

## Research Article

### Identification and characterization of honeybee flora in Jimma Zone, Ethiopia

Tesfa Mossie<sup>1\*</sup> and Hayat Worku<sup>1</sup>

<sup>1</sup> Ethiopian Institute of Agricultural Research (EIAR), Jimma, Ethiopia

Corresponding author: mtesfa6@gmail.com

Received: November 30, 2022; Received in revised form: April 12, 2023; Accepted: May 3, 2023

**Abstract:** Due to the existence of diverse floral resources and favorable ecological conditions, Ethiopia is still one of the top ten natural honey producers worldwide. The study was conducted to identify and characterize the phenology and pollen potential of major bee forages in the various Agro-ecological conditions of Jimma zone. A total of 90 beekeepers were purposefully selected from three districts and interviewed using semi-structured questionnaire. The density and abundance of flowering plants were determined using sixty main quadrant sampling techniques. In addition, sixty-six pollen specimens were collected for one year using pollen traps at seven-day intervals and were also traced back to plant species level under a light microscope. The diversity of the bee flora was determined using the Shannon-Wiener diversity index. Based on survey, pollen load collection, and plant inventory data, the study has revealed the presence of 141 pollen and/or nectar-source honeybee plant species belonging to 62 families in the study area. Herbs were the most dominant bee flora growth forms, accounting for 62 (44%) of a total of 141 honeybee plant species, followed by trees at 48 (34%) and shrubs at 31 (22%), respectively. Herbaceous plant had a greater density value of plant species per plot than did trees and shrubs. The families with the highest number of species were Fabaceae 18 (12.8%), Asteraceae 11 (7.8%), Poaceae 9 (6.4%), Solanaceae 6 (4.3%), Acanthaceae 4 (2.8%), and Euphorbiaceae 4 (2.8%) in the study area. One hundred fifteen (81.6%) bee forage species were both sources of pollen and nectar, whereas fifteen (10.6%) were pollen sources and the remaining eleven (7.8%) were nectar source plant species. The Shannon diversity index and evenness were found to be 2.8 and 0.6, respectively. This indicated that the study area has a rich bee floral plant species and is suitable for beekeeping. The midland Agro-ecology relatively has the highest species diversity, richness and evenness compared to the highland and lowland Agro-ecologies. Two main flowering periods of honeybee plants were followed by two honey flow season. Therefore, beekeepers should follow floral calendar of honeybee plants to exploit the potential of the area for honey production.

**Keywords:** Agro-ecology, flora resources, floral calendar, flowering period



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#### 1. Introduction

Apiculture is a livestock industry that contributes significantly to the national and international economies of a country, mainly in Africa. Ethiopia is still one of the top ten natural honey producers worldwide due to the existence of diverse floral

resources and favorable ecological conditions (Fitchl and Admassu, 1994; Gidey and Mekonen, 2010; Bareke and Addi, 2020). It directly and indirectly contributes to household income and the national economy (Fenet and Alemayehu, 2016). The production of honey, beeswax, pollen, royal jelly, and

other by-products is the direct income source for the users. Contributing to plant pollination and the conservation of the natural environment is the indirect role of honey bee production. Honeybees and plants have had a strong relationship for over 50 million years (FAO, 1986). Beekeeping conserves natural resources and protects the global environment. It can be integrated with agricultural practices like crop production, horticulture crops, and conservation of natural resources (Gezahegn, 2001; Bareke and Addi, 2020). Honey bees require feed for their production and reproduction like other livestock species. It depends on flowering plants for their nutrition and protection. About 40, 000 plant species are used as honeybee forage across the world (Crane, 1990). Among the flowering plants found in Ethiopia, 500 species are rich in nectar and pollen (Fichtl and Admasu, 1994). Plants are classified as nectar or pollen source plants based on the honeybee's activity of extending their proboscis and hind legs into flowers, respectively (Wubie *et al.*, 2014; Jenberie *et al.*, 2016; Pande and Gi, 2018). Honeybees' main food sources are pollen and nectar. Nectar is a major component in the production of honey, whereas pollen is used as larval food, which is important in colony reproduction (Facade and Paul, 2006).

Ethiopia has abundant natural and cultivated flora as well as diverse agro-ecological and climatic conditions that are ideal for beekeeping. The presence of a large number of honey plants is important for the country's honeybee colonies, production, and productivity. The botanical composition of natural vegetation differs depending on the Agro-ecology, climate, and soil type (Gebretsadik, 2016). The type and quantity of flora present determines productivity and reproduction performance of honeybees (Amssalu, 2007). Oromia is one of the Federal Republic of Ethiopia's regional states that is rich in natural resources and has favorable climatic conditions for improved beekeeping development. The region has virgin forests with a high biodiversity, such as Harena, Yayu, Dindin, Anfarara, Munessa, Jibat, Chilimo, and Menagesha-Suba that are ideal for beekeeping. The region also contains cultivated crops such as oil and horticultural crops, as well as pulses, all of which can help to further the development of beekeeping.

These make the region one of the potential areas for honeybee production.

Despite the region's diverse Agro-ecological, climatic conditions, abundance of natural and cultivated flora, beekeepers lack a floral calendar for honeybee foraging and honey production. Flora calendar is a timetable that indicates the approximate duration of the flowering period, abundance, distribution, and honey potential of honeybee forages in various Agro-ecological zones of the country (Admasu *et al.*, 2004; Amssalu, 2004). Identification and documentation of bee forages and their flowering calendar is critical for the sub-sector's development endeavors since the flowering periods of honeybee plants differ depending on the diversity of plant habits and environmental conditions (Tilahun, 2003). Therefore, establishing a floral calendar is a critical tool for planning various beekeeping management operations, such as hive super adding, and predicting the frequency and period of honey flow in a given area. The length of flowering period, nectar and pollen production, and honeybee plant availability in a specific area are all determined by agro-ecology and season. Therefore, assessing the different Agro-ecological zones for determining the availability of bee forage, their life forms and establishing a flowering calendar of honey plants that enable effective seasonal colony management is paramount important. Furthermore, for optimal honey production, beekeepers should be aware of the flowering seasons of both main and minor nectar and pollen sources of plants in the vicinity of their apiary site (Pearson and Braiden, 1990). The study's overarching goal was to characterize and document major bee forages contributing to honey production, as well as to develop an appropriate flora calendar for effective bee management in various Agro-ecological conditions of the Jimma zone.

## 2. Materials and Methods

### 2.1. Description of the study area

The study was conducted in beekeeping potential areas of the Jimma zone of Oromia regional state, which geographically lies at a latitude of about 7°13'–8°05'N and a longitude of about 35°02'–37°03'E. The area has high humidity and is rich in fauna and flora biodiversity. Three study districts (Goma, Gera, and Shebe Sombo) were selected based

on ecological differences and beekeeping potential. Agro-ecological representation is used to exploit bee flora species in different ecologies in the study area.

## 2.2. Honeybee flora inventory

Three kebeles were selected from each district depending on their Agro-ecological variation and potential for beekeeping activities. Household beekeepers were selected based on their experience in beekeeping and after discussion with district experts. A total of ninety (90) beekeepers, thirty (30) from each district, were also purposefully selected to get sound information on honey source plant lists, flowering periods, duration, beekeeping experience, number of colonies, number of harvest per year and presence of poisonous plants. Semi-structured questionnaires were used to collect the primary data from respondents. A group discussion with experts, community groups, development agents, and farmer beekeepers was held to generate relevant information. Necessary and supportive data on plant nature and habitats, feeding resources, and plant phenology were collected following field observation. During data collection, the types of honeybee forage, honey flow season, plants with adverse effects, swarming seasons, and management practices were all considered.

## 2.3. Pollen sample collection and laboratory analysis

The total of 18 honeybee colonies was established in nine different locations across three districts of the study area in different Agro-ecologies. At each site, two honeybee colonies were established for pollen trapping and pollen sample collection. Honeybee colonies were fitted with pollen traps and loads to collect dislodge pollen pellet samples at seven-day intervals. In one year, a total of 66 pollen specimens were collected and used to determine the botanical origin of honeybee pollen. The fresh and dry weight of pollen pellets was recorded. The collected pollen was dried at room temperature, and the fresh and dry pollen pellets were weighed and sorted by color. Each sorted pollen samples were identified at generic and species level under light microscope following diluting with ether solution. Using prepared pollen reference materials, reference books, pollen atlases, plant species were identified from each type of pollen by comparing the shape, size, and apertures of the

pollen. Pollens that we couldn't identify botanically using either analysis technique have been labeled as "unidentified".

## 2.4. Honeybee flora species composition and diversity

Assessment of plant species composition and diversity were performed in purposively selected districts based on the beekeeping potential. For vegetation analysis using quadrant sampling techniques, two representative kebeles were chosen from each district based on vegetation coverage and ecological difference. The diversity and composition of honeybee plants were determined according to Tesfaye *et al.* (2013) plant density determination method. The quadrant/plot size varied depending on vegetation types. Honeybee plants were classified as trees, shrubs, and herbaceous. Tree and shrub sampling plots were 20m × 20m in size, whereas herbaceous plant sampling plots were 2m x 2m in a two-kilometer radius every 0.1km from the hive to estimate the frequency and density of bee plants.

The main plots were laid out systematically considering the availability of vegetation coverage, and then small quadrants of 2m x 2m plots were laid out at different sites of the main plots to understand the forgeable area of honey plants. A total of 60 plots were taken for the districts, representing different Agro-ecologies. Then plant species within quadrants were counted for the assessment of plant density and frequency at specific sampling sites. Honeybee flora species abundance was defined and computed in all quadrants, and density was calculated in hectares. Plant specimens were collected during flowering seasons with necessary botanical features like leaves, flowers and portion of stem. The collected specimens were pressed, identified and then compared to the published report at the Holeta Bee Research Center.

## 2.5. Richness and diversity of bee forage plants

The Shannon–wiener diversity index, species richness, and Shannon's evenness were used to determine the diversity of bee forage plant species. The Shannon-Wiener diversity index is the most widely used for non-sample-size-dependent measure of species diversity (Ramirez-Arriaga *et al.*, 2011).

$$\text{Shannon index } (H') = \sum (p_i * \ln p_i) \quad [1]$$

Where,  $H'$  is Shannon index,  $p_i$  is proportion of individual species and  $\ln$  is log base  $n$ .

$$\text{Evenness } (J) = \frac{H'}{H'_{\max}} = \frac{H'}{\ln S} \quad [2]$$

Where,  $H'$  is Shannon diversity index,  $H'_{\max} = \ln S$  where  $S$  is the number of species,  $\ln = \log$  basen. The value of evenness is found between zeros to one (Kent and Coker, 1992).

## 2.6. Statistical analysis

Data on bee flora species, abundance, frequency, diversity, and pollen count were summarized using descriptive statistics. The data was thoroughly examined using Microsoft Excel and the Statistical Package for Social Sciences (SPSS).

