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Beekeeping management practices and constraints in Eastern Tigray, Ethiopia

Kiros Welay Gebreyohans*, Tsegay Teklebrhan Gebremariam

School of Animal and Range Sciences, Haramaya University, Ethiopia

**Corresponding author: kirosw47@gmail.com*

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Abstract: The study was designed to assess beekeeping management practices and challenges in the eastern zone of Tigray. The study was carried out in three purposively selected districts of Eastern Tigray region. Accordingly, a total sample size of 120 beekeepers, 40 beekeepers from each districts were interviewed randomly. A semi-structured questionnaire, field observation and focal group discussion were employed to collect primary data. Descriptive statistics such as mean, frequency, and standard deviation were used to analyze the data. Beekeepers indicated that frame hive technology was most preferred. Even though, some equipment such as casting mold and honey extractor were not durable and available as required. The study reveals frame hive was more productive than tradition in the study area. Smoking during harvesting and plant species influenced the test and color of honey. Hence, honey produced especially from *Leucas abyssinica* is a special white and highly demanded honey in Tigray region. Beekeepers indicating a large amount of honey were harvested in September and October. However, low amount of honey harvested in July and August of the year. Bee forage and absconding due to pests are major constraints of honey bee production in the study area. Honeybees required feed supplementation during the dry season; higher supplements were made during February to March and followed by December to January. The commonly used supplements were sugar, roasted spiced pulses flour *(shiro)* and barely flour (*besso*).

Keywords: Apiculture, bee flora, constraints, hive preference

Introduction

Ethiopia is home to most of diverse flora and fauna in Africa. The forests and woodlands contain diverse plant species that provide surplus nectar and pollen to foraging bees (Girma, 1998). This diversity makes it highly suitable for sustaining a large number of bee colonies (Adgaba, 2007). The total honey bee colonies of Ethiopia

is estimated to be around 10 million honeybee colonies, of which 7 million are kept in local hives by farmers and the remaining, exist in the forests as wild colonies. This makes the country to have the highest bee density in Africa (Adgaba, 2002). Moreover, due to a high number of bee colonies and surplus honey production, the country is leading producer of honey and beeswax in Africa. Accordingly, Ethiopia produces about 43,373 metric tons of crude honey per year (i.e. 23.5% of Africa and 2.35 % of world's honey production). This makes the country rank first in Africa and tenth in the world (USAID, 2012).

Although thousands of tons of honey have been produced every year, the products obtained from the subsector have been observed to be still low as compared to the potential of the country (Edessa, 2005). Moreover, Ethiopia has the long tradition of beekeeping, having the highest bee density and leading honey producer as well as one of the highest beeswax exporting countries in Africa, the contribution of the sub-sector to the total Gross Domestic Product (GDP) is assumed to be very low. This is because of beekeeping production is backyard (poor in quality and yield), type of hives used and the methods of processing and storage facility of honey are poor. As a result, the beekeepers in particular and the country, in general, are not benefiting from the sub-sector provided that it's potential. Therefore, to improve the productivity and contribution of the sector to the community and the country, recently, different beekeeping development attempts have been made by the governmental and non-governmental organizations. For instance, the government has been given more attention for the promotion and expansion of movable frame hive to the community as well as the nation as a whole through the Ministry of Agriculture and Rural Development Extension system. Similarly, a special fund has been allocated and a number of movable frame hives with expensive beekeeping accessory equipment have been provided with subsidized prices. Beekeeping is a very long-standing practice in the farming communities of the Tigray region and Eastern part of Tigray region where the survey study conducted is also endowed with a diversified type of vegetation and crops and the potential for beekeeping activities. It plays a significant role as a source of income and nutrition for many farmers. It is an integral part of the smallholder farming system in Eastern Zone of Tigray. Though there is high beekeeping potential in the study area there is no information on the hive preference and constraints of honeybee production in the area. Therefore, information about the beekeeping production potential, hive preference and challenges are crucial for researchers, policy makers and other stakeholders to make and suggest intervention strategies to improve the productivity of the sector and its contribution to the development of the nation. Therefore this study was designed to assess the beekeeping management practices and challenges in Eastern zone of Tigray Regional State.

