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Original research article

Honeybee Colony Management Practices and Identification of Honeybee Floras in Eastern Amhara, Ethiopia

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Abstract The art and science of managing and breeding honeybee colonies in the artificial hive for the sake of the economy are known as beekeeping or apiculture. It contributes to the increment of food and cash crop products through pollination services and protects and stabilizes fragile environments. The sector depends on floras to survive and produce honeybee products. Those plants were categorized as either nectar or pollen or both depending on their content. Assess the honeybee colony management practice and identification of honeybee flora intended to document the indigenous knowledge for the establishment of the best management decisions. Therefore, this study aimed to assess the honeybee colony management practices and identify the honeybee floras in eastern Amhara, Ethiopia. This study was conducted in the selected district of eastern Amhara based on the relative suitability and potential for beekeeping. A questionary survey was conducted for 122 beekeepers. Additionally, key informant interviews and honey pollen analysis were performed to support the questionary survey. The result of this study showed the beekeeper farmers had trouble with seasonal feed shortages for their honeybee colonies besides absconding and swarming were also prominent in the area. Furthermore, this study revealed that about 104 bee flora species were identified, which include shrubs, trees, herbs, and crops with the major proportion of shrubs. Most honeybee floras were perennial plants. Additionally, the seasonal bee forage fluctuation could be categorized into dearth, moderate, and honey flow season. The dearth period occurred from January–March and July–August. The moderate period was from April–June, and the honey flow period was from September–November. Therefore, seasonal management of the colonies should be adjusted with the dearth periods. Further study must be done about the frequency and density of the honeybee plants.

Keywords Floral calendar, Honeybee flora, Honeybees, Seasonal management, Species

INTRODUCTION

Beekeeping or apiculture is the art and science of breeding and managing honeybee colonies in artificial hives for economic benefits (Yusuf *et al*., 2014; Mazorodze, 2015; Alebachew and Eshetie, 2019; Alebachew *et al*., 2020; Wakgari *et al*., 2021). In Ethiopia, beekeeping is one of the essential farming sectors. It contributes to the country's economy through export earnings. Among the export commodities of agricultural products, both honey and beeswax have their contribution. Moreover, beekeeping stabilizes and protects the fragile environment and increases the production of agricultural food and cash crops through pollination services from honeybees (Teferi, 2018; Bihonegn and Begna, 2021).

Ethiopia has a long beekeeping tradition (Alebachew *et al*., 2020). The economic value of the pollination service in Ethiopia agriculture through animal pollinators and the vulnerability of agriculture due to lack

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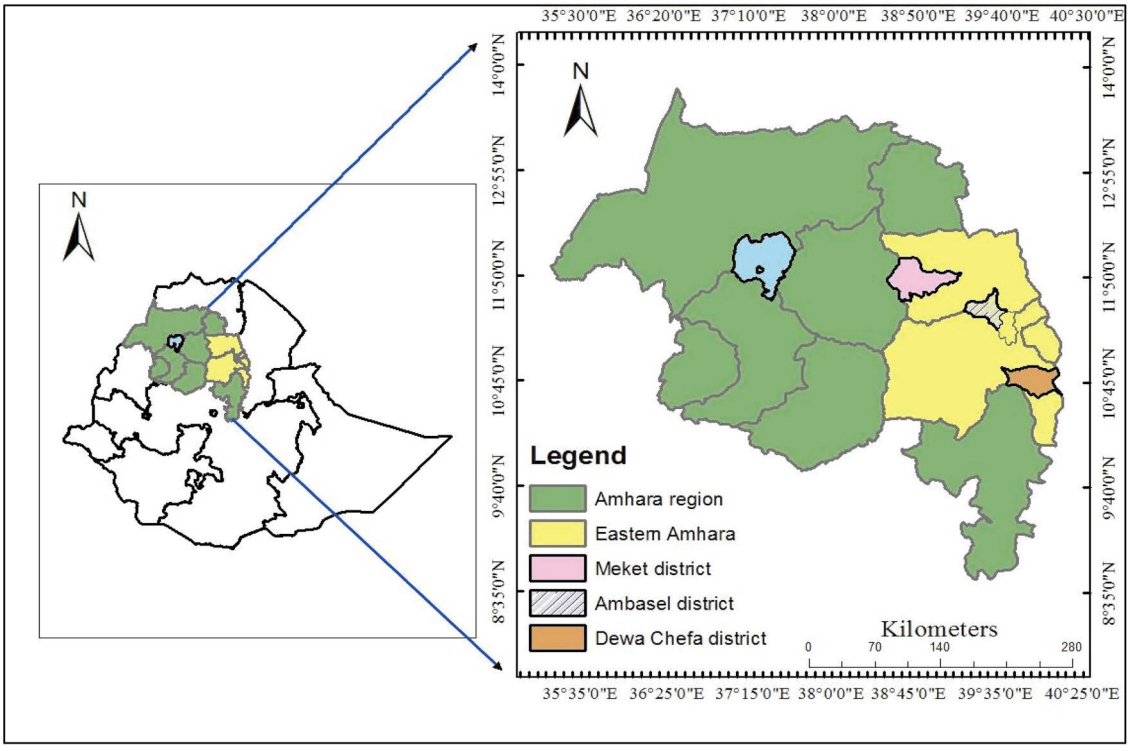

