland; X^2 – chi-square value; N – number of respondents.

Table 4. Sources of honeybee colony to start beekeeping and means of stock increment

Variables (%)	Response	Agro-ecology				X^2	*P*-value
		HL (N = 22)	ML (N = 83)	LL (N = 51)	Overall (N = 156)		
Colony source	Gift from parents (%)	4.5	12	9.8	10.3	5.59	0.471
	Catching swarms (%)	90.9	85.5	82.4	85.3		
	Buying/purchasing (%)	0	0	3.9	1.3		
	Gift and catching swarms	4.5	2.4	3.9	3.2		
Colony increment	By swarm catching	100	100	96.1	98.7	4.17	0.124
	Swarm catching and purchasing (%)	0	0	3.9	1.3		

X^2 – chi-square value; N – number of respondents.

for few landless youths, there were no farmers that merely depend on beekeeping.

Colony holding and honey production

The overall colony holding of beekeepers in the study area was 4.76 ± 1.78 and 5.20 ± 6.98 colony per household in traditional and modern hives, respectively. Statistically, highly significant ($P < 0.001$) difference was observed in mean colony holding in both traditional and modern beehive across agro-ecologies. The lowland agro-ecology had highest colony holding (5.87 ± 1.82), while the lowest colony holding was observed in highland agro-ecology (Table 5).

Concerning the production of honey, the overall honey yield was 5.81 ± 5.09 and 20.05 ± 4.31kg per hive per year in traditional and modern hives, respectively. Highly significant difference ($P < 0.001$) in honey yield in both traditional and modern beehives across agro-ecologies was observed (Table 6). The highest honey yield obtained from traditional hive was recorded in lowland location as compared to the highland. Regarding the productivity of modern beehives across three agro-ecologies, the highest honey yield was recorded in lowland, whereas the lowest yield was recorded in highland location.

(a) (b) (c)

(d) (e)

Figure 2. Traditional beekeeping practice: model beekeeper carrying his traditional beehives to hang at forest trees in order to catch swarms (a); numerous traditional beehives hanged at forest trees in order to catch swarms (b and c). Modern beekeeping practice: in lowland (d) and highland (e).

Table 5. Average colony holding per household across agro-ecologies

Agro-ecology	Number of traditional hives with colony				Number of modern hives with colony			
	N	Mean ± SD	Min	Max	N	Mean ± SD	Min	Max
Highland	22	3.64 ± 1.00^{c}	2	5	5	2.60 ± 1.14^{b}	1	4
Midland	83	4.45 ± 1.61^{b}	1	10	35	2.91 ± 1.12^{b}	1	6
Lowland	46	5.87 ± 1.82^{a}	2	10	35	7.86 ± 9.54^{a}	3	60
Overall	151	4.76 ± 1.78	1	10	75	5.20 ± 6.98	1	60
P-value		0.000***				0.007**		

N – number of households

Table 6. Average honey yield from traditional and modern beehives

Agro-ecology	Honey yield per hive per year (kg)			
	Traditional hive		Modern hive	
	N	Mean ± SD	N	Mean ± SD
Highland	22	5.13 ± 6.19[b]	5	15.4 ± 5.67[c]
Midland	83	5.78 ± 4.12[a]	35	19.1 ± 3.35[b]
Lowland	46	6.18 ± 5.17[a]	35	21.6 ± 8.36[a]
Overall	151	5.81 ± 5.09	75	20.05 ± 4.31
P-value		0.002**		0.001**

**Significant at $P < 0.001$; [a,b]column means with different letter (s) differ significantly; N – number of households; SD – standard deviations; kg – kilogram.

Trends in honey yield and colony size

The trend of total colony number and honey yield in the two hive types across the last five years (2014 – 2018) is depicted in Figure 3 below. The data collected during the household survey indicated that the total honey yield from traditional hive has decreased from 3600 kg in the year 2014 to 3484 kg in 2015 and then increased up to 3796 kg in the year 2016. Thereafter, the yield decreased consistently to 2958 kg in the year 2018, which confirmed the decreasing trend of honey yield in traditional beehives. However, the total honey yield, obtained from modern beehives, increased from 3869 kg in the year 2014 to 3965 kg in the year 2016, and then decreased consistently to 3213 kg in the year 2018. Honey yield was better in the years 2016. Total honey yield in both hives was also decreased from 7469 kg in the year 2014 to 6171 in the year 2018. Similarly, the total honeybee colony size across the last five years showed decreasing trend in both traditional and modern beehives. The main reasons for decreasing trend in the bee colony and honey yields were risky utilization of agrochemicals, absconding and lack of bee forage during dearth period according to their importance, as revealed in focus group discussion.