Material and methods

The study was conducted in the selected districts of Ganta-Afeshum, Hawzen and Atsbi-Wonberta districts of Eastern zone of Tigray, Northern Ethiopia. The annual average rainfall of the districts ranges from 400-600mm and the minimum and maximum temperature ranges from 6-21.8^{O}C with an altitude of 2000-3000 meter above sea level. In the study area, the maximum rainfall occurs from mid-June to September and the minimum rainfall occurs from April to May. Previous studies in Tigray region by Ayalew (2005) identified about 65 plant species as potential, mid potential and low potential such as *Eucalyptus globulus*, *Acacia sp and Calpurnia aurea* to foraging bees and to beekeeping intervention. There are also wide varieties of plants in the region which are used as honeybee flora including cultivated crops (Gidey and Mekonen, 2010). According to Bureau of Agriculture and Rural Development (BoARD, 2014), the production system in Eastern zone is mixed farming with crop and livestock production and livestock ownership is important for livelihoods.

Sampling Procedure and Data Collection

Prior to the actual survey, information was gathered from secondary data and preliminary study. Based on that, a semi-structured questionnaire was developed. Discussions were conducted at regional, zonal and district level with agricultural officers' about the potential beekeeping activities of the study area. Based on the experience and availability of information in line with the objective of the study, three districts were selected purposively. Thus, total sample sizes of 120 beekeepers, 40 beekeepers from each district were interviewed randomly. Mixed methods, such as surveys, key informant interviews and observations, were used for data collection to capture all of the relevant information. A sample of individuals from each district for focus group discussions was selected with the help of agricultural development agents considering their experience with beekeeping activity, knowledge about the major bee flora, beehive types, honey storage and major constraints of beekeeping.

Honey bee floras were first identified using the local name, then followed filed trip physical identification with the help of filed assistance and some of the plants were photographed with a digital camera. Unfamiliar plants were identified using botanical field guides and taxonomic key using flora books of Ethiopia and Eritrea (Hedberg and Edwards, 1989; Hedberg *et al.,* 2003, 2006; Mesfin, 2004).

Data Analysis

The collected data were analyzed using appropriate statistical packages for social

sciences (SPSS) software version 20. Descriptive statistics such as mean, frequency, and standard deviation were used. Results were presented and interpreted using tables, bar charts, and pictures.

Results

Background of Respondents

Majority of the respondents were in the age of 30-45 years. This indicates people in the productive ages were actively engaged in beekeeping activities. Majority of beekeepers were men in the study area. However, women were also involved in beekeeping activities. The study noted that beekeepers have been working for about 12 years on beekeeping activity. This indicates that beekeepers have better working experience in the sector.

Table 1 - Description of respondents

CATEGORIES	N	%
Age		
≤ 29	26	21.7
30-45	80	66.7
46-60	14	11.6
TOTAL	120	100
Sex		
Male	110	91.7
Female	10	8.3
TOTAL	120	100
Year of bee farming	N	Mean±SD
Average working year on bee farming	120	12± 4.6

N= number of respondents; SD= standard deviation

Sources of Bee Colonies

About 38% of the respondents have obtained their colonies as a gift from their parents followed by buying (35%). In addition, 15% of the respondents' got from the government and non-governmental organizations (Figure 1).

Types of Bee Hive and Their Location

The study reveals that there were two types of beehive technologies in the study area. Accordingly, the majority of beekeepers owned both frame hive and traditional (41.7%) followed by frame hive only (33.3%) (Table 2).