Fig. 1. The representative sampled districts in eastern Amhara.

of pollinators was estimated at USD 815.2 million and 16%, respectively, in the 2015/16 crop production season. Hence, the economic benefit of the pollination service of the honeybee was projected 4.58-fold greater than the honey production (Alebachew, 2018).

Beekeeping is a floral-based industry, and honeybees depend on it for their food (Begum *et al*., 2021; Wakgari *et al*., 2021). Plants are categorized as nectar sources based on honeybee's activity of extending their tongue into the flowers to gather nectar. When honeybees are collecting pollen with their hind legs, those plants are pollen source plants (Portman *et al*., 2019; Begum *et al*., 2021). Nectar source plants are used for honey making, and pollen source plants are important in providing pollen as a major component of larval food which is vital in colony reproduction (Begum *et al*., 2021; Shegaw and Giorgis, 2021). The favorable and diversified agro-ecological conditions of Ethiopia have been endowed with over 7000 plant species, which support foraging bees and many other insects (Berhe *et al*., 2016; Teferi, 2018; Shuma and Dinsa, 2020). The diversified flowering plants in Ethiopia and their blooming season greatly vary from place to place; this enables the country to sustain many honeybee colonies (Adal *et al*., 2015; Tesfaye *et al*., 2017; Olana and Demrew, 2019).

Identification of honeybee flora aimed to document major and minor honeybee floral resource plant species for the establishment of the floral calendar for ease of honeybee colonies management (Jenberie *et al*., 2016). Since there is no information yet on the documentation and description of honeybee floras in easter Amhara, this study aimed to illustrate honeybee colony management practices, and identify honeybee florals in eastern Amhara for future improvement and design of honeybee management options.

MATERIALS AND METHODS

1. Study area

The study was conducted in three districts of the eastern Amhara, namely, Dawa Chefa, Ambasel, and Meket districts (shown in Fig. 1). Dawa Chefa district is located at 10°43′ N latitude and 39°52′ E longitude. The altitude of the area ranges from 1500 to 2300 m.a.s.l.

The rainfall distribution is highly seasonal and temporal variations. It has two main rainy periods in a year i.e., from February to March (short rainy season) and from July to September (main rainy season). The predominant production system in this area is mixed crop-livestock farming (Amakelew *et al*., 2015).

Ambasel district is a part of the South Wollo zone. It is located at 11°31′05″N and 39°36′34″E with an elevation of about 3500 m a.s.l. It receives a mean annual rainfall of 500–800 mm in a bimodal pattern. The long rainy period ranges from June to September and is followed by a dry season ranging from October to February; the short rainy season lasts from March to May the average temperature is 19°C (Alebachew and Eshetie, 2019). Meket district is one of the districts in the north Wollo of Amhara region with elevations ranging from about 1200 m a.s.l. at the northwestern-most point to over 3000 m a.s.l. along the eastern part of its southern border (Alebachew and Eshetie, 2019). It is located at 11°46′4.2″N and 38°44′9″E.

2. Site selection and data collection

From potential beekeeping districts of the eastern Amhara, three representative districts were selected purposefully. From each district, two-three sampling *kebeles* (the smallest administrative unit), a total of 8 sampling *kebeles* were selected based on vegetation cover and altitude difference (highland, midland, and lowland to represent the major agro-ecologies) for questionnaire survey, floral identification, and honey sample collection. The questionnaire was administered to the randomly selected beekeepers in the study areas. A total of 122 beekeeper respondents have been interviewed from three districts.

Key informants (such as *kebele* level livestock production experts, and district level apiculture experts) were interviewed about honeybee colony management practices and bee flora issues based on the questionnaire. Moreover, to strengthen the questionnaire survey, field observation has been made on the nature and habit of plants, feed sources, and duration of flowering. The identified honeybee floras sample were collected and taken to the laboratory for further determination of scientific name and the biological characteristics with the help of a botanist. Furthermore, the local name and scientific name of the honeybee floras were confirmed with the picture and other information from Natural Database for Africa (NDA) software version 2.0 and a book authored by Bekele and Tengnäs (2007).