Hive placement

About 70.5 % of traditional hived colonies and 87.8 % of modern hived colonies were placed at backyards indicating that backyard beekeeping is the most common

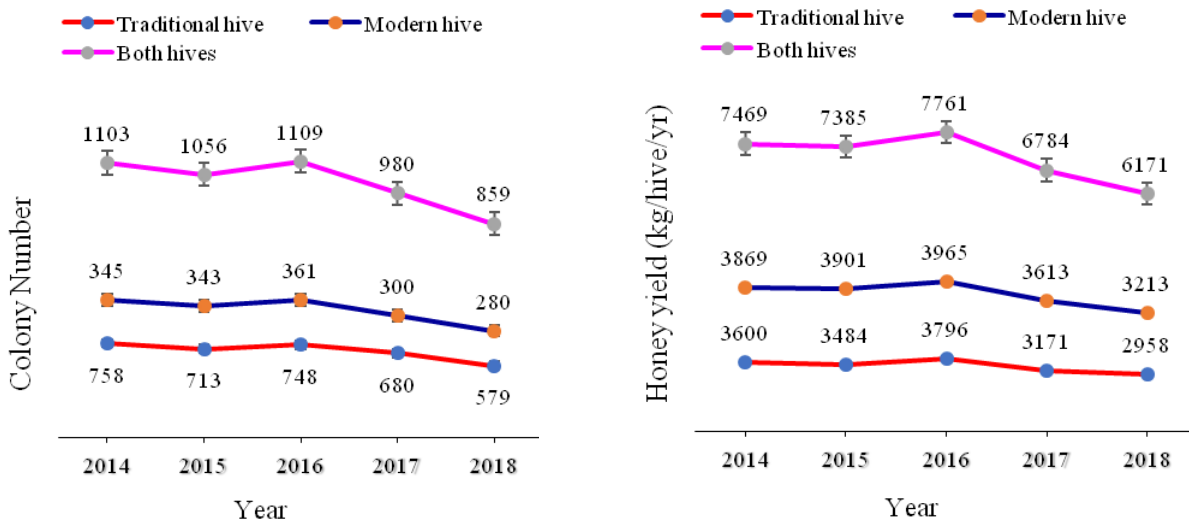

Figure 3. Trends of colony number and honey yield across the last five years (2014 – 2018)

practice of honey production in the study areas. The survey result indicated that majority (87.8 %) of the colonies in modern beehives were placed at backyard (Table 7).

Colony inspection and apiary visit

Almost all beekeepers (92.3 %) have visited and inspected their beehives, of whom 87.9 % undertook external inspection and cleaned their apiary to prevent ants and other insect pests from getting access to hives. Internal hive inspection was limited only to modern beehives and had been performed by not more than 42.2 % of the sample beekeepers who use modern beehives (Figure 4). Beekeepers inspected colonies when colonies became weak and during honey harvesting seasons.

Types and features of honeybees in the study area

Beekeepers in the study area have their own ways of categorizing their honeybees, mostly based on the colour

Table 7. Hive placement practices of the beekeepers in the study area

Hive placement (%)	Agro-ecology				X^2	*P*-value
	HL (N = 22)	ML (N = 83)	LL (N = 51)	Overall (N = 156)		
Traditional hives (%)						
Backyard (%)	90.9	73.5	56.9	70.5		
Under the eaves of the house (%)	0	3.6	0	1.9	14.13	0.078
Inside a simple shelter	0	1.2	3.9	1.9		
Hanging on trees near homestead (%)	0	4.8	5.9	4.5		
Hanging on trees in forests (%)	9.1	16.9	33.3	21.2		
Modern hives (%)						
Backyard	100	89.2	84.4	87.8	1.15	0.886
Under the eaves of the house	0	2.7	3.1	2.7		
Inside a simple shelter	0	8.1	12.5	9.5		

N – number of households.