## 3. Results and Discussion

### 3.1. Major honeybee plant species identified by beekeepers

A total of 39 pollen and/or nectar source plant species belonging to 23 families were identified during the survey work (Table 1). The species of bee plants reported by beekeepers through survey were more or less comparable to those found by plant inventory and pollen analysis. This has demonstrated that beekeepers' indigenous knowledge is significant for bee plant inventory results.

The most frequently reported bee floral species by beekeepers were *Vernonia spp.*, *Coffea arabica*, *Croton macrostachyus*, and *Guizotia scabra* with 90 (100%), 83 (92.2%), 77 (85.6%) and 73 (81%) rate, respectively. The most bee floral plant species has been known as the best indicators of adaptation to the area and climatic condition (Wubie *et al.*, 2014). However, no single bee floral plant species has been identified by beekeeper respondents in the midland. This demonstrated that the midland has an overlapping bee flora plant species or vegetation distribution.

Bee floral plant species were classified as herbs, shrubs and trees and wild and cultivated based on growth forms and source of bee plants. According to beekeeper respondents, trees (62.5%) were the most important source of bee forages, followed by herbs (25%) and shrubs (12.5%). This finding is consistent with the findings of Kebede and Gebrechirstos (2016) and Haftom *et al.* (2013) in Tigray, who found trees

to be a major source of feed for honeybees. The current survey findings, however, contradict to the findings of Teklay (2011), who reported that herbs are the most common floral plant species. These variations might link with the changes in geographical location, soil type and climatic situation.

The foremost sources of honeybee forages were wild 116 (82.3%) and cultivated 25 (17.7%). These findings indicated that majority of bee floral plant species were found in wild sources since beekeepers had no practices to cultivate bee floral plant species. Honeybee plant species reported by beekeepers during the survey were categorized as very good, good, and poor based on their abundance in the study area (Table 1). Most of the bee floral species identified through the survey were categorized as good in their abundance.

*Coffea arabica*, *Croton macrostachyus*, *Vernonia Spp.*, *Guizotia scabra*, *Eucalyptus camaldlensis*, *Coffea arabica* *Cordia africana*, *Mangifera indica*, and *Combretum molle* were the most common honeybee plant species identified by beekeepers in different agro-ecologies (Table 1). The dominant honeybee plant species in the highland were *Vernonia Spp.*, *Schefflera abyssinica*, *Croton macrostachyus*, *Coffea arabica*, and *Bidens spp.*, while the most frequently visited bee floral species in lowland ecology were *Cordia africana*, *Guizotia scabra*, *Combretum molle*, *Eucalyptus camaldlensis*, *Bidens spp.*, and *Coffea arabica*. On the other hand, *Guizotia scabra*, *Vernonia Spp.*, *Coffea arabica*, *Croton macrostachyus*, and *Bidens spp.*, were the most abundant floral plant species in midland agro-ecology based on survey results. *Vernonia Spp.*, *Cordia africana*, and *Guizotia scabra* were the most abundant plant species in the highland, midland, and lowland, respectively. Frequently indicated bee floral species by beekeepers were *Vernonia spp.*, *Coffea arabica*, *Croton macrostachyus*, and *Guizotia scabra* with 90 (100%), 83 (92.2%), 77 (85.6%) and 73(81%) rate, respectively. The most widely distributed bee flora species in all agro-ecology is *Vernonia spp.*, *Schefflera abyssinica* and *Combretum molle*.

About 69.9% of beekeepers harvested honey yields twice a year, while 17.8% of beekeepers harvested

honey yields three times in different agro-ecologies of the study area. This result is consistent with the study done by Shegaw and Giorgis (2021), who found that there are two main harvesting seasons. Honeybee plants are present at different periods of the year because plant flowering times vary depending on species, topography, climate and farming practices (Rijal *et al.*, 2018). The average honey yields of frame hives in highland, lowland, and midland were 25.3, 23.3, and 30.2 kg respectively. The major honey flow seasons in the study area are October to December, February to April, and May to June (Figure 1). The maximum and minimum flowering duration of bee plant species were ninety and seven days, respectively. *Croton macrostachyus*, *Vernonia spp.*, *Eucalyptus camaldensis*, *Guizotia scabra*, and *Trifolium spp.* had the longest flowering periods and offered a steady supply of nectar and pollen to honeybees on the hunt. Bareke and Addi (2019) and Zeleke *et al.* (2019) conducted comparable studies in the Gera forests and selected parts of South Nations Nationalities and Peoples of Ethiopia, respectively. On the other hand, according to beekeepers respondents, the study areas dearth

periods were August, July, and January. Shegaw and Giorgis (2021) conducted similar study in selected areas of the Southern Nations Nationalities and Peoples of Ethiopia. A drought period can cause the depletion of stored food inside the hive, which has a negative impact on honeybee productivity. Therefore, beekeepers should know the dynamics of honeybee colonies in accordance with bee floras, flowering periods and duration of flowering times in different Agro-ecologies. Almost all beekeepers in the study area were familiar with the honeybee colony dynamics conditions. This findings agrees with the study conducted by Lemessa (2006), Fichtl and Admassu (1994) and Teklay (2011) in colony dynamics conditions. Beekeepers were identified as bee flora depending upon the intensity of flowers visited by honeybees. The knowledge gained in identifying bee flora assists beekeepers in recognizing the honey harvesting season and managing the beehives. The identification of flora calendar assists beekeepers in planning various beekeeping activities (Genet, 2002).

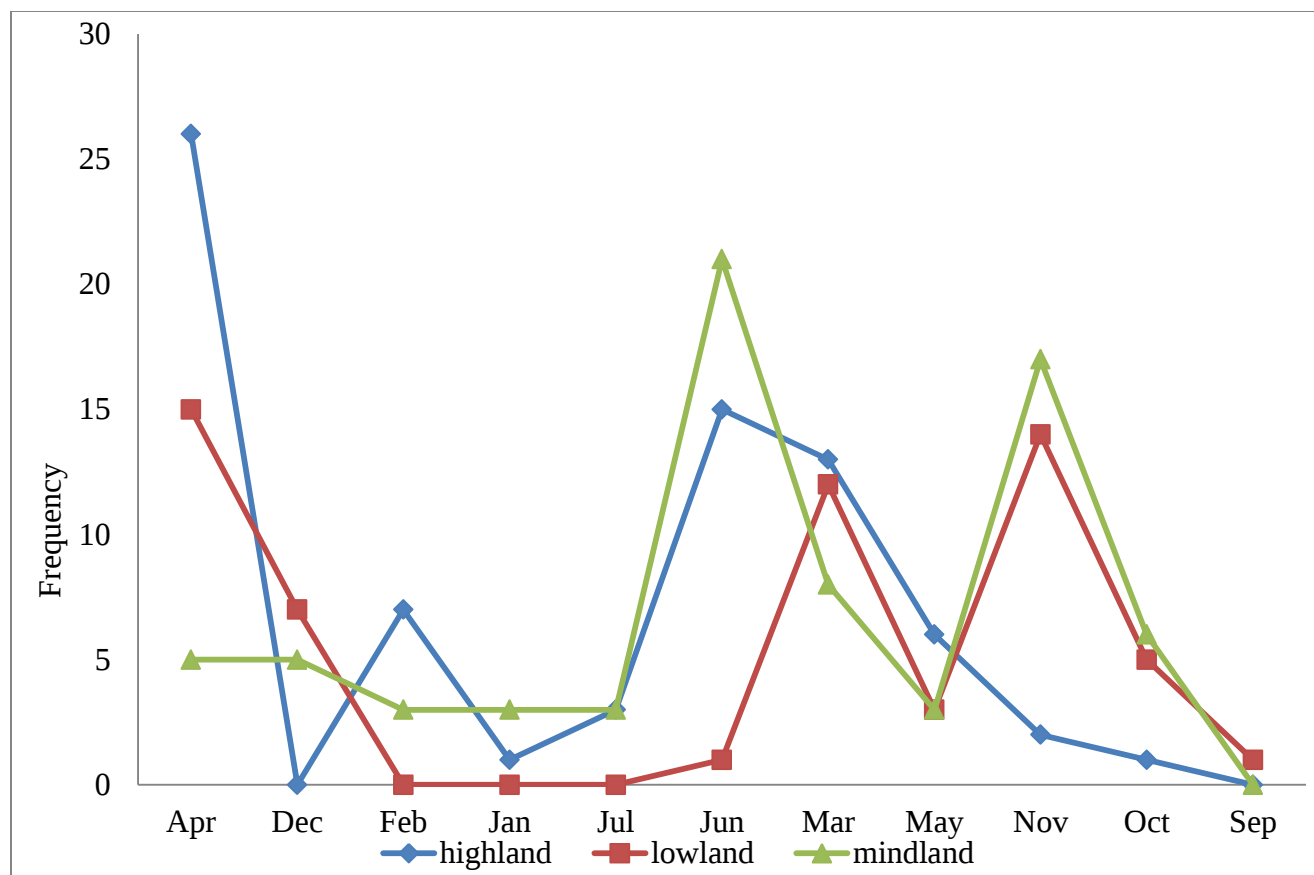


Figure 1: Honey flow month in different agro-ecologies

Table 1: Major honeybee plants identified by beekeepers

| Local name | Scientific name                       | Family name   | Species abundance | Life forms | Food source   | Flowering month     | Duration (days) |
|------------|---------------------------------------|---------------|-------------------|------------|---------------|---------------------|-----------------|
| Buna       | <i>Coffea arabica</i>                 | Rubiaceae     | 2                 | Shrub      | Pollen/Nectar | Feb, Mar            | 60              |
| Bisana     | <i>Croton macrostachyus</i>           | Euphorbiaceae | 2                 | Tree       | Pollen/Nectar | Jun, May, Aug, Apr  | 90              |
| Girawa     | <i>Vernonia Spp.</i>                  | Asteraceae    | 1                 | Tree       | Nectar        | Dec-Mar             | 90              |
| Tufo       | <i>Guizotia scabra</i>                | Asteraceae    | 2                 | herb       | Pollen/Nectar | Aug-Dec             | 90              |
| Bahrzaf    | <i>Eucalyptus camaldlensis</i>        | Myrtaceae     | 3                 | Tree       | Pollen/Nectar | Year round          | 90              |
| Wanza      | <i>Cordia africana</i>                | Boraginaceae  | 2                 | Tree       | Pollen/Nectar | Aug, Jul, Sep       | 60              |
| Abalo      | <i>Brucea antidysenterica Fresen.</i> | Simaroubaceae | 3                 | Tree       | Pollen/Nectar | Apr, Mar            | 15              |
| Avocado    | <i>Persea americana</i>               | Lauraceae     | 2                 | Tree       | Pollen        | Sep, Oct, Jan, Feb, | 90              |