3. Honey pollen analysis techniques

To verify the identification, honey samples were collected from farmgate during the harvesting season and analyzed for pollen composition (Adgaba *et al*., 2020; Layek *et al*., 2020). Following the methodology of Louveaux *et al*. (1978), and Sawyer (1988) with some modification, honey pollen analysis was carried out using 10 honey samples collected from each *kebeles*. For ease of identification of pollen from honey samples, reference slides were prepared from a collected flower bud during the flowering periods in the area. The collected flowers were air-dried and stored until the laboratory work. The collected data were analyzed and presented in percentage and table forms.

RESULTS AND DISCUSSION

1. Characteristics of the respondents

About 95.1% of the respondents were household heads, of which 91% were male household heads and only 9% were female. Age had its effect on their social, economic, and working interactions (Alebachew and Eshetie, 2019). Hence, the majority age of the respondent beekeepers was between 36 and 45 (30.6%) which is the most productive age group, followed by 46–54 (26.2%), 18–35 (24.6%), 55–65 (12.3%), and older than 65 (5.7%). Similarly, a study on the beekeeper youth group indicated that the majority (71%) of the member were above the age of 29 (Alebachew and Eshetie, 2019).

Education is an important entry point for the fast transfer of knowledge on improved beekeeping technologies. Moreover, the educational level of the farming households may have significant importance in the determination of the type of development and the extension of needed services (Mujuni *et al*., 2012; Amulen *et al*., 2017; Alebachew and Eshetie, 2019; Bihonegn *et al*., 2021; Mulatu *et al*., 2021). Hence, most of the respondent's education levels ranged from reading and writing to grade eight. Similar results were reported by Abejew and

Table 1. Beekeeping experience of the respondent

Beekeeping experience	Proportion (%)
>15 years	45.1
10–15 years	11.5
5–9 years	23.0
1–4 years	20.5

Table 2. Months of the year where feed shortage occurs

Months of the year	Seasonal feed shortage (%)
January–March	83.2
April–June	3.0
July–September	12.9
October–December	1.0

Zeleke (2017). However, about 29.5% were illiterate.

Alebachew and Eshetie (2019) distinguished that most of the honey production comes from the traditional hive (cylindrical shaped local hive) with notable numbers of empty hives on the youth beekeeper's hand. Similarly, in this study, about 53.3% and 24.9% of the respondents have 1–2 and 3–14 traditional hives with honeybee colonies, respectively, whereas about 23% of the respondents have traditional hives without honeybee colonies. About 75.5% of the respondents have transitional hives (Kenyan top bar hives) without honeybee colonies and only about 24.5% have transitional hives with honeybee colonies. Additionally, only 50% of the respondents have modern frame hives (Langstroth hive) with honeybee colonies, while the rest 50% of the respondents had modern frame hives without honeybee colonies.

The beekeeping experience has a positive correlation with the usage of improved beekeeping technologies and has indigenous knowledge to identify honeybee races, behavior, and productivities (Abejew and Zeleke, 2017). In this study, most of the respondents (about 45.1%) have beekeeping experience of more than 15 years (Table 1), a similar result was reported by Abejew and Zeleke (2017).

2. Basic honeybee management practices

1) Honeybee feed shortage occurrence

Knowledge of honeybee flora across seasons is vital to utilize or supplement if there is a shortage. In this study, most of the respondents (82.8%) noticed the problem of feed shortage. The more series months of the year where feed shortage occurs were given in Table 2. About 58.6% of respondent beekeepers, provide additional feed for their bee colonies during the feed shortage period. Of which 44.1% of respondents have used sugar syrup as the supplementary feed, while, about 26.5% of the respondents were separately fed sugar syrup, roasted wheat flour, and roasted barley flour for their honeybee colonies. The rest 29.4% of respondents fed the combination of roasted chickpea flour, roasted bean flour, and roasted chickpea flour for their honeybee colonies during the dearth period.

Table 3. Seasons of honeybee colony abscond occurs

Seasons of the year	Absconding rate (%)
January–March	13.7
April–June	56.9
July–September	15.7
October–December	13.7

2) Honeybee colony absconding condition in the study area

The honeybee colonies' dynamics were varied based on several factors such as management and season. About 86.6% of respondents have noticed the problem of colony absconding. Of those respondents, 23.3% lost at least one honeybee colony in each production year. The rest 20.4%, 15.5%, and 42.1% of the respondents experienced losses of about 2, 3, and 4 honeybee colonies, respectively. Months from April to June were the seasons when higher honeybee colony abscond occurred, whereas from October to December and from January to March lower abscond was observed (Table 3).

3) Reason for honeybee colony absconding and swarming

The most important reasons for the absconding of honeybee colonies were poor honeybee management, especially for frame hives (49%), shortage of feed (22%), and others (29.2%). Lemma *et al*. (2016) report that the absconding may be due to frequent disturbances, pest attacks shortage of bee forage, lack of bee shelter, and generally poor management.