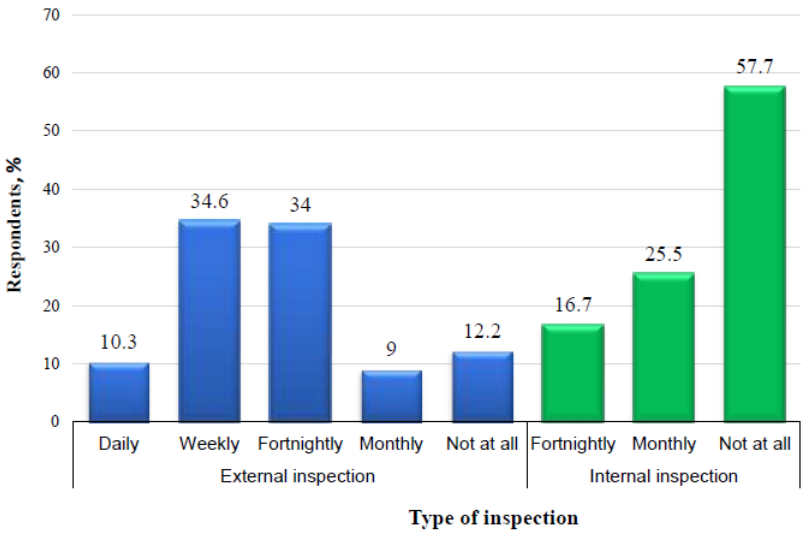

Figure 4. Honeybee colony inspection frequency as reported by beekeepers

of the honeybees. Accordingly, they divide bees into two groups namely, dark bees locally called "ocha/dhoshuma" and a slightly brown bees, "Xexumate", as revealed in the focus group dis-cussion. These bees have their own characteristics in temperament, productivity and body size. The slightly brown colour bees "xexumate" are aggressive, productive and relatively small in body size. Besides, this group of honeybees shows higher reproductive swarming and absconding behaviour. The dark bees "dhoshuma" are docile, relatively less productive and bigger in size, when compared to the red coloured bees. In agreement with this study, Teklu and Dinku (2016) reported two types of hon-eybees: black and red honeybees in selected Districts of Gedeo zone. Tessega (2009) also reported two groups of honeybees: "Wanzie or Shimbrie" (nearly yellow) and "Shanko" (black) types of honey-bees in Burie District of Amhara region. Similarly, two distinct groups of honeybees, namely, dark bees "Tikur" and red bees "Faki" were reported by Solomon and Seid (2015) in Delo-Mena and Mad-da-Walabu Districts of Bale zone of Oromia regional state. It was also reported that both black and red coloured varieties occur together in the same colonies. This might be because the queen may be mated with drones that come from different hives having varied colours. However, it is difficult to consider such type of bees as a race by looking the colour and size; it requires morphological and geographical characterization.

Major constraints of beekeeping

The major challenges of the beekeeping in the study area are shortage of bee forage especially during dry periods followed by absconding, pests and predators and unwise application of agrochemicals (Table 8).

Opportunities of beekeeping

Despite the challenges and constraints currently facing the beekeeping subsector, there are substantial opportunities and potentials to boost honey production in the district. Based on the information obtained from key informants, focus group discussions and field observations, the major opportunities for beekeeping development are as follows: firstly, the availability of a large number of bee colonies presents significant opportunities for beekeepers, who wish to expand and increase their honey production in the future. Additionally, the presence of a queen rearing centre in the study district offers avenues for increasing honeybee colony numbers and, consequently, honey production. Secondly, the existence of ample melliferous

Table 8. Major constraints of beekeeping in Arba Minch Zuria District

Major constraints	Index	Rank
Shortage of bee forage	0.147	1st
Absconding	0.116	2nd
Pests and predators	0.114	3rd
Unwise application of agrochemicals	0.109	4th
Lack of credit	0.100	5th
Lack of attention (awareness gap)	0.095	6th
Swarming/migration	0.081	7th
Lack of improved beehives and beekeeping equipment	0.073	8th
Inadequate access to training and poor extension service	0.047	9th
Human interference (theft)	0.040	10th
Recurrent drought	0.029	11th
Death of colony	0.027	12th
High rainfall	0.014	13th
Shortage of water	0.004	14th
High wind (storm)	0.003	15th

*Index – sum of 3 × number of responses for the first rank + 2 × number of responses for the second rank + 1 × number of responses for the third rank for each farming activity divided by the sum of 3 × total responses for the first rank + 2 × total responses for the second rank + 1 × total responses for the third rank for overall activities.

plants providing pollen and nectar to honeybees during active period is advantageous for beekeeping development in the area. Thirdly, the proximity of tourist attraction sites to the study area presents excellent market opportunities for beekeepers in the surrounding areas. Arba Minch city has become a favourite destination for foreign and local visitors due to its various tourist attractions, such as the two rift valley lakes, Abaya and Chamo, the God's bridge, the forty springs of natural gift, the crocodile ranch and the scenic evergreen forest. The tourists, who visit these natural wonders, create a good market for beekeepers as they can sell their honey products at premium prices to them. Fourthly, the government is currently giving stronger emphasis, than ever before, to the beekeeping subsector using it as an effective tool for poverty reduction and national export diversification. Finally, owing to relatively low start-up costs and minimum land requirements, beekeeping offers significant employment opportunities for the landless and youth. The beekeeping subsector in the district has significant opportunities and potentials for growth and development. By leveraging the opportunities outlined above, beekeepers can increase their honey production, create employment opportunities and contribute to national export diversification.