|                |                                                 |                      |   |       |                   |                                  |    |
|----------------|-------------------------------------------------|----------------------|---|-------|-------------------|----------------------------------|----|
|                |                                                 |                      |   |       |                   | Apr                              |    |
| Mango          | <i>Mangifera indica</i>                         | <i>Anacardiaceae</i> | 3 | Tree  | Pollen/<br>Nectar | Mar, Dec,<br>Feb                 | 60 |
| Tensa          | <i>Combretum molle</i>                          | Combretaceae         | 1 | Tree  | Nectar            | Mar, Apr,<br>Feb                 | 60 |
| Boqolo         | <i>Zea mays</i>                                 | <i>Poaceae</i>       | 2 | herb  | Pollen            | Jul, Jun,<br>May                 | 60 |
| Adeye<br>ababa | <i>Bidens spp.</i>                              | <i>Asteraceae</i>    | 1 | herb  | Pollen            | Sep, Oct,<br>Nov, Dec            | 60 |
| Girar          | <i>Acacia spp.</i>                              | Fabaceae             | 2 | Tree  | Pollen/nectar     | Apr,<br>May,<br>Dec, Jan,<br>Feb | 60 |
| Geteme         | <i>Schefflera abyssinica</i>                    | <i>Araliaceae</i>    | 1 | Tree  | Pollen/nectar     | Apr, Mar,<br>May                 | 60 |
| Kerero         | <i>Aningeria altissima</i>                      | Sapotaceae           | 2 | Tree  | Nectar            | Apr, Jun,<br>May Jul             | 60 |
| Turba<br>abeba | <i>Brugmansia<br/>suaveolens</i>                | <i>Solanaceae</i>    | 3 | Shrub | Pollen/nectar     | Almost<br>year<br>round          | 60 |
| Siddessa       | <i>Trifolium spp.</i>                           | Fabaceae             | 3 | Herb  | Pollen/nectar     | Sep, Oct,<br>Jn, Feb,<br>Mar     | 90 |
| Rejii          | <i>Vernonia rueppellii<br/>sch.</i>             | <i>Asteraceae</i>    | 2 | Shrub | Pollen/<br>nectar | Dec, Jan,<br>Feb, Mar            | 60 |
| Sesbania       | <i>Espania sesban</i>                           | Fabaceae             | 2 | Shrub | Pollen            | Year<br>round                    | 15 |
| Sesa           | <i>Albizia gummifera</i>                        | Fabaceae             | 2 | Tree  | Pollen<br>/nectar | Feb, Mar                         | 30 |
| Wandabiy<br>o  | <i>Apodytes dimidiata</i>                       | Icacinaceae          | 2 | Tree  | Pollen/nectar     | Feb, Oct,<br>Mar                 | 30 |
| Bayya          | <i>Olea welwitschi</i>                          | Oleaceae             | 2 | Tree  | Pollen/nectar     | Dec, Feb,<br>Jan                 | 60 |
| Keryo          | <i>Polyscias fulva</i>                          | <i>Araliaceae</i>    | 2 | Tree  | Pollen/nectar     | Apr, Mar,<br>May, Jun            | 30 |
| Mashila        | <i>Sorghum bicolor</i>                          | Poaceae              | 2 | Herb  | Pollen            | Sep, Oct,<br>Mar                 | 30 |
| Kenchib        | <i>Euphorbia tirucalli</i>                      | Euphorbiaceae        | 3 | Herb  | Nectar            | Sep, Oct,<br>Mar                 | 60 |
| Nuge           | <i>Guizotia abyssinica</i>                      | <i>Asteraceae</i>    | 3 | Herb  | Pollen/Nectar     | Sep, Oct                         | 30 |
| Sio            | <i>Rhus sp.</i>                                 | <i>Anacardiaceae</i> | 2 | Tree  | Pollen/nectar     | Aug, Jul,<br>Sep, Oct            | 60 |
| Sombo          | <i>Ekebergia capensis<br/>(E. rueppelliana)</i> | Maliaceae            | 3 | Tree  | Pollen<br>/nectar | Dec, Jan,<br>Mar, Oct,<br>Nov    | 30 |
| Zytune         | <i>Psidium guajava</i>                          | Myrtaceae            | 3 | Tree  | Pollen/nectar     | Jan                              | 7  |
| Giravilla      | <i>Grevillea robusta</i>                        | Proteaceae           | 2 | Tree  | Pollen            | Mar                              | 20 |

|         |                               |               |   |       |                   |                               |    |
|---------|-------------------------------|---------------|---|-------|-------------------|-------------------------------|----|
|         |                               |               |   |       | /nectar           |                               |    |
| Ruze    | <i>Oryza sativa</i>           | Poaceae       | 3 | Herb  | Pollen            | Sep, Oct                      | 30 |
| Sesame  | <i>Sesamum indicum</i>        | Pedaliaceae   | 2 | Herb  | Pollen<br>/nectar | Mar,<br>May, Jun,<br>Sep      | 60 |
| Sole    | <i>Olinia rochetiana</i>      | Penaeaceae    | 2 | Tree  | Pollen/nectar     | Sep, Mar                      | 60 |
| Bedesa  | <i>Syzygium guineens</i>      | Myrtaceae     | 2 | Tree  | Pollen<br>/Nectar | Jan, Feb,<br>Mar, Sep,<br>Aug |    |
| Maget   | <i>Trifolium Spp.</i>         | Papilionaceae | 2 | Tree  | Nectar            | Mar                           |    |
| Korch   | <i>Erythrina abyssinica</i>   | Fabaceae      | 3 | Shrub | Pollen<br>/nectar | Jan, Mar                      | 30 |
| Zembaba | <i>Phoenix reclinata</i>      | Arecaceae     | 3 | Tree  | Pollen            | Mar                           | 15 |
| Derbata | <i>Terminalia laxiflora</i>   | Combretaceae  | 3 | Tree  | Nectar            | Sep, Mar                      | 30 |
| Seho    | <i>Allophylus abyssinicus</i> | Sapindaceae   | 3 | Tree  | Pollen/nectar     | Aug                           | 60 |

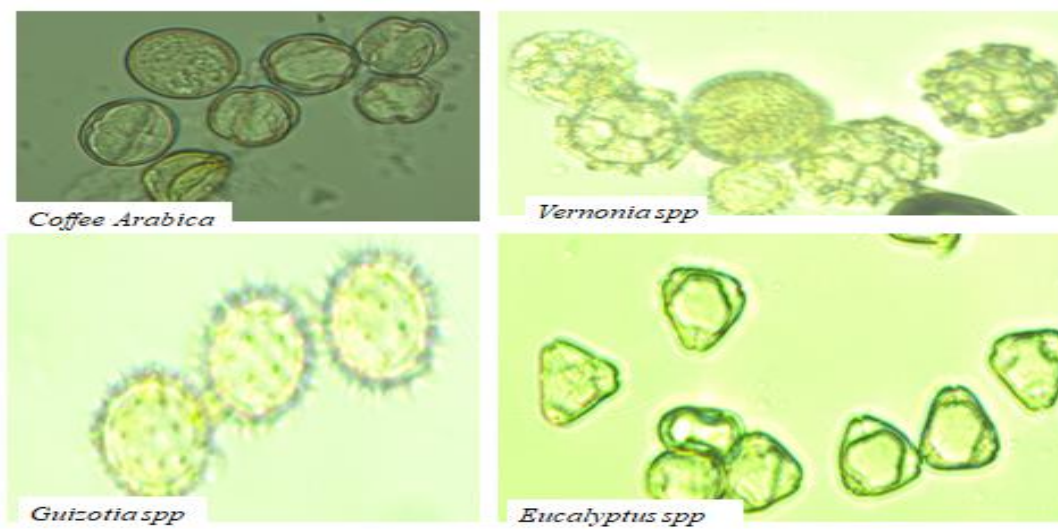
### 3.2. Plants poison to honeybees

In fact, not all honey bee plants are equally important in the lives and honey production of different bee species. The most frequently identified poisonous plant species in the study area, according to current findings, was *Euphorbia cotinifolia* (Key abeba). The result showed that 77.2% of beekeepers were aware of the presence of poisonous plants for honeybees. About 27.8% of the beekeepers have no awareness of the availability of poisonous honeybee plants in their surrounding areas. In the Kaffa zone of southwest Ethiopia, similar findings were reported by Addi (2018), as most of the beekeepers were aware of the presence of poisonous plants for honeybees. *Euphorbia cotinifolia* is a shrub that belongs to the family *Euphorbiaceae*, which bears flowers at different months of the year. This plant is easy to adapt and propagate by cutting, and it also acts as a living fence in the study area. It is mainly found in highland and midland Agro-ecology. The major flowering months of *Euphorbia cotinifolia* species are September to November, February to April, and May to June in the study areas.

### 3.3. Bee pollen analysis

Twenty-four honey bee plant species belonging to ten families were identified from a total of sixty six (66)

pollen samples collected in different districts (Table 2). *Guizotia abyssinica*, *Vernonia spp.*, *coffea arabica* and *eucalyptus spp.* were the major pollen-source for honeybees (Figure 2). On the other hand, *Bersama abyssinica*, *Olea afriicana*, *Syzygium guineense* (Willd.) DC and *Syzygium spp.* were the minor pollen sources for honeybees. The current study found that the highest proportion of pollen grains was collected in October (46.3%) and November (14.6%). This is due to the fact that the majority of plant species bloom following the long rainy season (June to August). The lowest pollen loads, on the other hand, were recorded in July and August because rain impairs honeybees' ability to fly, which in turn lowers their ability to collect pollen. Low temperatures may also impede the growth and flowering of bee plant species, which would reduce pollen production and nectar secretion. The findings are consistent with those of studies carried out in the Kaffa Zone, Southeast Oromia Zone, and central Ethiopia by Bareke and Addi (2020), Lemessa and Addi (2009), respectively, in the collection of pollen grains in October and November. Contrary to the current findings, Wubie *et al.* (2014) reported that the most pollen grains were collected during the main rainy season. This might occur since the flowering period differs with different agro-ecologies.