At the same time, about 37.5% of colonies swarmed in their apiaries, and the rest 62.5% did not. Of those who have got reproductive swarm, the majorities 45.2% have only one reproductive swarm and about 28.6% have got two. Three and above were about 26.2%. This is maybe due to the tropical honeybees having high reproductive swarming impulses and tendencies (Alemu *et al*., 2014; Lemma *et al*., 2016; Abejew and Zeleke, 2017; Dubale, 2017). The respondents noted that the major reasons for swarming were a type of management (33.3%), type of vegetation and pollen availability (41.2%), instinct behavior of the colony (7.8%), and small hive volume (3.9%), and others (13.7%).

4) Months of colony transfer and honey harvest

Most respondents (75%) transfer their honeybee colonies from traditional hives to the modern or transitional hives from July to September, some (13.4%) in April to June and others (11.6%) in October to December. The reason for the selection of transferring period is the availability of flowers about 77.6%, and other reasons about 22.4%. About 90.7% of honey is harvested in October–December, followed by April–June (3.4%). Rarely, it is also harvested in July–September, and January-March (5.1%).

5) Amount and frequency of honey harvest and practices of honey grading

Honey production and productivity depend on various factors including the type of the honeybee races, agro-ecology, weather conditions, the availability of flora, health status, and strength of the colonies (Lemma *et al*., 2016). Hence, the respondent beekeeper farmers harvest honey from the three types of hives, i.e., traditional, transitional, and modern hives. In this study, they have harvested honey from traditional hives in the range of 2 to 35 kg with an average of 8.15 kg annually. About 76% of respondents have harvested honey from transitional hives from 20 to 30 kg. About 65.3% of respondents have harvested from 4 to 50 kg of honey from modern hives. Lemma *et al*. (2016) reported that the mean honey yield per harvest per frame hive was 15.2 kg at the Wag-Himra zone using experimental colonies.

The frequency of honey harvest ranges from one to three times per annum. About 56.9% of the respondents were harvested twice a year, about 33.6% harvested once, and the remaining 9.5% harvested three times a year. About 88.5% of the respondents classify their honey, and 11.5% do not. The parameters to classify their honey was color (70.1%), taste (9.3%), plant sources (1.9%), and both colors of the honey and plant sources were 18.7%.

3. Identified honeybee floras in eastern Amhara

1) Honeybee flora composition

Due to its favorable climatic conditions and edaphic factors, a wide range of species of cultivated and uncultivated honey plants that comprise herbaceous, shrubs, and trees are grown in Ethiopia (Ejigu *et al*., 2017). About 104 plant species were identified as honeybee floras either pollen or nectar source or both, and some can be propolis sources like Tid (*Juniperus* species). Of which about 15 (14.4%), 21 (20.2%), 39 (37.5%), and 29 (27.8%) were domesticated cultivated crops, wild herbs (including grass and legume), shrubs, and tree plants, respectively, this result was summarized in Table 4 and the details of each flora were explained in Table 7. Hence, a lower number of bee flora species were reported by Jenberie *et al*. (2016), which was a total of 80 honeybee floral resource plant species (composed of 7.5% grasses, 21.25% herbs, 41.25% shrubs, and 30% trees) in the Wag-Lasta area of the Amhara Region.

The number of identified bee flora species was lower than Ejigu *et al*. (2017), who found a total of 290 important bee plant species in the Western Amhara Region, Ethiopia. Besides, in this study, about 23 (22.1%) were annuals, while 81 (76.2%) were also perennials bee forages. Shrubs were the dominant honeybee plants followed by trees, herbs, and domesticated crops, respectively. This may be because shrubs grow in different land-use systems, including steep mountainous areas with shower rain in a short period (Jenberie *et al*., 2016). Additionally, about 61.7% of respondents plant honey-

Table 4. The proportion of the type of identified honeybee floral

Type of identified floral	Number	Proportion (%)
Domesticated cultivated crops	15	14.4
Wild herbs (grass and legume)	21	20.2
Shrubs	39	37.5
Trees	29	27.9
Total	104	100

bee floras around their apiaries site, but 38.3% did not. The source of such plant seedling is government nurseries (47.6%), other sources (30.2%), private nurseries (9.5%), and a combination of one or two of the above sources (7.9%).