DISCUSSIONS

All interviewed beekeepers represented male-headed households. During group discussions with beekeepers, it became evident that the absence of women in beekeeping activities stemmed from two primary reasons. Firstly, women expressed apprehension regarding the risk of honeybee stings. Secondly, their extensive responsibilities in managing household affairs left them with insufficient time to engage in beekeeping activities. This finding resonates with previous studies by Sisay *et al.* (2015) and Shibru *et al.* (2016), who also reported that all interviewed beekeepers in Jigjiga zone and Gambella Zuria and Godere woreda were from male-headed households. Furthermore, this observation aligns with the research of Hartmann (2004), as cited by Getachew (2018), who highlights the historical predominance of men in beekeeping roles in Ethiopia. Highly significant differences ($P < 0.001$) were observed across different agro-ecological zones concerning the educational background of respondents. Variations in beekeeping experience among respondents may influence their attitudes and receptivity towards adopting new beekeeping technologies, as noted by Hussien *et al.* (2015). On average, respondents held farmland of 1.27 ± 0.06 hectares. This result is comparable with the mean national landholding (1 – 1.5 ha; CSA 2017).

The primary mean of livelihood in the study areas was mixed crop-livestock farming system. Crop production, livestock production and beekeeping were ranked as first, second and third sources of income, respectively. In line with this result, Kalayu *et al.* (2017) and Dinku (2018) noted that beekeeping ranked third source for household income in North-East dry land areas of Amhara region and Sidama zone of Southern region, respectively. This is probably due to the fact that the beekeeping operation requires small initial capital with possibility of keeping honeybee in marginal farmlands, where crop production is not possible and even by hanging in forest trees far away from homestead when farm land is not available, as it was pointed out during discussion with key informants. Besides, trade and other off-farm activities such as weaving, irrigation, fish production and carpentry were also available means to support their subsistence livelihood. This indicates the possibility of keeping honeybees' side by side along with on-farm and other off-farm activities.

The study revealed that almost all the interviewed beekeepers (96.8 %) owned traditional beehive and kept their colony in it. Like the current study, Bekele *et al.* (2017) stated, that the majority of the beekeepers in Bale Zone (98.26 %) practiced traditional production system and only few (1.36 %) beekeepers started using modern beekeeping practice. Colony and apiary inspections are very crucial to protect honeybee colonies from different natural risks and enemies such as pests, predators, diseases and chemical poisoning (Abebe, 2017). The study revealed that most of the beekeepers used swarm catching to establish their foundation stock. This is due to the fact that farmers could catch colonies easily when reproductive swarming is active. This finding agrees with the reports of Bekele (2017), Kiros and Tsegay (2017) and Dinku (2018), who indicated that majority of beekeepers started beekeeping through swarm catching in Bale zone, Jimma and Illubabor zone and Sidama Zones, respectively.

Based on the input used and their management practices, two types of beekeeping practices are mainly used for honey production in the district: local (traditional) and modern (frame) beehive beekeeping. The traditional

beekeeping was practiced in two forms. At traditional forest beekeeping, beehives were hanged on trees with numerous branches in forest without any management employed for bees and bee products. Traditional back yard beekeeping was practiced around homestead with relatively better management provided to bee colonies, as compared to forest beekeeping. Regarding modern beekeeping practice, the adoption rate of modern hive was very low due to the lack of credit facilities to buy inputs, shortage in supply of beehive accessories, lack of knowledge on how to operate the box hive and weak beekeeping extension services and lack of intervention on beekeeping by government and non-governmental organizations in the study area.