**Figure 2: Major honeybee flora species identified through pollen analysis**

**Table 2: Bee plant species identified from pollen analysis and pollen harvesting period**

| Scientific/species name            | Family name    | Life forms | Source of food | Harvesting period |
|------------------------------------|----------------|------------|----------------|-------------------|
| <i>Guizotia abyssinica</i>         | Asteraceae     | Herb       | Pollen/nectar  | Sep-Feb           |
| <i>Vernonia amygdalina</i>         | Asteraceae     | Tree       | Pollen/nectar  | Jan-Feb, Apr      |
| <i>Coffea arabica</i>              | Rubiaceae      | Shrub      | Pollen/nectar  | Jan-Apr, Oct-Nov  |
| <i>Euclyptus</i>                   | Myrtaceae      | Tree       | Pollen/nectar  | Dec-Jan, Oct-Nov  |
| <i>Bidens spp</i>                  | Asteraceae     | Herb       | Pollen/nectar  | Oct-Jan           |
| <i>Trifolium spp</i>               | Fabaceae       | Herb       | Pollen/nectar  | Oct, Dec-Jan      |
| <i>Parkinsonia aculeata</i>        | Fabaceae       | Tree       | Pollen/nectar  | Oct, Nov          |
| <i>Rubus spp</i>                   | Rosaceae       | Herb       | Pollen/nectar  | Oct, Dec-Jan      |
| <i>Schefflera abyssinica</i>       | Araliaceae     | herb       | Pollen/nectar  | Oct, Jan          |
| <i>Grass spp</i>                   | not id         | Herb       | Pollen/nectar  | Oct               |
| <i>Plantago lanceolata</i>         | Plantaginaceae | Herb       | Pollen         | Mar               |
| <i>Olea africana</i>               | Oleaceae       | Tree       | Pollen/nectar  | Feb               |
| <i>Bersama abyssinica</i>          | Francoaceae    | Tree       | Pollen/nectar  | Oct               |
| <i>Brassica spp.</i>               | Brassicaceae   | Herb       | Pollen/nectar  | Oct               |
| <i>Calesulpinia</i>                | Francoaceae    | Herb       | Pollen/nectar  | Dec               |
| <i>Calesulpinia decapital</i>      | Francoaceae    | Shrub      | Nectar         | Dec               |
| <i>Combretum molle</i>             | Combretaceae   | Tree       | Nectar         | Oct               |
| <i>Datura arborea</i>              | Solanaceae     | Shrub      | pollen         | Dec               |
| <i>Syzygium guineense (Willd.)</i> | Myrtaceae      | Tree       | Pollen/nectar  | Oct               |
| DC                                 |                |            |                |                   |
| <i>Echioripis spp</i>              | Cactaceae      | -          | pollen         | Dec               |
| <i>Ejursaw spp</i>                 | not id         | -          | pollen         | Feb               |
| <i>Rubuytmaesolonceolata</i>       | not id         | -          | pollen         | Mar               |
| <i>Syzygium spp</i>                | Myrtaceae      | Tree       | pollen         | Oct               |

### 3.4. Honeybee flora species abundance and density

Density and frequency of honeybee floral species found in each quadrant have been summarized in Table 3. During the plant inventory investigation, a total of 98 honeybee plant species belonging to 47 families were identified from 60 main plots and subplots (Table 3). These honeybee plant species were classified as herbs, shrubs, and trees, depending on growth forms of plants. Herbs were the most frequently visited plant growth form, accounting for 49 (50%) of all visits, followed by trees at 26 (26.5%) and shrubs at 23 (23.5%) in sample plots. The Fabaceae (31.9%), Asteraceae (19.1%) and Poaceae (14.8%) families had the most honeybee plant species encountered in quadrant samples. The best predictor of adaptation to the area and local conditions is thought to be the highest frequency of bee plant species. Due to their climate preferences for growth, Boraginaceae, Rubiaceae, Poaceae, and Myrtaceae were the most prevalent families in

sample plots. Herbaceous plant species had a greater density value of plant species per plot than did trees and shrubs. This result is consistent with Wubie *et al.* (2014) and Addi *et al.* (2004), who found that herbaceous plant species had a higher density value per plot than trees and shrubs.

The most common or top ten floral honeybee plant species in highland sample plots/quadrants were *Cynoglossum lanceolatum* Forssk, *Coffea arabica*, *Isoglossa species*, *Snowdenia polystachya* (Fresen.) Pilg, *Pennisetum glaucum* (Linn.) R Br, *Desmodium species*, *Tinospora cordifolia*, *Acanthus eminens* C.B Clarke, *Eucalyptus camaldensis* and *Cyclamen purpurascens* (Table 4). *Cynoglossum lanceolatum* Forssk, *Snowdenia polystachya* (Fresen.) Pilg, *Bidens spp.*, *Sorghum bicolor*, *Isoglossa spp.*, *K. pinnata*, *Erythrina abyssinica*, *Euphorbia tirucalli*, *Vernonia auriculifera* Hiern and *Lippia adoensis* Hochst. ExWalp were the most frequent honeybee plant species in lowland ecology

(Table 4) whereas *Cynoglossum lanceolatum* Forssk, *Eucalyptus camaldensis*, *Colocasia esculenta*, *Snowdenia polystachya* (Fresen.) Pilg, *K. pinnata*,

*Erica spp.*, *Psidium guajava*, *Arum maculatum* and *Guizotia scabra* were the dominant honeybee plant species in midland sample plots (Table 4).

**Table 3: Honeybee plant species density and frequency in sample quadrants**

| Local name       | Scientific name                              | Family         | Plant type | Plant count | Plant density | Plot observed |
|------------------|----------------------------------------------|----------------|------------|-------------|---------------|---------------|
| Ambebesa/sesa    | <i>Albizia gummifera</i>                     | Fabaceae       | Tree       | 44          | 267           | 9             |
| Arenchi          | <i>Pavonia urens</i>                         | Malvaceae      | Herb       | 89          | 8663          | 8             |
| Bahrzaf          | <i>Eucalyptus camaldensis</i>                | Myrtaceae      | Tree       | 704         | 4689          | 8             |
| Banana           | <i>Musa acuminata</i>                        | Musaceae       | Tree       | 82          | 2050          | 3             |
| Bisana           | <i>Croton macrostachyus</i>                  | Euphorbiaceae  | Tree       | 34          | 174           | 12            |
| Buna/Coffee      | <i>Coffea arabica</i>                        | Rubiaceae      | Shrub      | 1739        | 4329          | 30            |
| Castor/gulo      | <i>Ricinus communis</i>                      | Euphorbiaceae  | Shrub      | 47          | 279           | 10            |
| Demekese         | <i>Ocimum lamiifolium</i> Hochst             | Labiatae       | Herb       | 16          | 4782          | 4             |
| Dergu            | <i>Isoglossa species</i>                     | Acanthaceae-N  | Herb       | 464         | 69074         | 50            |
| Emo              | <i>Colocasia esculenta</i>                   | Araceae        | Herb       | 352         | 1996          | 10            |
| Girawa           | <i>Vernonia Spp.</i>                         | Asteraceae     | Tree       | 77          | 261           | 22            |
| Girnche/chifrig  | <i>Sida schimperiana</i> Hochst. ex A. Rich. | Malvaceae      | Herb       | 222         | 2500          | 19            |
| Kello/adey abeba | <i>Bidens spp.</i>                           | Asteraceae     | Herb       | 497         | 37499         | 30            |
| Metene           | <i>Cynoglossum lanceolatum</i> Forssk.       | Boraginaceae   | Herb       | 2514        | 68281         | 110           |
| Muja             | <i>Snowdenia polystachya</i> (Fresen.) Pilg  | Poaceae        | Herb       | 944         | 141250        | 31            |
| Rejii            | <i>Vernonia auriculifera</i> Hiern           | Asteraceae     | Shrub      | 133         | 762           | 13            |
| Susbania         | <i>esbania sesban</i>                        | Fabaceae       | Shrub      | 72          | 679           | 9             |
| Tufo             | <i>Guizotia scabra</i>                       | Asteraceae     | Herb       | 60          | 67944         | 25            |
| Ulmaye/limich    | <i>Clausena anisata</i> (Willd.) Benth       | Rutaceae       | Shrub      | 22          | 244           | 7             |
| Abayi/qalawa     | <i>Maesallanceolataforssk</i>                | Myrsinaceae    | Tree       | 14          | 200           | 4             |
| Arebe duberti    | <i>Carduus schimperi</i> Sch. Bip            | Asteraceae     | Herb       | 58          | 42916         | 7             |
| Birbira          | <i>Milletia ferruginea</i>                   | Fabaceae       | Tree       | 7           | 113           | 3             |
| Bosoke           | <i>Kalanchoe sp.</i>                         | Crassulaceae   | Herb       | 95          | 52000         | 9             |
| Chat             | <i>K. pinnata</i>                            | Crassulaceae   | Shrub      | 320         | 4001          | 4             |
| Cheda dima       | <i>Euphorbia tirucalli</i>                   | Euphorbiaceae  | Shrub      | 142         | 1354          | 5             |
| Desmodium        | <i>Desmodium species</i>                     | Fabaceae       | Herb       | 209         | 29583         | 20            |
| Endod            | <i>Phytolacca dodecandra</i>                 | Phytolaccaceae | Herb       | 29          | 46250         | 5             |
| Gomenzer         | <i>Brassica Carinta</i> A.br.                | Brassicaceae   | Herb       | 15          | 37500         | 2             |
| Haallaal         | <i>Urera hypselodenron</i> (A.Rich) wedd     | Urticaceae     | Shrub      | 44          | 83750         | 4             |
| Kontir           | <i>Caesalpinia decapetala</i>                | Fabaceae       | Shrub      | 65          | 1116          | 4             |
| Korch            | <i>Erythrina abyssinica</i>                  | Fabaceae       | Tree       | 143         | 1131          | 6             |
| Mango            | <i>Mangifera indica</i> L.                   | Anacardiaceae  | Tree       | 2           | 50            | 2             |
| Qortobi          | <i>Plantago lanceolata</i> L.                | Plantaginaceae | Herb       | 42          | 31875         | 6             |
| Sanaa maki       | <i>Senna didymobotrya</i> (Fresen.) Irwin    | Fabaceae       | Shrub      | 8           | 200           | 2             |