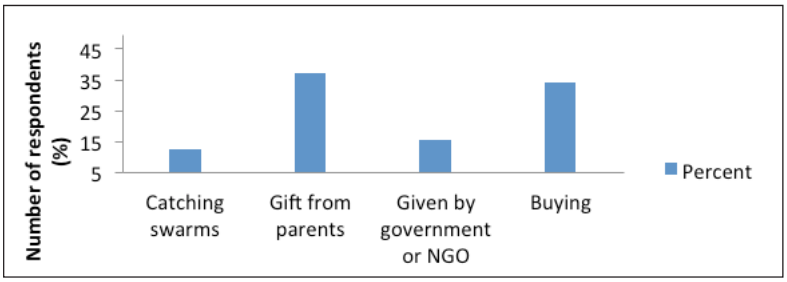

Figure 1 - Sources of bee colonies

Table 2 - Type of hives in the study area

TYPES OF HIVES	N	%
Traditional hive only	30	25
Frame hive only	40	33.3
Both frame and traditional hive	50	41.7
TOTAL	120	100

N= number of respondents

Majority of respondents reported that both traditional and modern bee hive is located at backyard (Table 3). During the field observation, traditional hives were attached to a side of the main house where the household lived in and around the homestead areas very close to the main house. Discussants argued that it would be difficult to manage and affected by the rodents, ants (*Dorylus fulvus*) and other predators and even stolen by others if it is located far from the main house. However, few (5.6%) respondents reported that frame hives were located far from home having their own small apiary. This placement might be better than the traditional and might have fewer disturbances to the bee colony and damage to human and animals.

Table 3 - Placement of hives

PLACEMENT OF BEE HIVES	N	%
Traditional		
Backyard (homstead)	61	76.2
Attached with side of the house	15	8.8
Far from home	4	5
TOTAL	80	100
Frame hive		
Backyard (homstead)	85	94.4
Attached with side of the house	0	0
Far from home	5	5.6
TOTAL	90	100

N= number of respondents

Bee Hive Inspection

Both internal and external hive inspections were conducted. However, internal inspection is conducted rarely by the majority of beekeepers (49.2%). External inspection was done sometimes (37.5%). Discussants also claimed that bee will be disturbed if internal inspection is very frequent as did in external inspection (Table 4).

Table 4 - Bee hives inspection

BEEHIVE INSPECTION	N	%
Internal inspection		
Frequently	19	15.8
Sometimes	42	35.0
Rearly	59	49.2
TOTAL	120	100
External Inspection		
Frequently	33	27.5
Sometimes	45	37.5
Rarely	42	35.0
TOTAL	120	100

N= number of respondents

Locally Available Beekeeping Equipment

Local equipment such as a smoker, queen catchers, knife and water sprayers were produced by beekeepers in the study area. Among which, smoker (98.9%) and knife (91.1%) were predominately made locally as compared to other bee equipment. Queen catcher was the least equipment (14.4%) which can be made by beekeepers. As it was mentioned in the group discussion, some equipments such as casting mold and honey extractor were not made locally. These are either purchased or donated by governments and non-governmental organizations through cooperatives and unions. However, these equipments were not in use because of lack of spare parts and durability related to quality.

Table 5 - Homemade bee equipment

HOMEMADE EQUIPMENT	N	%
Smoker	89	98.9
Queen catcher	13	14.4
Knife	82	91.1
Water sprayer	31	34.4

N= number of respondents

Preference of Hive Technology

Respondents preferred to keep frame hive technology (Table 6) followed by both modern and traditional (25%) as compared with traditional (8.3%). This is because a high yield of honey (71.4%) and easiness for harvesting (31.7%) were the criterias. However, honey from frame hive was hardly used for the medicinal purpose (9.5%). Honey is widely used as a remedy for respiratory irritations, specially for coughing. In contrast, the traditional hive was preferred for wax production (66.7%), due to less dependent on external input (70.3%) and less cost (66.7%).