2) Easily propagated honeybee floras

Honeybee floras are a source of either pollen or nectar or both. If those plants are easily propagated (such as higher rates of seed germination, a short time from sowing to blooming, and grown in poor fertile soil), they are more advantageous for the beekeeping sector. According to the respondent beekeepers, the easiest propagative floras in decreasing order were *Zea mays*, *Guizotia abyssinica*, *Sorghum bicolor*, *Eucalyptus species*, *Cordia africana*, *Acacia abyssinica*, *Guizotia scabra*, *Carissa edulis*, *Croton macrostachya*, *Coffea arabica*, *Helianthus annuus*, *Zizyphus spynachristus*, *Lantana camara*, *Sesamum indicum*, *Ehretia cymosa*, *Citrus sinensis* and *Brassica niger* in Dawa Chefa district; *Guizotia scabra*, *Vicia sativa*, *Schinus molle*, *Bidens pachyloma*, *Helianthus annuus*, *Cordia africana*, *Euclea racemosa*, and *Eucalyptus species* in Meket district as well as *Euphorbia abyssinica*, *Euphorbia tirucalli*, *Agave americana*, *Eucalyptus species*, *Acacia abyssinica*, *Aloe berhana*, *Cordia africana*, *Ehretia cymosa* in Ambasel district.

3) Floras have a longer flowering period and bloom more than once a year

In giving flower for a longer period, *Eucalyptus species*, *Acacia abyssinica*, *Cordia africana*, *Carissa edulis*, *Zea mays*, *Zizyphus spynachristus*, *Coffea arabica*, *Helianthus annuus*, *Guizotia abyssinica*, *Grevillea robusta*, *Citrus sinensis*, *Musa x-paradisiaca*, *Carica papaya*, *Croton macrostachya*, and *Mangifera indica* has been selected in Dawa Chefa district, *Bidens pachyloma*, *Eucalyptus species*, *Croton macrostachya*, *Acacia abyssinica*, *Schinus molle*, *Guizotia scabra*, *Guizotia scabra*, *Vicia sativa*, *Guizotia abyssinica*, *Helianthus annuus*, and *Cordia africana* has been selected in Meket district, as well as *Euphorbia tirucalli*, *Eucalyptus species*, *Schinus molle*, *Acacia abyssinica*, *Cordia africana*, *Acacia brevispica*, *Erica arborea*, *Agave sisalana*, *Typha genus* in Ambasel district.

When the frequency of giving flowers more than once in a year is concerned, *Eucalyptus species*, *Acacia abyssinica*, *Cordia africana*, *Croton macrostachya*, *Zea mays*, *Acacia brevispica*, *Musa x-paradisiaca*, *Pterrolobium stellatum*, *Guizotia abyssinica*, *Ehretia cymosa*, *Zizyphus spynachristus*, *Citrus sinensis*, *Coffea arabica*, *Schinus molle*, *Trifolium rueppellianum*, *Sorghum bicolor*, *Carissa edulis*, *Typha genus*, *Helianthus annuus* were mentioned in Dawa Chefa district. In Meket district, *Bidens pachyloma*, *Cordia africana*, *Trifolium rueppellianum*, *Guizotia scabra*, *Vicia sativa*, *Croton macrostachya*, *Euclea racemosa*, *Acacia abyssinica*, *Eucalyptus species*, *Helianthus annuus* were flower more than once in a year. *Eucalyptus species*, *Schinus molle*, *Cordia africana*, *Ehretia cymosa*, *Pterolobium stellatum*, *Lippia adoensis*, and *Aloe berhana* were flowered more than once a year in the Ambasel district.

4) Major bee floras in each district and flowering calendar in eastern Amhara

The honeybee flora sources used as major sources of honey and pollen production in Dawa Chefa district were *Cordia africana*, *Eucalyptus species*, *Acacia abyssinica*, *Zea mays*, *Guizotia abyssinica*, *Sorghum bicolor*, *Carissa edulis*, *Citrus sinensis*, *Croton macrostachya*, *Coffea arabica*, *Ehretia cymosa*, *Mangifera indica*, *Helianthus annuus*, *Guizotia scabra*, *Rersea americana*, *Zizyphus spynachristus*, *Citrus aruntifolia*, *Brassica niger*, *Lippia adoensis*, and *Grevillea robusta*.

In Meket district, *Cordia africana*, *Bidens pachyloma*, *Schinus molle*, *Guizotia scabra*, *Vicia sativa*, *Euclea racemosa*, *Helianthus annuus*, *Eucalyptus species*, *Croton macrostachya*, *Acacia abyssinica*, *Cicer arietinum*, *Euphorbia tirucalli*, *Lippia adoensis*, *Trifolium rueppellianum*, and *Sorghum bicolor* were the major honey source plants. Whereas in Ambasel district, *Cordia africana*, *Eucalyptus species*, *Euphorbia tirucalli*, *Pterolobium stellatum*, *Euclea racemosa*, *Zizyphus spynachristus*, *Bidens pachyloma*, *Acacia abyssinica*, *Guizotia scabra*, *Croton macrostachys*, *Erica arborea*, *Rhus natalensis*, *Hypoestes triflora*, *Lippia adoensis*, *Carissa edulis*, *Ehretia cymosa*, and *Euphorbia abyssinica* were selected honey sources.