|                     |                                                                            |                       |       |     |        |   |
|---------------------|----------------------------------------------------------------------------|-----------------------|-------|-----|--------|---|
|                     | <i>and Barneby</i>                                                         |                       |       |     |        |   |
| Sindedo             | <i>Pennisetum thunbergii</i> Kunth                                         | Poaceae               | Herb  | 18  | 45000  | 2 |
| Sokoro              | <i>Acanthus eminens</i> C.B Clarke                                         | Acanthaceae           | Herb  | 97  | 681    | 5 |
| Ulaga               | <i>Ehretia cymosa</i> Thonn.                                               | Boraginaceae          | Tree  | 5   | 58     | 4 |
| Wanza               | <i>Cordia africana</i>                                                     | Boraginaceae          | Tree  | 17  | 148    | 9 |
| Zeytuna             | <i>Psidium guajava</i>                                                     | Myrtaceae             | Tree  | 145 | 925    | 7 |
| Adenguare           | <i>Phaseolus vulgaris</i> L                                                | Fabaceae              | Herb  | 3   | 7500   | 1 |
| Agam                | <i>Carissa spinarum</i>                                                    | Apocynaceae           | Shrub | 4   | 100    | 1 |
| Alenge              | <i>Arum maculatum</i>                                                      | Araliaceae            | Herb  | 121 | 302500 | 1 |
| Allala              | <i>Allamanda</i> spp.                                                      | Apocynaceae.          | Herb  | 13  | 16250  | 2 |
| Ananno              | <i>Periploca linearifolia</i> Quart.-Dill.<br>and A. Rich.                 | Asclepiadaceae        | Shrub | 30  | 375    | 2 |
| Apple               | <i>Malus pumila</i>                                                        | Rosaceae              | Shrub | 2   | 50     | 1 |
| Asangira            | <i>Datura stramonium</i> L.                                                | Solanaceae            | Herb  | 9   | 11250  | 2 |
| Askira              | <i>Milletia ferruginea</i> (Hochst.) Bak                                   | Fabaceae              | Tree  | 15  | 63     | 6 |
| Avocado             | <i>Persea Americana</i>                                                    | Lauraceae             | Tree  | 5   | 25     | 5 |
| Baddessa/Doki<br>ma | <i>Syzygium guineens</i>                                                   | Myrtaceae             | Tree  | 2   | 50     | 1 |
| Besobila /kefo      | <i>Salvia nilotica/Ocimum basilicum</i>                                    | Lamiaceae             | Herb  | 6   | 15000  | 1 |
| Boqqo               | <i>Bersma abyssinica</i>                                                   | Melanthaceae          | Tree  | 1   | 25     | 1 |
| Bosoka              | <i>Eriobotrya japonica</i>                                                 | Rosaceae              | Tree  | 1   | 25     | 1 |
| Butte               | <i>Ammocharis tinneana</i> (Kotschy and<br>Peyr.) Milne-Redh. And Schweick | Amoryllidaceae        | Herb  | 8   | 10000  | 2 |
| Cassava             | <i>Euphorbiaceae</i>                                                       | Manihot esculent<br>a | Shrub | 124 | 1550   | 2 |
| Cheka               | <i>Calpurnia aurea</i> (Aiton) Benth                                       | Fabaceae              | Tree  | 4   | 100    | 1 |
| Chibo               | <i>Vernonia leopoldi</i>                                                   | Asteraceae            | Shrub | 18  | 450    | 1 |
| Damisa              | <i>Centella asiatica</i>                                                   | Apiaceae              | Herb  | 7   | 17500  | 1 |
| Dhumuga             | <i>Justicascimperiana</i> (Hochst.ex.Nee<br>s) T. Andres                   | Acanthaceae           | Shrub | 16  | 400    | 1 |
| Potato              | <i>Solanum tuberosum</i>                                                   | Solanaceae            | Herb  | 20  | 16666  | 3 |
| Dobbi/sama          | <i>Urtica simensis</i> steud.                                              | Urticaceae            | Herb  | 34  | 42 500 | 2 |
| Enselal             | <i>Foeniculum vulgare</i> Mill/ <i>Anethum</i><br><i>graveolens</i> L.     | Apiaceae              | Herb  | 2   | 5000   | 1 |
| Enset               | <i>E. ventricosum</i>                                                      | Musaceae              | Shrub | 33  | 413    | 2 |
| Girar               | <i>Acacia</i> spp.                                                         | Fabaceae              | Tree  | 3   | 75     | 1 |
| Gomera              | <i>Capparis tomentosa</i> Lam.                                             | Capparidaceae         | Shrub | 1   | 25     | 1 |
| Guriyo              | <i>Tinospora cordifolia</i>                                                | Menispermaceae        | Herb  | 141 | 88125  | 4 |
| Harbu/shola         | <i>Ficus sur</i> Forssk.                                                   | Moraceae              | Tree  | 2   | 50     | 1 |
| Hidda bofa          | <i>Momordica foetida</i> (Ao) Schumach                                     | Cucurbitaceae         | Herb  | 1   | 25     | 1 |
| Hiddaa lafaa        | <i>Dregea schimperii</i> (Decne.) Bullock                                  | Asclepiadaceae        | Herb  | 8   | 6666   | 3 |
| Hiddi               | <i>Solanum incanum</i> L.                                                  | Solanaceae            | Shrub | 5   | 4166   | 3 |
| Jajjab              | <i>Setaria megaphylla</i> (Steud.) Th.<br><i>Dur. and Schinz.</i>          | Poaceae               | Herb  | 26  | 32500  | 2 |

|                 |                                                        |                  |       |     |         |   |
|-----------------|--------------------------------------------------------|------------------|-------|-----|---------|---|
| Karaba          | <i>Sida rhombifolia</i> L.                             | Malvaceae        | Herb  | 26  | 7222    | 9 |
| Kase            | <i>Lippia adoensis</i> Hochst. ex Walp                 | Verbenaceae      | Herb  | 86  | 107,500 | 2 |
| Kishkishe       | <i>Senna septemtrionalis</i> (Viv.) Irwin and Barneby  | Fabaceae         | Herb  | 7   | 17500   | 1 |
| Kunche          | <i>Chenopodium album</i>                               | Amaranthaceae    | Herb  | 21  | 17500   | 1 |
| Kusaye          | <i>Lantana trifolia</i> L.                             | Verbenaceae      | Shrub | 2   | 50      | 1 |
| Lochisa         | <i>Bersama abyssinica</i>                              | Melianthaceae    | Herb  | 35  | 875     | 1 |
| Mixoo/dido/didu | <i>Galiniera saxifrage</i> (Hochst.) Birdson           | Rubiaceae        | Shrub | 2   | 50      | 1 |
| Mulberry        | <i>Morus alba</i>                                      | Moraceae         | Shrub | 3   | 75      | 1 |
| Nanaye          | <i>Pennisetum glaucum</i> (Linn.) R Br                 | Poaceae          | Herb  | 196 | 61 250  | 8 |
| Pepper /berberi | <i>Capsicum annum</i> L.                               | Solanaceae       | Herb  | 18  | 4500    | 1 |
| Qalawa/qaawa a  | <i>Grewia mollis</i> Juss                              | Tiliaceae        | Tree  | 1   | 25      | 1 |
| Qumudu          | <i>Nymphoides indica</i>                               | Menyanthaceae    | Herb  | 41  | 34166   | 2 |
| Raafu           | <i>Kleinia grantii</i> (Oliv. & Heiern) Hook.f.        | Asteraceae       | Herb  | 17  | 21250   | 3 |
| Ret/ Alovera    | <i>Aloe debrana</i> Christian (syn.A.berhana Reynolds) | Xanthorrhoeaceae | Herb  | 17  | 42500   | 1 |
| Rhodus          | <i>Chloris gayana</i>                                  | Poaceae          | Herb  | 1   | 2500    | 1 |
| Shajara         | <i>Cyclamen purpurascens</i>                           | Primulaceae      | Herb  | 80  | 33333   | 6 |
| Shenkora        | <i>Saccharum officinarum</i> L.                        | Poaceae          | Shrub | 6   | 150     | 1 |
| Shultee         | <i>Rumex nepalensis</i>                                | Polygonaceae     | Herb  | 6   | 15000   | 1 |
| Siddisa/wazma   | <i>Trifolium rueppellianum</i> Fresen.                 | Fabaceae         | Herb  | 39  | 97500   | 1 |
| Siglu           | <i>Fagaropsis angolensis</i> (Engl.) Dale              | Rutaceae         | Tree  | 6   | 150     | 1 |
| Sorghum         | <i>Sorghum bicolor</i>                                 | Poaceae          | Herb  | 135 | 1688    | 2 |
| Suufi/suff      | <i>Carthamus tinctorius</i>                            | Asteraceae       | Herb  | 56  | 46666   | 3 |
| Togo            | <i>Dielliptera acanthaceae</i> C.B.el                  | Acanthaceae      | Tree  | 10  | 25000   | 1 |
| Tsid            | <i>Juniperus procera</i> Hochst. ex Endl               | Cupressaceae     | Tree  | 40  | 1000    | 1 |
| Uregessa        | <i>Clausena anisata</i> Benth                          | Rutaceae         | Tree  | 11  | 138     | 2 |
| Vetch           | <i>Vicia sativa</i>                                    | Fabaceae         | Herb  | 6   | 15000   | 1 |
| Welensu         | <i>Erythrina brucei</i>                                | Fabaceae         | Tree  | 41  | 513     | 2 |
| Yeriwo garo     | <i>Solanecio</i> sp.                                   | Asteraceae       | Herb  | 1   | 25      | 1 |

Table 4: Honeybee plant species density and their frequency of occurrence

| Scientific name                 | Family name   | Highland |         |      | Lowland |         |      | Midland |         |      |      |
|---------------------------------|---------------|----------|---------|------|---------|---------|------|---------|---------|------|------|
|                                 |               | Count    | Density | Plot | Count   | Density | Plot | Count   | Density | Plot | Type |
| <i>Vernonia Spp.</i>            | Asteraceae    | 48       | 100     | 12   | 10      | 42      | 6    | 19      | 119     | 4    | T    |
| <i>Coffea arabica</i>           | Rubiaceae     | 425      | 1181    | 9    | 604     | 1373    | 11   | 710     | 1775    | 10   | T    |
| <i>Croton macrostachyus</i>     | Euphorbiaceae | 20       | 84      | 6    | 1       | 25      | 1    | 13      | 65      | 5    | T    |
| <i>Vernonia rueppellii</i> sch. | Asteraceae    | 27       | 135     | 5    | 92      |         | 5    | 14      | 167     | 3    | S    |