Table 6 - Preference of hive technologies

TYPES OF HIVES	N		%	
Modern (frame hive)	80		66.7	
Both	30		25.0	
Traditional	10		8.3	
TOTAL	120		100	
Reasons for preference of hives	*Traditional*		*Modern hive*	
	N	%	N	%
More honey is harvested	0	0	45	71.4
Quality of honey	10	37	12	19.0
Material availability	12	44.4	0	0
Easy to harvest honey	3	11.1	20	31.7
Less costive	18	66.7	0	0.00
Get more swarm	4	14.8	13	20.6
Honey quality (traditional medicinal)	12	44.4	5	9.5
Les dependent on external in put	19	70.3	0	0
For wax purpose	18	66.7	5	7.9

N = number of respondents

Honey Production and Trends

The study shows more honey is harvested in the modern hive (24.8±8.34) as compared to traditional (7.5±2.67). Discussants indicated the price of pure and filtered honey was 170 ETB/kg and 300/kg for wax in the study area, which is 6.63 and 11.71 Euros respectively as (1Euro=25.61 Birr). Majority of beekeepers (42.5 %) replied, since last ten years honey bee production trend had been increased. This is because the price for honey was attractive (51%) and rehabilitation of rangelands. Moreover, respondents indicated that support from the government for training and awareness given by the development workers were the key for increasing of honey bee production over the last ten years. However, 27.5% and 30% respondents replied honey bee production was decreased and no change over the last 10 years respectively (Table 7).

Table 7 - Honey production and trends

HONEY PRODUCTION (kg)	MEAN±SD	
Modern hive	24.8±8.34	
Traditional hive	7.5±2.67	
Production trends	N	%
Increasing	51	42.5
Decreasing	33	27.5
The same	36	30.0
TOTAL	120	100
Reason of increment		
Due to good market price	26	51
Due to rehabilitations of degraded lands	15	29.4
Awareness and training	10	19.6
TOTAL	51	100

N= number of respondents; SD= standard deviation

Types of Honey bee and production characteristics

Discussants claimed that there was a strong positive relationship between characteristics and productivity of bee. Accordingly, aggressive bee noted that better productivity than docile bee. This might be the aggressive bee was defensive to their tertiary than docile counterparts.

Frequency and Season of Honey Harvesting

More honey harvesting frequency was observed in modern hive than in the traditional hive (Table 8). It is obvious that bees required more time to make the foundation comb in the traditional hive and extend time to produce honey as compared to frame hive. Majority of beekeepers (75%) replied September and October are the best seasons for harvesting honey. Few respondents (34.16%) also harvest in July and August. This is related to rainfall and flowering season of honeybee forages.

Collection of Bees Wax

Bees wax is one of the products of bee and was collected from bee hive since it has economic benefit next to honey. Wax was collected during honey harvesting mainly from traditional hives (50%) followed by colony absconding (33%). However, rarely was collected from the left over of home consumption of honey (17%) (Figure 2).

Table 8 - Frequency and season of honey harvesting

FREQUENCY OF HARVEST	MEAN ± SD	
Number of harvest in traditional hive	1.4 ±0.51	
Number of harvest in frame hive	2.2 ±0.41	
Season of harvest	N	Percent
September and October	90	75
November and December	73	60.83
July and August	41	34.16
TOTAL	204	100

SD = Standard deviation; N = number of respondents

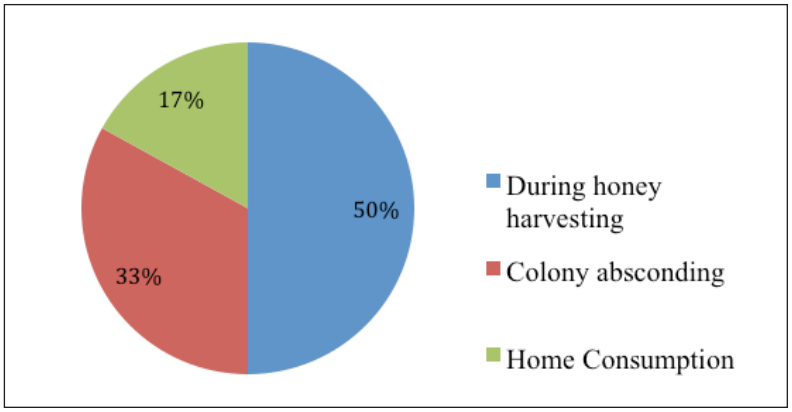

Figure 2 - Sources of bee wax

Honey Bee Flora and Flowering Seasons

The major honey bee floras identified in the study area were classified on to trees, shrubs and herbs (Table 9). Beekeepers indicated the flowering calendar of each bee flora annually. In addition based on their experience and indigenous knowledge, beekeepers had identified major poisonous bee flora in the study area.