Bareke and Addi (2019), and Adgaba *et al*. (2017) noted that characterizing the flowering calendar of the area is an important tool for effective management of the honeybee colonies. Hence, this study revealed that there were floras that give flowers from three days to

Table 5. Major honeybee floras (either pollen or nectar source) and flowering calendar in eastern Amhara

Scientific name	Local name (Amharic)	Floral calendar (months) and scores											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pterolobium stellatum	Kentefa	–	–	–	3	–	–	–	–	5	5	3	2
Carissa edulis	Agam	–	–	–	5	–	–	–	–	5	3	–	–
Rhus natalensis	Takuma	–	–	–	–	–	–	–	5	5	–	–	–
Cordia Africana	Wanza	–	–	–	4	3	–	–	–	–	5	3	–
Acacia Policanta	Sirinkagirar	–	–	–	–	5	2	–	–	–	–	–	–
Sorghum bicolor	Mashila	–	–	–	–	–	–	–	–	5	1	–	–
Zea mays	Bekolo	–	–	–	–	–	–	–	5	4	–	–	–
Eucalyptus species	Bahr zaf	–	–	–	–	5	5	3	–	–	2	5	3
Acacia species	Girar	3	3	2	2	1	–	–	–	3	3	5	4
Euclea racemose	Dedeho	–	3	2	1	–	–	–	–	–	–	–	–
Cajanus cajan	Pigeon pea	–	–	–	–	–	–	–	–	5	5	3	–
Guizotia abyssinica	Nug	–	–	–	–	–	–	–	–	–	4	5	–
Ehretia cymose	Game	–	–	–	–	3	–	–	–	–	–	3	–
Zizyphus species	Kurkura	–	–	–	–	–	–	–	–	–	–	5	–
Carthamus tinctorius	Suf	–	–	–	–	–	–	–	–	5	–	–	–
Dovyalis abyssinica	Koshim	–	–	–	3	3	3	5	–	–	–	–	–
Chamaecytisus proliferus	Tree lucern	–	–	–	–	–	5	–	–	5	3	1	–
Thymus species	Tosign	1	–	–	–	–	–	–	–	–	5	4	4
Echinops pappii	Koshele	–	–	–	–	–	–	–	–	–	5	3	–
Clematis species	Hareg	–	–	–	–	–	–	–	–	–	3	5	–
Rumex nervosus	Embacho	–	–	–	–	–	–	–	–	–	3	5	4
Urtica simensis	Sama	–	–	–	–	5	4	–	–	–	–	5	4
Lens culinaris	Misir	–	–	–	–	–	–	–	2	5	–	–	–
Juniperus species	Tid	It is a propolis source, and it can be used year-round											
Total value		4	6	4	18	25	24	8	10	57	47	55	21

Key: The value ranges from 1 to 5, 1 indicates the lower flowering and 5 indicates the highest flowering month.

a year-round. According to the respondents, the major flowering seasons for the flora were identified based on prolonged floral periods, and the largest abundant and values were given ranges from one to five for each month of the year, one for the lowest and five for the highest flowering month (Table 5).

Based on the total values for each month, three classifications can be made for the sake of honeybee colonies management. The result in Table 1 indicates that a severe dearth period occurred starting from January–March due to flower shade, July–August also due to over rain that washes nectar and pollen of the floras. This indicates intensive feeding is an essential management option during these months. Moderate period, from April to June, and December, during this period moderate level feeding in is essential. Honey flow period, during this period, there was ample bee flora. This period extends from September to November. This was the honey harvesting season. Similar bee flora flowering pattern was reported in the Wag-Lasta area, Amhara Region (Jenberie *et al*., 2016).

5) Honey pollen analysis marks

Honey pollen analysis is important to identify the major and minor flora in the area and to authenticate the beekeeping farmer's knowledge and experience in the identification of honeybee floral resource plants (Jenberie *et al*., 2016). According to the honey pollen analysis result, there were different pollen sources of flowering plant species for each district and sampling site. Table 6 indicates the honey pollen analysis result for each district and sampling site.