|                                                                                             |                  |     |         |     |     |        |    |     |       |    |   |
|---------------------------------------------------------------------------------------------|------------------|-----|---------|-----|-----|--------|----|-----|-------|----|---|
| <i>Albizia gummifera</i>                                                                    | Fabaceae         | 8   | 67      | 3   | 1   | 25     | 1  | 35  | 175   | 5  | T |
| <i>Eucalyptus camaldensis</i>                                                               | Myrtaceae        | 112 | 933     | 3   | 3   | 75     | 1  | 589 | 3681  | 4  | T |
| <i>Malus pumila</i>                                                                         | Rosaceae         | 2   | 50      | 1   | -   | -      | -  | -   | -     | -  | S |
| <i>Acacia spp.</i>                                                                          | Fabaceae         | 3   | 75      | 1   | -   | -      | -  | -   | -     | -  | T |
| <i>Acanthus eminens</i><br><i>C.B Clarke</i>                                                | Acanthaceae      | 93  | 581     | 4   | -   | -      | -  | 4   | 100   | 1  | H |
| <i>Allamanda spp.</i>                                                                       | Apocynaceae      | -   | -       | -   | 13  | 16250  | 2  | -   | -     | -  | H |
| <i>Aloe debrana Christi</i><br><i>an (syn.A.berhana</i><br><i>Reynolds)</i>                 | Xanthorrhoeaceae | -   | -       | -   | -   | -      | -  | 17  | 42500 | 1  | H |
| <i>Ammocharis tinneana</i><br><i>(Kotschy and Peyr.) Milne-</i><br><i>Redh.and Schweick</i> | Amaryllidaceae   | 8   | 10000   | 2   | -   | -      | -  | -   | -     | -  | H |
| <i>Arum maculatum</i>                                                                       | Araliaceae       | -   | -       | -   | -   | -      | -  | 121 | 30250 | 1  | H |
| <i>Bersama abyssinica</i>                                                                   | Melanthaceae     |     | 36      | 900 | 2   | -      | -  | 35  | 875   | 1  | T |
| <i>Bidens spp.</i>                                                                          | Asteraceae       | 32  | 13333   | 6   | 407 | 56 527 | 18 | 58  | 24166 | 6  | H |
| <i>Brassica Carinta</i><br><i>A.br.</i>                                                     | Brassicaceae     | 11  | 27500   | 1   | --  | -      | -  | 4   | 10000 | 1  | H |
| <i>Caesalpinia decapetala</i>                                                               | Fabaceae         | 23  | 192     | 3   | -   | -      | -  | 42  | 924   | 1  | S |
| <i>Calpurnia aurea</i><br><i>(Aiton) Benth</i>                                              | Fabaceae         | -   | -       | -   | -   | -      | -  | 4   | 100   | 1  | T |
| <i>Capparis tomentosa</i> Lam.                                                              | Capparidaceae    | -   | -       | -   | 1   | 25     | 1  | -   | -     | -  | S |
| <i>Capsicum annum L.</i>                                                                    | Solanaceae       | -   | -       | --  | -   | -      | -  | 18  | 4500  | 1  | H |
| <i>Carduus schimperi</i><br><i>Sch. Bip</i>                                                 | Asteraceae       | 26  | 16250   | 4   | -   | -      | -  | 32  | 26666 | 3  | H |
| <i>Carissa spinarum</i>                                                                     | Apocynaceae      | -   | -       | -   | -   | -      | -  | 4   | 100   | 1  | S |
| <i>Carthamus tinctorius</i>                                                                 | Asteraceae       | -   | -       | -   | 56  | 46666  | 3  | -   | -     | -  | H |
| <i>Centella asiatica</i>                                                                    | Apiaceae         | 7   | 17500   | 1   | -   | -      | -  | -   | -     | -  | H |
| <i>Chenopodium album</i>                                                                    | Amaranthaceae    | 21  | 17500   | 3   | -   | -      | -  | -   | -     | -  | H |
| <i>Chloris gayana</i>                                                                       | Poaceae          | 1   | 2500    | 1   | -   | -      | -  | -   | -     | -  | H |
| <i>Clausena anisata</i><br><i>(Wild.) Benth.</i>                                            | Rutaceae         | 2   | 50      | 1   | 9   | 56     | 4  | 22  | 276   | 4  | S |
| <i>Colocasia esculenta</i>                                                                  | Araceae          | -   | -       | -   | 54  | 675    | 2  | 286 | 1021  | 7  | H |
| <i>Cordia africana</i>                                                                      | Boraginaceae     | -   | -       | -   | 8   | 67     | 3  | 5   | 31    | 4  | T |
| <i>Cyclamen purpurascens</i>                                                                | Primulaceae      | 80  | 33333   | 6   | -   | -      | -  | -   | -     | -  | H |
| <i>Cynoglossum lanceolatum</i> Forssk.                                                      | Boraginaceae     | 997 | 51, 927 | 48  | 643 | 53 583 | 30 | 874 | 68281 | 32 | H |
| <i>Datura stramonium</i><br><i>L.</i>                                                       | Solanaceae       | -   | -       | -   | 9   | 11250  | 2  | -   | -     | -  | H |
| <i>Desmodiumspecies</i>                                                                     | Fabaceae         | 142 | 29583   | 12  | -   | -      | -  | 104 | 21862 | 9  | H |
| <i>Dieliptera acanthaceae</i><br><i>C.B.el</i>                                              | Acanthaceae      | -   | -       | -   | 10  | 25000  | 1  | -   | -     | -  | T |
| <i>Dracaena afromontana</i>                                                                 | Dracaenaceae     | 12  | 300     | 1   | -   | -      | -  | -   | -     | -  | T |
| <i>Dregea schimperi</i> (D<br><i>ecne.) Bullock</i>                                         | Asclepiadaceae   | 8   | 6666    | 3   | -   | -      | -  | -   | -     | -  | H |
| <i>E. ventricosum</i>                                                                       | Musaceae         | -   | -       | -   | -   | -      | -  | 33  | 413   | 2  | S |
| <i>Ehretia cymosa</i><br><i>Thonn.</i>                                                      | Boraginaceae     | 4   | 33      | 3   | 1   | 25     | 1  | -   | -     | -  | T |
| <i>Eluesine folicofolia</i>                                                                 | Poaceae          | 4   | 10000   | 1   |     |        |    |     |       |    | H |
| <i>Erica genus</i>                                                                          | Ericaceae        | 1   | 2500    | 1   | -   | -      | -  | 166 | 69166 | 6  | H |
| <i>Eriobotrya japonica</i>                                                                  | Rosaceae         | -   | -       | -   | 1   | 25     | 1  | -   | -     | -  | T |
| <i>Erythrina abyssinica</i>                                                                 | Fabaceae         | 38  | 475     | 2   | 105 | 656    | 4  | -   | -     | -  | T |
| <i>Erythrina brucei</i>                                                                     | Fabaceae         | -   | -       | -   | -   | -      | -  | 41  | 513   | 2  | T |

|                                                               |                   |     |        |    |     |        |    |      |       |    |   |
|---------------------------------------------------------------|-------------------|-----|--------|----|-----|--------|----|------|-------|----|---|
| <i>esbania sesban</i>                                         | Fabaceae          | 28  | 116    | 6  | 1   | 25     | 1  | 43   | 538   | 2  | S |
| <i>Euphorbia tirucalli</i>                                    | Euphorbiaceae     | 41  | 512    | 2  | 101 | 842    | 3  | -    | -     | -  | S |
| <i>Euphorbiaceae</i>                                          | Manihot esculenta | -   | -      | -  | -   | -      | -  | 124  | 1550  | 2  | S |
| <i>Fagaropsis angolensis</i> (Engl.) Dale                     | Rutaceae          | -   | -      | -  | -   | -      | -  | 6    | 150   | 1  | T |
| <i>Ficus sur</i> Forssk.                                      | Moraceae          | 2   | 50     | 1  | -   | -      | -  | -    | -     | -  | T |
| <i>Foeniculum vulgare</i> Mill./ <i>Anethum graveolens</i> L. | Apiaceae          | -   | -      | -  | -   | -      | -  | 2    | 5000  | 1  | H |
| <i>Galiniera saxifrage</i> (Hochst.) Birdson                  | Rubiaceae         | 2   | 50     | 1  | -   | -      | -  | -    | -     | -  | S |
| <i>Grewia mollis</i> Juss                                     | Tiliaceae         | 1   | 25     | 1  | -   | -      | -  | -    | -     | -  | T |
| <i>Guizotia scabra</i>                                        | Asteraceae        | 4   | 10000  | 1  | 56  | 28000  | 5  | 10 2 | 29944 | 19 | H |
| <i>Isoglossa species</i>                                      | Acanthaceae       | 266 | 24629  | 27 | 120 | 30000  | 10 | 78   | 15000 | 13 | H |
| <i>Juniperus procera</i> Hochst. ex Endl                      | Cupressaceae      | -   | -      | -  | -   | -      | -  | 40   | 1000  | 1  | T |
| <i>Justicaschimperiana</i> (Hochst. ex. Nees) T. Andres       | Acanthaceae       | -   | -      | -  | -   | -      | -  | 16   | 400   | 1  | S |
| <i>K. pinnata</i>                                             | Crassulaceae      | -   | -      | -  | 109 | 1363   | 2  | 211  | 2638  | 2  | S |
| <i>Kalanchoe sp.</i>                                          | Crassulaceae      | 54  | 27000  | 5  | 41  | 25000  | 4  | -    | -     | -  | H |
| <i>Kleinia grantii</i>                                        | Asteraceae        | -   | -      | -  | -   | -      | -  | 17   | 21250 | 2  | H |
| <i>Lantana trifolia</i>                                       | Verbenaceae       | -   | -      | -  | -   | -      | -  | 2    | 50    | 1  | S |
| <i>Lippia adoensis</i> Hochst. Ex Walp                        | Verbenaceae       | -   | -      | -  | 86  | 107500 | 2  | -    | -     | -  | H |
| <i>Maesallanceolata</i> forssk                                | Myrsinaceae       | 9   | 75     | 3  | -   | -      | -  | 5    | 125   | 1  | T |
| <i>Mangifera indica</i>                                       | Anacardiaceae     | -   | -      | -  | 1   | 25     | 1  | 1    | 25    | 1  | T |
| <i>Millettia ferruginea</i> (Hochst.) Bak                     | Fabaceae          | 5   | 63     | 2  | 15  | 63     | 6  | 2    | 50    | 1  | T |
| <i>Momordica foetida</i> (Ao) Schumacher                      | Cucurbitaceae     | -   | -      | -  | 1   | 25     | 1  | -    | -     | -  | T |
| <i>Morus alba</i>                                             | Moraceae          | -   | -      | -  | -   | -      | -  | 3    | 75    | 1  | S |
| <i>Musa acuminata</i>                                         | Musaceae          | 32  | 800    | 1  | 13  | 325    | 1  | -    | -     | -  | T |
| <i>Nymphoides indica</i>                                      | Menyanthaceae     | -   | -      | -  | -   | -      | -  | 41   | 34166 | 3  | H |
| <i>Ocimum lamiifolium</i> Hochst                              | Labiatae          | -   | -      | -  | 12  | 11325  | 3  | 4    | 100   | 1  | H |
| <i>Pavonia urens</i>                                          | Malvaceae         | 41  | 5625   | 4  | 1   | 2500   | 1  | 47   | 538   | 3  | H |
| <i>Pennisetum glaucum</i> (Linn.) R Br                        | Poaceae           | 196 | 61 250 | 8  | -   | -      | -  | -    | -     | -  | H |
| <i>Pennisetum thunbergii</i> Kunth                            | Poaceae           | -   | -      | -  | -   | -      | -  | 14   | 35000 | 1  | H |
| <i>Periploca linearifolia</i> Quart. Dill. & A. Rich.         | Asclepiadaceae    | -   | -      | -  | -   | -      | -  | 30   | 37875 | 2  | S |
| <i>Persea Americana</i>                                       | Lauraceae         | -   | -      | -  | -   | -      | -  | 5    | 25    | 5  | T |
| <i>Phaseolus vulgaris</i> L                                   | Fabaceae          | -   | -      | -  | -   | -      | -  | 3    | 7500  | 1  | H |
| <i>Phytolacca dodecandra</i>                                  | Phytolaccaceae    | 15  | 37500  | 1  | 14  | 8750   | 4  | -    | -     | -  | H |
| <i>Plantago lanceolata</i> L.                                 | Plantaginaceae    | -   | -      | -  | 9   | 11250  | 2  | 33   | 20625 | 4  | H |
| <i>Psidium guajava</i>                                        | Myrtaceae         | -   | -      | -  | 9   | 75     | 3  | 136  | 850   | 4  | T |
| <i>Ricinus communis</i>                                       | Euphorbiaceae     | 4   | 50     | 2  | 6   | 75     | 2  | 37   | 154   | 6  | S |
| <i>Rumex nepalensis</i>                                       | Polygonaceae      | 6   | 15000  | 1  | -   | -      | -  | -    | -     | -  | H |
| <i>Saccharum officinarum</i> L.                               | Poaceae           | -   | -      | -  | -   | -      | -  | 6    | 150   | 1  | S |
| <i>Salvia nilotica</i> /Ocimum basilicum                      | Lamiaceae         | -   | -      | -  | -   | -      | -  | 6    | 15000 | 1  | H |