Perception on Characterization of Honey

Beekeepers replied the feeding or foraging habits of bee from different trees, shrubs and herbs can lead to changes in the color, taste, and aroma of the product. Accordingly, almost all beekeepers indicate that honeybee flora such as *Eucalyptus globulus, Becium grandflorum,* and *Leucas abyssinica* produced white

Table 9 - Major bee forages and flowering seasons in the study area

Scientific name	Local name (Tigrigna)	Type of plant	Flowering season
[1]*Maytenus senegalensis*	Kebkeb	Tree	May-June
Acacia sp	Lahay	Tree	February – March
Euphorbia abyssinica	Kolkal	Tree	October -November
Ficus sp.	Sagla	Tree	Year round
Ziziphus spina christi	Gaba or Giba	Tree	November-January
Acacia etbaica	Seraw	Tree	October -November
Cordia africana	Awhi/Aki	Tree	November- January
Dodonaea angustifolia	Tahsos	Tree	Year round
Calpurnia aurea	Hitsawutse	Tree	October -December
Croton macrostachyus	Tambuk	Tree	November-December
Rosa abyssinica	Kega	Tree	February – May
Eucalyptus globulus	Bahr zaf	Tree	Year round
Opuntia ficus indica	Beles	Shrub	February –May
Becium grandiflorum	Tebeb	Shrub	August –September
Rumex nervosus	Hohot	Shrub	October-November
Aloe elegance	Ere	Shrub	October-November
Sesbania sp	Sasbania	Shrub	October -November
Agave sisalana	Eqa	Shrub	September- October
Brassica rapa	Hamli	Herb	September- October
Ocimum basilicum	Sesseg	Herb	September-October
Carthamus tinctorius	Suf	Herb	September-October
Zea mays	Meshebahri/ifun	Herb	August-September
[1]*Euphorbia petitiana*	Hindukduk	Herb	September-October
[1]*Argemone mexicana L*	Eshok tilian	Herb	February-March
Guizotia abyssinica	Nihug	Herb	September-October
Leucas abyssinica	Swakerni	Herb	September-October
Hypostus auriculata	Grbia	Herb	September-November
Linum usitatissiumum	Entatie	Herb	September- October
Sorghum bicolor	Meshela	Herb	October -November
Cucurbita pepo	Duba	Herb	July- August
Pisum sativum	Ater	Herb	October -November
Vicia faba	Balengau	Herb	August- September
Bidens macroptera	Gelgelemeskel	Herb	September-October

[1]*indicates the poisonous flora identified in the study area*

honey and they believed that honey produced especially from *Leucas abyssinica* is a special white and highly demanded honey in Tigray. Besides, honey produced from all bee floras has had sweet taste except honey from *Eucalyptus globulus* that had a bitter taste (Table 10). However, the aroma of honey products was least influenced by bee forage types in the study area.

Table 10 - Effect of plant on color and taste of honey

Type of plant	Color			Taste
	Red	White	Yellow	
Euphorbia abyssinica (Kolkal)	X	x	√	Bitter
Eucalyptus globulus (Kelamitos)	X	√	X	Sweet
Ziziphus spina christi (Gaba or Giba)	√	x	X	Sweet
Becium grandflorum (Tebeb)	X	√	X	Sweet
Leucas abyssinica (Swakerni)	X	√	X	Sweet

x= no; √ = yes

Identification of Matured Honey

Knowledge of matured honey is important because the stage of maturity has an impact on storage and processing of the quality of honey. Accordingly, beekeepers identified maturity of honey by the behavior of bee (64%) and appearances of honey (60%). In addition, few of them can identify by taste and odor (Table 11).