Table 6. Honey sampling district, sites, and pollen spectrum

District	Sampling site	Pollen frequency classes
Meket	Taja	****Guizotia scabra ***Guizotia abyssinica **Eucalyptus camaldulensis *Maytenus abscura, Ocimum americanum
	Warkaye	****Eucalyptus globulus **Guizotia scabra *Eucalyptus camaldulensis, Nigella sativa, Rumex nepalensis
	Dibko	****Trifolium rueppellianum ***Guizotia scabra **Cirsium schimperi *Phaseolus vulgaris
Dawa Chefa	Kallo	****Eucalyptus camaldulensis ***Guizotia scabra, Ekebergia capensis
	Terefo	****Eucalyptus camaldulensis, Guizotia abyssinica **Bidens pachyloma *Trifolium reupelianum
	Sitr	Pollen not found
Ambasel	Golbo	***Hypoestes triflora, Guizotia abyssinica, Clematis hirsuta, Eucalyptus camaldulensis **Brassica carinata
	Robit	****Clematis hirsuta **Hypoestes triflora, Brassica carinata, Guizotia abyssinica, Bidens pachyloma, Eucalyptus camaldulensis

Key: ****Predominant pollen (more than 45%); ***Secondary pollen (16–45%); **Important minor pollen (3–15%); *Minor pollen (less than 3%).

6) Plants used for hive fumigation/smoking purposes

Plants were used for the fumigation/ smoking of the hive to attract honeybees as baiting and maintaining the colony in the hive. It is also important for disinfecting the hive from previously contaminant agents including honeybee pests and diseases. The smoking process may take hours with every ten minutes of smoking, the hive sprayed with a small amount of water. The process ends up when the hive internal becomes gray color and has attractive smells.

The best-selected honeybee floras used for hive smoking in Dawa Chefa were *Carissa edulis*, *Lippia adoensis*, *Flacourtia indica*, *Rosa abyssincia*, *Olea europaea*, and *Ocimum americanum*, whereas the best honey producing flora such as *Cordia africana*, *Acacia abyssinica*, *Eucalyptus species*, *Zea mays*, *Guizotia abyssinica*, *Croton macrostachys*, *Coffea arabica*, *Ehretia cymosa*, *Mangifera indica*, *Citrus sinensis*, *Helianthus annuus*, *Sorghum bicolor*, and *Guizotia scabra* were ranked as poor hive smoking plant.

In Meket district, *Syzygium guineense* was the only better hive smoking plant, and others such as *Cordia Africana*, *Helianthus annuus*, *Guizotia scabra*, *Acacia abyssinica*, *Eucalyptus species*, and *Schinus molle* were ranked as poor hive smoking. In Ambasel district, *Lippia adoensis*, *Olea europaea*, *Lippia adoensis*, and *Dodonaea angustifolia* were the best hive smoking plant species for the hive, but *Cordia africana*, *Carissa edulis*, *Croton macrostachyus*, *Euphorbia abyssinica*, *Typha genus*, *Eucalyptus species*, *Acacia abyssinica*, *Ehretia cymosa*, *Euclea racemosa*, *Pterolobium stellatum*, *Euphorbia tirucalli*, *Schinus molle*, *Aleo brahana*, *Cyperus longus*, *Erica arborea*, *Agave sisalana*, *Zizyphus spynachristus*, and *Bidens pachyloma* were ranked as poor hive smoking plants.

Table 7. Scientific, local name and floral types of identified honeybee floras in eastern Amhara