|                                                         |                |     |       |    |     |        |    |     |        |   |   |
|---------------------------------------------------------|----------------|-----|-------|----|-----|--------|----|-----|--------|---|---|
| <i>Senna septemtrionalis</i> (Viv.) Irwin and Barneby   | Fabaceae       | -   | -     | -  | 7   | 17500  | 1  | -   | -      | - | H |
| <i>Senna didymobotrya</i> (Fresen.) Irwin and Barneby   | Fabaceae       | 6   | 150   | 1  | 2   | 50     | 1  | -   | -      | - | S |
| <i>Setaria megaphylla</i> (Steud.) Th. Dur. and Schinz. | Poaceae        | -   | -     | -  | 26  | 32500  | 2  | -   | -      | - | H |
| <i>Sida schimperiana</i> Hochst . Ex A. Rich.           | Malvaceae      | -   | -     | -  | 55  | 11 458 | 12 | -   | -      | - | H |
| <i>Sida rhombifolia</i> L.                              | Malvaceae      | 26  | 7222  | 9  | -   | -      | -  | -   | -      | - | H |
| <i>Snowdenia polystachya</i> (Fresen.) Pilg             | Poaceae        | 200 | 5000  | 10 | 526 | 77 352 | 17 | 218 | 136250 | 4 | H |
| <i>Solanecio</i> sp.                                    | Asteraceae     | -   | -     | -  | -   | -      | -  | 1   | 25     | 1 | H |
| <i>Solanum incanum</i>                                  | Solanaceae     | -   | -     | -  | 5   | 4166   | 3  | -   | -      | - | H |
| <i>Solanum tuberosum</i>                                | Solanaceae     | -   | -     | -  | -   | -      | -  | 20  | 16666  | 3 | H |
| <i>Sorghum bicolor</i>                                  | Poaceae        | -   | -     | -  | 135 | 1688   | 2  | -   | -      | - | H |
| <i>Syzygium guineens</i>                                | Myrtaceae      | -   | -     | -  | -   | -      | -  | 2   | 50     | 1 | T |
| <i>Tinospora cordifolia</i>                             | Menispermaceae | 141 | 88125 | 4  | -   | -      | -  | -   | -      | - | H |
| <i>Trifolium rueppellianum</i> Fresen.                  | Fabaceae       | -   | -     | -  | 39  | 97500  | 1  | -   | -      | - | H |
| <i>Urera hypselodenron</i> (A. Rich)                    | Urticaceae     | 1   | 25    | 1  | 11  | 138    | 2  | -   | -      | - | S |
| <i>Urtica simensis</i> steud.                           | Urticaceae     | -   | -     | -  | -   | -      | -  | 34  | 42500  | 2 | H |
| <i>Vernonia auriculifera</i> Hiern                      | Asteraceae     | -   | -     | -  | 92  | 460    | 5  | -   | -      | - | S |
| <i>Vernonia leopoldi</i>                                | Asteraceae     | 18  | 450   | 1  | -   | -      | -  | -   | -      | - | S |
| <i>Vicia sativa</i>                                     | Fabaceae       | 6   | 15000 | 1  | -   | -      | -  | -   | -      | - | H |

**Note:** T = Tree; S = Shrub; H = Herb; Density is per ha

### 3.5. Diversity and composition of honeybee forages

Herbs, trees, shrubs, and different species of grass are among the plant growth forms that honeybees use as forages. Herbs were the most dominant bee flora, accounting for 62 (44%) of a total of 141 honeybee plant species, followed by trees at 48 (34%) and shrubs at 31 (22%), respectively (Figure 3). This finding is consistent with previous findings, as herbs are the most dominant bee flora plants in Kaffa Zone, Gera district (Addi, 2018; Bareke and Addi, 2019; Bareke and Addi, 2020), North Shewa zone of Amhara region (Abebe and Temam, 2016), and Tigray region (Teklay, 2011) The predominant of herbs are due to disturbance and existence of gaps in

the forest (Bareke and Addi, 2019). The families with the highest number of species were Fabaceae 18(12.8%), Asteraceae 11 (7.8%), Poaceae 9 (6.4%), Solanaceae 6(4.3%), Acanthaceae 4(2.8%) and Euphorbaceae 4 (2.8%) in the study area (Figure 4). The Fabaceae and Asteraceae families have the highest number of species. The study conducted in the Gera forests also revealed that the Fabaceae family had the dominant species composition, followed by Asteraceae, which is consistent with current findings (Mulgeta *et al.*, 2015). This study was focused on the overall floristic composition of Gera forest rather than identifying specific species of honeybee flora. The present findings, on the other

hand, contradict previous reports, as Asteraceae family has the highest species composition in Kaffa Zone and Gera forests (Addi, 2018; Bareke and Addi, 2019; Bareke and Addi, 2020). Not all Fabaceae species are plants that attract honeybees. As a result, it is not a dominating honeybee plant family in different study sites. However, the Asteraceae family is the most common bee foraging family in many forest areas (Bareke and Addi, 2020). The Asteraceae family's dominance may be ascribed to the ability of certain species to produce honey (Bareke and Addi, 2019).

Among a total of one hundred forty-one honeybee plant species, one hundred fifteen (81.6%) were both sources of pollen and nectar, whereas fifteen (10.6%) were pollen sources and the remaining eleven (7.8%)

were nectar source plant species. Forage sources (pollen/nectar) were confirmed with published and pollen specimen accounts. The present study revealed that bee plant species were the main source of both pollen and nectar rather than a single source of nectar or pollen. The findings also demonstrated that species of pollen-producing plants are more numerous than nectar-producing ones. This finding is aligned with those reported by Bareke and Addi (2020). Nectar and pollen are used for honey production and colony multiplication, respectively. Not all honeybee plants are similarly significant to bees and honey production. Only 16% of flowering plants are the origins of the majority of the honey in the world (Crane, 1990). This shows that there are only a handful of significant honey source plants in each geographical area.

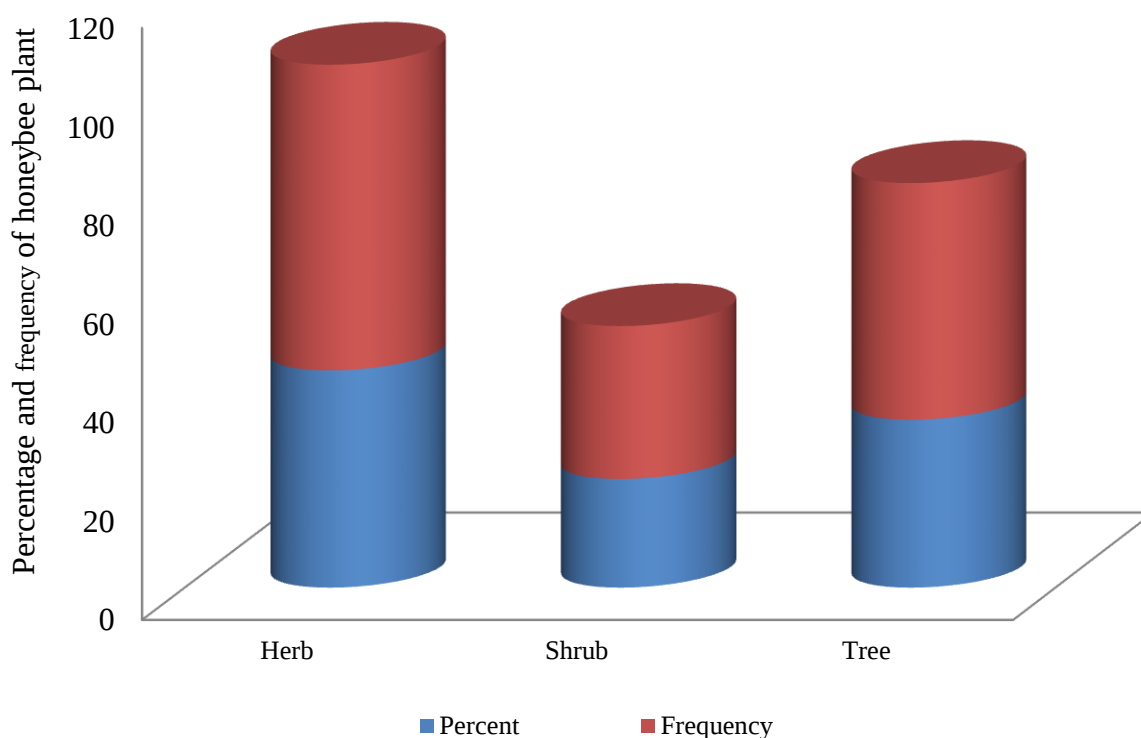
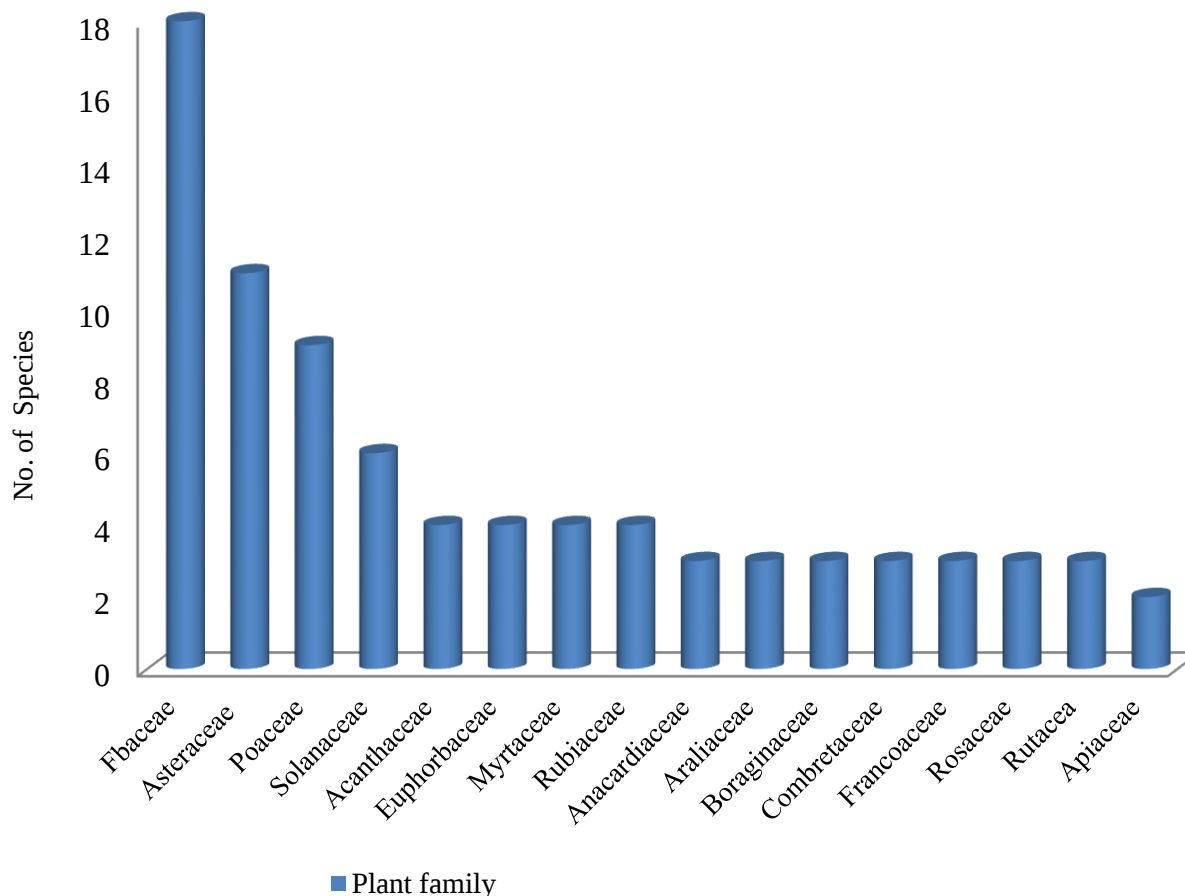