Table 11 - Farmers' knowledge on identification of matured honey

Characteristics	N	%
Behaviors of bee	58	64
Appearance of the honey	54	60
By taste	37	41
Odor of the honey	18	20
Appearance of the honey comb	54	60

N= number of respondents

Factors Affecting Honey Quality

There are tremendous factors that can influence pre and post handling of honey. Beekeepers noted that storage time and smoking during harvesting had an impact on post handling quality characteristics of honey products such as color, taste, and aroma. The study confirmed that taste was the most important quality attribute influenced by storage time. It has been indicated that honey can be stored up to 5.4 ±1.99 years safely without any adverse effect on honey quality. The study also *shows that 40% of the respondents believe that smoking and ingredients used for* smoking, in particular, had an important factor on the quality of honey. Accordingly, the taste was highly affected quality attribute followed by color. The raw materials used for smoking include cow dung, straws, and fire woods. Among which cow dung was commonly used for smoking followed by straw (Table 12).

Table 12 - Factors affecting honey quality and type of changes

FACTORS AFFECTING HONEY QUALITY	N	%
Storage time	78	65.0
Smoking during harvesting	48	40
Quality change due to storage		
Taste	42	72.4
Color	32	55.2
Quantity	4	6.9
Quality affected due to smoking		
Taste	33	68.8
Color	15	31.2
Materials used for smoking		
Cow dung	92	76.7
Straw	15	12.5
Firewoods	13	10.8
TOTAL	120	100

N= number of respondents; SD= standard deviation

Colony Feeding and Supplementations

Significant beekeepers replied honey bee required feed supplementation during the dry season and any time when required (Table 13). Accordingly, discussants mentioned, higher supplements were made during February to March and in very lesser extent May and June of the year. Beekeepers had a tradition of providing supplementary feed to keep the strength of their colony and to get additional honey yield. Commonly used supplements in the study area include sugar, roasted spiced pulses flour *(shiro)* and barely flour (*besso*). Sugar was predominantly used feed supplement in the study area followed by roasted spiced pulses flour (*shiro)*.

Table 13 - Colony feeding and supplementation

FEEDING AND SUPPLEMENTATION	N	%
Additional feeding during drought	75	62.5
No additional feeding at all	43	35.8
Additional feeding all the time	2	1.7
TOTAL	120	100
Kind of feed supplementation	*N*	*%*
Sugar	53	44.16
roasted spiced pulses flour *Shiro*	30	33.3
Barley flour (*Besso)*	13	10.8

N= Number of respondents

Marketing of Honey

Both women and men were involved in the marketing of honey in the study area. However, men were dominant (76%) in honey selling than women (24%). Respondents perceived that there was high demand for honey particularly in the domestic market for different purposes (Table 14). Individual consumers and traditional Ethiopian honey wine makers (*tej* houses) were the highest target consumers of honey followed by the whole seller. Beekeepers also replied that cooperatives and retailers were least users of the product.

Table 14 - Demand and consumers of honey

DEMAND FOR HONEY	N	%
High	83	69.2
Medium	28	23.3
Low	9	7.5
TOTAL	120	100
Type of consumers	N	%
Individual consumer	20	16.7
Traditional honey wine sellers (*Tej* house)	38	31.7
Whole seller (processor and exporter)	8	6.7
Beekeeper cooperatives	26	21.6
Retailer	28	23.3
TOTAL	120	100

N= number of respondents

In the study area beekeepers directly sold their honey to middlemen at the district or zonal level which directly deliver to traditional Ethiopian honey wine makers (*tej* houses) in their localities and/or transport to the capital city of the region. However, few producers sold their product to the retailers, cooperatives, whole sellers and individual consumers.

Generally, honey marketing in the study area was practiced both direct and indirect paths. Direct marketing was simply from producer to consumer and it benefits the smallholder farmers by minimizing unnecessary transaction costs.