Scientific name	Amharic name	Flora type	Scientific name	Amharic name	Flora type
Acacia abyssinica	Girar	Tree	*Guizotia scabra*	Mech	Herb
Acacia brevispica	Kentefa	Tree	*Hagenia abyssinica*	Koso	Tree
Acacia decurrens	Decurrens girar	Tree	*Helianthus annuus*	Yeferenj suf	Crop
Acacia Policanta	Sirinka girar	Tree	*Hygrophila auriculata*	Yesiet Mlas	Herb
Acacia saligna	Saligina	Shrub	*Hypoestes triflora*	Tqur Telenj	Herbs
Acacia species	Girar	Tree	*Jasminum abyssinicum*	Tembelel	Shrub
Achyranthes aspera	Telenj	Herb	*Juniperus species*	Tid	Tree
Agave americana	Kacha	Shrub	*Justicia schimperiana*	Sensel	Shrub
Agave sisalana	Kacha	Shrub	*Lantana camera*	Yewof Kolo	Shrub
Aloe berhana	Ret	Herb	*Lathyrus sativus*	Guaya	Crop
Argemone Mexicana	Nechlo	Herb	*Launaea cornuta*	Yeseytan Gomen	Herb
Argyrolobium ramosissimum	Gerengerie	Herb	*Lens culinaris*	Misir	Crop
Azadirachta indica	Neem	Tree	*Leucaena leucocephala*	Lucinea	Shrub
Bidens pachyloma	Adey Abeba	Herb	*Lippia adoensis*	Kesie	Shrub
Brassica napus	Gomen	Crop	*Maesa lanceolata*	Abaliyeh	Tree
Brassica niger	Senafich	Crop	*Mangifera indica*	Mango	Tree
Buddleja polystachya	Amfar	Tree	*Maytenus abscura*	Atatt	Shrub
Cajanus cajan	Yergib Ater	Shrub	*Moringa stenopetala*	Shiferaw	Tree
Calpurnia aurea	Digita	Shrub	*Musa x- paradisiaca*	Muz	Herb
Capparis tomentosa	Gimero	Shrub	*Nigella sativa*	Tiqur Azmud	Crop
Carica papaya	Papaya	Tree	*Ocimum americanum*	Besobila	Herb
Carissa edulis	Agam	Shrub	*Olea europaea*	Weira	Tree
Carthamus tinctorius	Suf	Crop	*Parkinsonia aculeate*	Jerusalum tree	Shrub
Chamaecytisus proliferus	Treelucern	Shrub	*Parthenium hysterophorus*	Kinche	Herb
Cicer arietinum	Shimbra	Crop	*Persea americana*	Avocado	Tree
Cirsium schimperi	Kosheshela	Herb	*Phaseolus vulgaris*	Boloke	Crop
Citrus aurantiifolia	Lomi	Shrub	*Phytolacca dodecandra*	Endod	Shrub
Citrus medica	Trngo	Shrub	*Podocarpus falcatus*	Zgba	Tree
Citrus sinensis	Brtukan	Shrub	*Pterolobium stellatum*	Kentafa	Shrub
Clematis hirsuta	Nech Yeazo Hareg	Shrub	*Pterolobium stellatum*	Qontr	Shrub
Clematis simensis	Azo hareg	Shrub	*Rhus glutinosa*	Embis	Shrub
Clematis species	Hareg	Shrub	*Rhus natalensis*	Taquma	Shrub
Coffea arabica	Buna	Shrub	*Ricinus communis*	Gulo	Shrub
Commelina benghalensis	Yewef Enqur	Herb	*Rosa abyssinica*	Kega	Shrub
Cordia africana	Wanza	Tree	*Rumex nepalensis*	Qtel Rejim	Herb
Croton macrostachyus	Bisana	Tree	*Rumex nervosus*	Embacho	Shrub
Cyperus longus	Enegecha	Herb	*Sansevieria genus*	Chiret	Shrub
Dodonaea angustifolia	Kitikita	Tree	*Schinus molle*	Kundo Berbere	Tree
Dovyalis abyssinica	Koshim	Shrub	*Sesamum indicum*	Selit	Crop
Echinops pappii	Koshele	Shrub	*Sesbania sesban*	Girangire	Shrub
Ehretia cymosa	Game	Tree	*Solanum giganteum*	Emboay	Shrub
Ekebergia capensis	Lol	Tree	*Sorghum bicolor*	Mashila	Crop
Erica arborea	Adal	Shrub	*Syzygium guineense*	Doqma	Tree
Eucalyptus camaldulensis	Key bahir zaf	Tree	*Thymus species*	Tosign	Herb
Eucalyptus globulus	Nech bahir zaf	Tree	*Trifolium rueppellianum*	Maget	Herb
Euclea racemosa	Dedeho	Shrub	*Typha genus*	Fila	Herb
Euphorbia abyssinica	Kulqual	Tree	*Urtica simensis*	Sama	Herb
Euphorbia tirucalli	Kinchib	Shrub	*Vernonia schimperi*	Grawa	Herb
Ficus vasta	Warka	Tree	*Vicia sativa*	Meno goaya	Crop
Flacourtia indica	Huda	Shrub	*Vicia faba*	Bakela	Crop
Gravilia robusta	Gravillea	Tree	*Zea mays*	Bekolo	Crop
Guizotia abyssinica	Nug	Crop	*Zizyphus species*	Kurkura	Tree

Note: Crops are domesticated and cultivated herbs

CONCLUSION

This questionary survey and honey pollen analysis study revealed that there were varieties of honeybee floras in the study area. About 104 bee flora species were identified inhabiting shrubs, trees, herbs, and domesticated crops with the major proportion of shrubs. Most honeybee floras were perennial plants. Most of the respondent beekeepers were in the productive age group. The respondent beekeepers experienced a high honeybee colony absconding and swarming rate due to multiple factors. They also harvest honey from the traditional, transitional, and modern types of hives. Additionally, there was seasonal bee forage fluctuation. Therefore, seasonal management of the colonies should be adjusted with flowering periods of identified major honeybee floras in the study areas. Hence, starting from January–March and July–August, intensive feeding to the honeybee colonies is essential. Additionally, from April–June, moderately feeding the honeybees is crucial for the survival of the colony and better honey production for the coming honey flow season. Protecting and conserving those potential honeybee floras from extinction is an indispensable role for the bee sector and the overall environment. Further study is needed about the frequency and density of the honeybee floras. Additionally, screening and propagation of potential honeybee floras should be done for multiplication and distribution to the beekeepers.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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