The average colony holding was 4.76 ± 1.78 per head, whereas the average honey production was 5.81 ± 0.09 kg/hive/year from traditional hive (Table 5). Highly significant ($P < 0.01$) difference was observed in mean colony holding in both traditional and modern beehives across the three agro-ecologies. This might be due to favourable weather, which supports the growth of diverse honey bee plants in the lowland areas (Table 5). Agreed with this, comparable finding reported by Bekele *et al.* (2017) stated that the average colony holding is 6.26 ± 0.92 colonies per head in Bale zone. However, the current study result was by far lower than the average colony holding observed in the Afar region (10.08 colonies per household; Gebrehaweria *et al.*, 2018) and Jimma and Illubabor Zone of Oromia region (10.7 ± 4.3 colonies per head; Kiros and Tsegay, 2017). The current study also indicated that the average honey yield from modern beehive was 20.05 ± 0.31 kg/hive/year, whereas the average colony holding per head was 5.20 ± 6.98 colonies (Table 5). The overall average honey productivity per beehive in traditional and modern beehives was 5.81 ± 0.09 kg and 20.05 ± 0.31 kg, respectively (Table 6). Similarly to this result, in the same zone of different districts, Nebiyu and Melesse (2013) reported that the average honey yield per year per beehive was 5.88 ± 1.96 and 20.64 ± 4.96 kg for traditional and modern beehives, respectively.

The total honey yield from both traditional and modern hives revealed undulating trend across the five consecutive years (Figure 2) but generally confirmed the decreasing trend of honey yield in traditional beehives. Honey yield was better in the years 2016 and 2017 due to better rainfall distribution, availability of ample bee forages and suitable climatic conditions for honeybees. Similarly, the total honeybee colony size across the last five years in both traditional and modern beehives showed decreasing trend due to multitude of reasons, among which irresponsible utilization of agrochemicals, absconding, lack of bee forage and pests and predators were found to be the most limiting factors. In line with this result, Dinku (2018) reported that the majority (78.8 %) of beekeepers in Sidama zone responded the decreasing trend of honeybee colonies over the past year due to indiscriminate use of agro-chemicals, shortages of bee forages and pests and predators. Similarly, Alemu (2015) noted that the majority (84.9 %) of the beekeepers in South Wollo and Waghimra Zones of Amhara region responded decreasing trend in the number of honeybee colonies and their products from time to time due to the availability and occurrence of various threatening factors, which had an adverse effect on honeybee health and their production potential. According to this author, presence of pests and predators, poor agrochemicals application on field crops and lack of bee forage, as a result of deforestation, were the main reasons (threatening factors) for the colony decreasing trends.

The study result indicates that most of the beekeepers kept their hives at backyard indicating that backyard beekeeping is the most common practice of honey production in the study areas. This agrees with the findings of Alemu (2015) and Haftu and Gezu (2014), who reported that the beekeepers at each of their respective study districts kept majority of their colonies around the backyards. The main reasons for beehive placement or apiary selection are close supervision, controlling from theft and availability of bee flora. Similar findings were reported by Yetimwork (2015) and Abebe (2017). Almost all beekeepers reported overcrowding of honeybee colonies as the major cause for the incidence of swarming. Similarly, absconding was also common problem in the study area, which is caused by shortage of bee forage, poor utilization of agrochemicals, honeybee pests and enemies.

Shortage of bee forage during dearth periods, absconding pests and predators and risky application of agrochemicals were among major constraints of beekeeping ranked in order of severity. The availability of huge number of bee colonies, existence of ample melliferous plants that provide pollen and nectar, availability of tourist attraction sites near to the study area, strong emphasis from government of Ethiopia on beekeeping sector were available. Therefore, there are huge opportunities to exploit the huge beekeeping potential of the study area.

CONCLUSIONS

Beekeeping in the study area exhibits a gendered pattern, primarily undertaken by male-headed households within economically active age groups. It predominantly manifests as a traditional practice, encompassing forest and backyard beekeeping. The adoption of improved beekeeping methods remains minimal due to the prohibitive costs associated with acquiring improved hives and accessories. Over the past five years, there has been a noticeable decline in both colony populations and honey yields, attributed to various factors including indiscriminate use of agrochemicals, absconding, inadequate bee forage during dearth periods and threats from pests and predators. This study revealed significant disparities in honey yields among different agro-ecological zones, with the highest yields observed in lowland areas. This discrepancy suggests the presence of more favourable conditions such as abundant vegetation, favourable climates and effective colony management practices in lowland agroecology. However, the realization of beekeeping's untapped potential in the study area is impeded by several constraints, including scarcity of bee forage during dearth periods, absconding, pest and predator pressures, misuse of agrochemicals, limited access to credit, inadequate extension services, lack of attention and recurrent droughts. Addressing these challenges is essential to fully capitalize on the opportunities presented by beekeeping in the region.

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AUTHOR'S CONTRIBUTIONS

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All authors have read and agreed to the published version of the manuscript.

DATA AVAILABILITY STATEMENT

The data presented in this study are available on request from the corresponding author.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

THE AUTHOR'S DECLARATION

This manuscript has not been published anywhere else. However, it has been submitted to preprint servers. Specifically, we have submitted it to Research Square to obtain a preprint.

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