Training of Beekeepers

Beekeepers were provided different capacity building training in study area mainly organized by government and nongovernmental organizations. Accordingly, 62.5% respondents trained in near the towns followed by in the Farmer Training Centers (FTC). However, very rare trainings (8.3%) were given in regional city.

Table 15 - Training of beekeepers

Training on beekeeping	N	%
Beekeepers got training	96	80.0
Beekeepers had no training	24	20.0
Total	120	100
Place of training		
FTC	28	29.2
Near town	60	62.5
Regional capital city	8	8.3
Total	96	100

N= number of respondents

Constraints of beekeeping

Bee forage was the first constrained reported by the respondents (83.3%) particularly during the dry season. However, during field observation, we noticed that in Tigray region there are a lot of activities related to soil and water conservation and rehabilitation of degraded rangelands and this would reduce the shortage of bee fodder in the future.

Absconding of bee was identified as the second most important problem in the study area.

The possible reasons for absconding were insects such as wax moth mainly *Achroia grisella*, ants (*Dorylus fulvus*) and predators such as honey budger(*Mellivora capensis*) as indicated by the respondents in order of importance (Table 16).

Table 16 - Major constraints of beekeeping

Constraints	N	%
Bee forage	75	83.3
Absconding due to many factors	54	60
Disease and pests	35	38.9
Predatory	26	29
Using of agrochemicals	7	7.8
Reason of absconding		
Insects like wax moth (*Achroia grisella)*	34	63.0
Due to ant (*Dorylus fulvus*)	23	42.6
Due to birds	22	40.7
honey budger (*Mellivora capensis*)	17	31.5
Total	96	100

N= number of respondents

These pests and predators have serious negative impact on beehives and their products and hence their long-term impact can cause the complete loss of the apiary and their products unless some proactive and intervention techniques have been imposed. However, smallholder farmers have been practiced some traditional methods to tackle these problems (Table 17). Cleaning of apiary and smoking were the best strategies did by beekeepers to protect the apiary from the threats.

Table 17 - Local control methods for predators

Major Control methods	N	%
Cleaning of apiary	22	84.6
Smoking	18	69.2
Fencing	8	30.8
Killing of predators	4	15.4

N= number of respondents

Discussion

Majority of the respondents in the study were ranged between the ages of 30-45 years with an average experience of 12 years. Moreover, the main sources of bee colonies for the beginners were gifted from their parents. This indicated that beekeepers had knowledge on bee farming from their parents before they had their own. Opposed to this study, Haftu and Gezu (2014); Addis and Malede (2014) reported that beekeepers obtained their colony by catching swarms and buying, respectively.

More than 40% of beekeepers owned both frame and traditional hives followed by only modern. Similarly, beekeepers in Central Tigray region had own both traditional and modern as indicated by Haftu et al. (2015). As mentioned by discussants, the main reason of keeping traditional with modern hive was, to have wax and less dependent on external inputs. Keeping the factors (e.g., equipment such as casting mold, honey extractor and higher cost for modern hive), respondents preferred to have frame hive technology than the traditional hive. This is because of more honey is harvested in modern hive as compared to traditional. Similarly, Belet and Berhanu (2014) reported that the adoption of box hives makes smallholder beekeepers more profitable than with traditional hives, with a 20% increase in the variability of input cost and output prices. The finding is also in line with Melaku (2005), who reached a similar conclusion that box hives were more beneficial and remunerative. Similar to this, a study by Workneh (2011) concluded that beekeepers can increase their profit more than double by using box hives instead of traditional hives. However, a study reported by Nebiyu and Mesele (2013) stated most of the beekeepers in Gamo Gofa zone of Southern Ethiopia preferred traditional hive over transitional and modern

beehives.

Honey bee floras such as *Eucalyptus globulus, Becium grandflorum,* and *Leucas abyssinica* are believed to affect color and test of the honey. Accordigly, a special white honey believed to be produced from *Leucas abyssinica* which is highly demanded honey in Tigray region. Similar finding was observed by (Gebreegziabher et al. 2013). In his finding, 89.47% honey was predominantly of light color in Tigray and this could be marketed for direct consumption. White et al. (1962) observed that variations are almost entirely due to the plant source of the honey, although climate may modify the color somewhat through the darkening action of heat.