Figure 3: Growth forms of bee plant species



**Figure 4: Number of species within each family**

### 3.6. Species diversity, richness and evenness of honeybee plant species

The Shannon diversity index analysis revealed that the midland Agro-ecosystem had the most species diversity in sample plots compared to the highland and lowland Agro-ecosystem. The species diversity in highland and lowland ecosystems was the same (Table 5). The species richness varied by ecosystem. Midland ecology had comparatively the most species (59 species in 34 families), followed by highland (50 species in 29 families) and lowland (47 species in 26 families) ecologies. The midland Agro-ecology moderately has the most species diversity, richness, and evenness in sample plots compared to the highland and lowland agro-ecologies. These findings, however, contradicted the findings of Wubie *et al.* (2014), who indicated that highland agro-ecology had more species diversity and richness than midland and

lowland ecological systems. This variation could be attributed to differences in the geographical location, soil type, and climatic conditions of the study areas. Nevertheless, this doesn't mean that areas with a higher quantity of plant diversity are good for honey production since the productivity of the beekeeping sector is reliant on the abundance and density of plants. The Shannon diversity index and evenness were found to be 2.8 and 0.6, respectively. The higher the evenness and Shannon index values, the more even the species and the diversity in the ecology or plots. The current finding further supported the notion that the species diversity and evenness in sample plots fell within acceptable bounds of 1.5 and 3.5 (Kent and Coker, 1992).

**Table 5: Shannon diversity indices of honeybee plant species**

| Agro ecology | Richness | Shannon | H'max (lns) | Shannon Evenness =H'/lnS |
|--------------|----------|---------|-------------|--------------------------|
| Highland     | 50       | 2.7     | 3.9         | 0.6                      |
| Lowland      | 47       | 2.6     | 3.8         | 0.6                      |
| Midland      | 59       | 3       | 4.1         | 0.7                      |

#### 4. Conclusion and Recommendation

The study area has a diverse range of floral species, which may aid in the production of honey for national and international markets. A total 141 pollen and/or nectar source honeybee plant species belonging to sixty-two families were identified in the study area. The Fabaceae and Asteraceae families have the highest number of species. Herbaceous plant species had a greater density value of plant species per plot than did trees and shrubs. There are two main flowering periods of bee plants and two main harvesting periods in the study area. The identification of bee plant species as well as their floral calendar helps the beekeepers in planning various beekeeping activities. Therefore, beekeepers should follow a floral calendar of honeybee plants to exploit the potential of the area for honey production.

#### Funding statement

This research received financial and material supports from Ethiopian Institute of Agriculture Research and Holeta Bee Research Center, respectively.

#### Data availability statement

Data will be made available on request.

#### Declaration of interest's statement

The authors declare no competing interests.

#### References

- Abebe, D. and Temam, T.D. (2016). Floristic Composition and Structure of Zerat Forest, Central Ethiopia. *American Scientific Research Journal for Engineering Technology, and Sciences*, 18(1): 326–342.
- Addi, A. (2018). The Ecology, Carbon Stock, Bee Forage Diversity in a Moist Afromontane Forest of Gesha and Sayilem Districts in Kaffa Zone, South West Ethiopia. *Biomass Chemical Engineering*, 3(2): 1–272.
- Admasu, A., Debissa, L. and Amssalu, B. (2004). Botanical inventory and phenology of bee plants in rift valley regions of East Showa Zone: Proceedings of the 13<sup>th</sup> annual conference of the Ethiopian Society of Animal Production (ESAP), 25-27 August, 2004, Addis Ababa, Ethiopia. Pp. 31-40.
- Amssalu, B. (2004). Nature and phenology of honey plants in central highlands of Ethiopia, Proceedings of 12<sup>th</sup> National Annual Conference of Ethiopian Society of Animal production, 12-14 August, Addis Ababa, Ethiopia. pp. 93-96.
- Amsalu B (2007). Seasonal intensity of flowering and pollen-forage selectivity by honeybees, *Apis mellifera bandasii* in central highlands of Ethiopia. Proceedings of the 14th annual conference of the Ethiopian Society of Animal Production (ESAP), Addis Ababa, Ethiopia pp.3-10.
- Bareke, T. and Addi, A. (2019). Bee flora resources and honey production calendar of Gera Forest in Ethiopia. *Asian Journal of Forestry*, 3(2): 69–74.
- Bareke, T. and Addi, A. (2020). Bee flora diversity in different vegetation communities of Gesha-Sayilem forest in Kaffa Zone, south-western Ethiopia. *Plants and Environment*, 2(4): 138–148.
- Crane, E. (1990). Bees and beekeeping: Science, practice and world resources. Heinemann Newness
- Façade, T. and Paul, S. (2006). Bee Flora. *Heritage*, April, 1–9.
- FAO (1986). Tropical and sub-tropical Apiculture. FAO Agricultural Services Bulletin 68, FAO, Rome, Italy. 285p.
- Fenet, B. and Alemayehu, O. (2016). The significance of honey production for livelihood in Ethiopia. *Journal of Environment and Earth*

- Science*, 6(4): 46–53.
- Fichtl, R. and Admasu, A. (1994). Honey bee flora of Ethiopia. The National Herbarium, Addis Ababa University and Deutscher Entwicklungsdienst (DED) Mergaf Verlag, Germany. 510p.
- Gebretsadik, T. (2016). Assessment of major Honey bee flora resources on selected districts of Sidama and Gedeo zones of South nations nationalities and peoples regional state, Ethiopia. *Journal of Agricultural Economics*, 4(2): 368–381.
- Genet, W. (2002). Identification of Honey Bee Floras and Their Flowering Times in Wondo Genet, Southern Ethiopia. *Journal of Resources Development and Management*, 59: 1–11.
- Gezahegn, T. (2001). Agriculture Development Strategies, Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.
- Gidey, Y. and Mekonen, T. (2010). Participatory Technology and Constraints Assessment to Improve the Livelihood of Beekeepers in Tigray Region, Northern Ethiopia. *MEJS* 2(1): 76–92.
- Haftom, G., Tesfay, Z., Murutse G. and Estifanos A. (2013). Seasonal honeybee forage availability, swarming, absconding and honey harvesting in Debrekidan and Begasheka Watersheds of Tigray, Northern Ethiopia. *Livestock Research for Rural Development*. 25
- Jenberie, A., Tsegaye, A. and Bihonegn, A. (2016). Identification and Characterization of Honeybee Flora in Wag-Lasta area, Amhara Region. *9th Annual Regional Conference on Completed Livestock Research Activities*, 339.
- Kebede, H. and Gebrechirstos, S. (2016). Floral establishment of major honey plants in north western zone of Tigray, Ethiopia. *International Journal of Scientific and Engineering Research*, 7(9): 543–550.
- Kent, M. and Coker, R. (1992). Vegetation description and analysis: A practical approach. CRC Press, Inc., London. Kent.
- Lemessa, D. (2006). The Roles of Apiculture in Vegetation Characterization and Household Livelihoods in Walmara District, Central Ethiopia. M.Sc thesis, Hawassa University, Hawassa, Ethiopia.
- Lemessa, D. and Addi A. (2009). Identification and Evaluation of Bee Flora resources in arid and Semiarid Agro-ecological Zones of Southeast of Oromia. In proceedings of 17<sup>th</sup> Annual Conference of Ethiopia society of Animal production, 24 to 26 September, Addis Ababa, Ethiopia. Pp.181-191.
- Mulugeta, Y., Tamrat, B. and Ensermu, K. (2015). Floristic Composition, Species Diversity and Vegetation Structure of Gera Moist Montane Forest, Jimma Zone of Oromia National Regional State, Southwest Ethiopia. *Ethiopian Journal of Biological Sciences*, 14(1): 45-68.
- Pande, R. and Gi, R. (2018). Diversification of Honey bees ' flora and bee flora calendar for Nagpur and Wardha districts. *Journal of Entpmology and Zoology Studies*, 6(2): 3102–3110.
- Pearson, W.D. and Braiden, V. (1990). Seasonal Pollen Collection by Honeybees from Grass/Shrub Highlands in Canterbury, New Zealand. *Journal of Apicultural Research*, 29(4): 206-213.
- Ramirez-Arriaga, E., Navarro-Calvo, L.A. and Diaz-Carbajal, E. (2011). Botanical characterization of Mexican honeys from a subtropical region (Oaxaca) based on pollen analysis. *Grana*, 50(1): 40-54.
- Rijal, S.P., Thapa, R.B., Sharma, M.D., Sah, S.K. and Yubak Dhoj G.C. (2018). Bee Floral Calendar of Cultivated and Wild Plants available in Different Agroecosystems of Chitwa. *International Journal of Research-Granthaalayah*, 6(11): 222–245.
- Shegaw, T. and Giorgis, D.H. (2021). Identification, characterization and evaluation of honeybee floras in Kafa, Sheka and Bench Maji Zones of Southern Nations Nationalities and Peoples Region (SNNPR), Ethiopia. *Journal of Agricultural Science and Food technology*, 7(3), 310–326.
- Teklay, A. (2011). Seasonal Availability of Common Bee Flora in Relation to Land Use and Colony Performance in Gergera Watershed Atsbi Wembwerta District, Eastern Zone of Tigray, Ethiopia. M.Sc.thesis, Hawassa University, Hawassa, Ethiopia.
- Tesfaye, B., Kiteessa, H. and Ensermu, K. (2013). Floristic Composition and Structural Analysis of Jibat Humid Afromontane Forest, West

- Shewa Zone, Oromia National Regional State, Ethiopia. *Ethiopian Journal of Education and Science*. 8(2):12-33.
- Tilahun, A. (2003). Natural Resources Degradation and Environmental Concerns in the Amhara National Regional State: Impact on Food Security, Proceedings of the Natural Resource Management Conference, 24- 26 July, Bahir Dar, Ethiopia, pp. 33-50.
- Wubie, A.J., Bezabeh, A. and Kebede, K. (2014). Floral phenology and pollen potential of honey bee plants in NorthEast dry land areas of Amhara region, Ethiopia. *IOSR Journal of Agriculture and Veterinary Science*, 7(5): 36–49.
- Zelege, B., Debara, M., Negash, D. and Bekele, B. (2019). Assessment and Establishment of Honey Bee Flora Calendar to Increase Honey Production in Selected Areas of SNNPR State, Ethiopia. *Finance and Economics Review*, 1(1): 2019.