The frequency of harvesting honey in the traditional hive was once per year and twice for modern hive. The same findings were reported in different regions of the country by (Tessega, 2009; Tesfa *et al*., 2013; Taye and Marco, 2014; Haftu and Gezu, 2014; Haftu *et al*., 2015). Majority of beekeepers reply a large amount of honey was harvested in September and October followed by November to December of the year. Similarly, beekeepers harvest honey two times per year at the beginning of October and at the end of December in Gamo Gofa zone of southern Ethiopia and South West Shewa Zone of Oromia as reported by (Nebiyu and Messele, 2013; Taye and Marco 2014). In agreement with this study, Tesfa *et al*. (2013) reported that months of October, November, and December were regarded as the main honey flow season and harvesting period of the year as this period is the main flowering season of the year.

Beekeepers in the study area had an experience of feed supplementation during the dry season. Commonly used supplements in the study area include sugar, roasted spiced pulses flour *(shiro)* and barely flour (*besso*). This is in line with the report of (BoA, 2004) who stated that during dearth period when there is little honey bee forage, beekeepers provided supplementary feeds. Tesfa *et al*. (2013), indicated that sugar syrup, hot pepper, roasted pea flour, water, honey syrup, roasted bean flour, and roasted barley flour are the major feed types they used as a supplementary feed during dearth period.

Respondents noted that bee forage was the most constrained in the study area. Moreover, Yirga *et al*. (2012) reported that shortage of bee forage was the major constraints affecting the honey sub-sector. Lack of adequate bee forages were the pressing factors for beekeeping business (Gidey and Kibrom, 2010; Gidey *et al*., 2012; Tesfa *et al*., 2013; Haftu and Gezu, 2014; Haftu *et al*., 2015). Absconding of bee was identified as the second most important problem in the study area. Similar to this result Nebiyu and Messele (2013); Yirga *et al.* (2012); Haftu *et al*. (2015) reported that absconding is a challenging factor for beekeeping business. Moreover, wax moth (*Achroia grisella*) is the most important pests followed by ants (*Dorylus fulvus*) that could threat bee hives and honey products. Similarly, ants were among the most common predators of honeybees and it was ranked first as reported by (Gidey *et al*.,

2012; Haftu *et al*., 2015). In addition, Taye and Marco (2014) indicated that major bee pests and predators include wax moth, spider, ants, birds, honey badger and beetles were serious problems in beekeeping development.

There is no marketing problem for honey in the study area. Individual consumers and traditional Ethiopian honey wine makers (*tej* houses) were the highest target consumers of honey followed by the whole seller. This is attractive for smallholder farmer in the study area to engage easily and benefited economically in the sector. The economic value of honeybees in Tigray is not only of honey but also from selling the colonies such that about 70% of the beekeepers in Dega agroecology were earning income from this practice (Tilahun *et al*., 2016).

Conclusion

Information on the acceptability, productivity and overall management practice of hive technology are important to address constraints and adopt the technology. Despite modern hive is more productive and preferable by the majority, they own both the traditional and modern hives. Wax quality and availability, availability of the accessories and high cost are factors that limit beekeepers to have all modern hives even though they prefer it. The study suggested that honey bee floras such as, *Eucalyptus globulus, Becium grandflorum,* and *Leucas abyssinica* are believed to affect color and test of honey. Thus, special white honey believed to be produced from *Leucas abyssinica* which is highly demanded honey in Tigray region. But this needs to considered pollen analytical study to verify it confidentially. Honey harvesting is more or less seasonal, which depends on the flowering calendar and a large amount of honey was harvested in September and October followed by November to December of the year. The study suggests that bee forage, absconding and pests and predators, were the major constraints in the study area. However, recently a lot of activities related to soil and water conservation and rehabilitation are conducted. In addition, motivations due to high demand of honey in the region and awareness through trainings seems better in the region for apiculture production.

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