Hindawi
International Journal of Forestry Research
Volume 2023, Article ID 2797159, 15 pages
https://doi.org/10.1155/2023/2797159

Research Article

Floral Calendar of Honeybee Plants in Kellem and West Wollega Zone, Western Ethiopia

Ofijan Tesfaye [1] and Etenesh Mekonnen [2]

[1] *Oromia Agricultural Research Institute, Haro Sabu Agricultural Research Center, Addis Ababa, Ethiopia*
[2] *Oromia Agricultural Research Institute, Holata Apiculture Research Center, Addis Ababa, Ethiopia*

Correspondence should be addressed to Ofijan Tesfaye; apistesfaye@gmail.com

Received 15 April 2023; Revised 5 July 2023; Accepted 7 July 2023; Published 19 July 2023

Academic Editor: Anna Źróbek-Sokolnik

Beekeeping has significantly contributed to environmental conservation and the preservation of natural resources. Although the quality and quantity of flora available play a major role in the success of the sector, the botanical makeup of natural vegetation varies greatly. This study was conducted targeting the identification and documentation of major honeybee floras and their flowering calendar. Midland and lowland agroecologies were purposively selected. Continuous field plant registration was performed. Melissopalynological analysis from bee pollen and honey were used to identify floral origin. Field observations identified 59 and 63 plants in the midland and lowlands, respectively. Season 1 had the highest pollen yields, ranging from 11051.8 ± 56.4 g (midlands) to 878.3 ± 18.3 g (lowlands), while season 4 ranged from 16.8 ± 6.3 g (midlands) to 15.6 ± 7.4 g (lowlands) and had the lowest pollen yield. In both regions, February, March, July, and August are the months when pollen is not brought into the hive and could be used as starvation periods. A total of 1430.8 ± 75.4 and 1291.8 ± 71.4 g of bee pollen/hive were collected throughout the year in midland and lowland, respectively, and *Asteraceae* was the richest family accounting around 90% of pollen weight. In both agroecologies, honey is harvested three times a year. In the midland, monofloral honey, namely, *Guizotia* spp (64.42%) and *Croton macrostychus* (47.42%), was harvested in November and May, respectively, while honey harvested in February was multifloral type. Similarly, in the lowlands, monofloral honey of *Guizotia* spp (51.85%), *Coffee arabica* (55.22%), and *Croton macrostychus* (50.42%) was harvested in December, March, and June, respectively. Based on the results, *Bidens prestinaria, Bidens pilosa*, *Guizotia* spp, *C. macrostachyus*, *Eucalyptus* spp, *Lepidium sativum*, *Zea mays*, *Hypostes trifolia*, *Vernonia* spp, *Trifolium* spp, *Helianthus annuus*, *C. arabica*, *Brassica abyssinica*, *Andropogon abyssinicus*, *Sorghum bicolor*, *Cordia africana*, *Syzygium guineense,* and *Terminalia* spp are major bee plants. It is found that the study area is rich in bee plant diversity and hence has a potential for honey production.

1. Introduction

Beekeeping plays an important role in protecting the country's natural resources and the national economy. Bees and flowering plants have interdependencies that strengthen coevolution [1]. The bees pollinate these plants when flowering plants provide them with food in the form of pollen and nectar [2]. For all management activities in beekeeping, for example, supering and reducing hives, predicting honey frequency and timing, and creating flower calendars are important tools. Identification and documentation of productive bee forages and their flowering calendars are important for beekeeping activities to increase its production [3]. Analysis of pollen abundance from bee plants and melissopalynological analysis of honey samples provides a true picture of the local bee flora that provides food for bees and other pollinators within the ecosystem [4].

Agroecological zones and seasons can influence the availability, flowering duration, flowering period, and nectar and pollen production of different bee plants at a particular site [5]. There is a strong connection between the seasonal cycle of a bee colony and the bee floral calendar, so it can be applied to practical seasonal colony management. Timing of management actions consistent with the seasonal patterns of bee plants in the area is critical for establishing colony populations before the main nectar flow and beekeepers should ensure that the maximum population is before or during the nectar flow [6].

However, bee diets in the study area (Kellem and West Wollega zones in Ethiopia) are not well documented, and correlations with seasonal colony management calendars have not been established. Therefore, beekeeping, an environmentally friendly and agricultural business activity that contributes significantly to the profitability of beekeepers, was not proportionate to the existing potential of the study area. Therefore, assessing the different agroecological zones of the study area for determining the availability of bee forage and establishing flowering calendar of honey plants that enable effective seasonal colony management is paramount important.

2. Materials and Methods

2.1. Study Area. Activities were conducted in the Kellem and West Wollega zones. Two districts were purposively selected from each zone, based on honey production and agroecology. Accordingly, Nejo and Gulisso districts of West Wollega and Dale Sedi and Sedi Chanka districts of Kellem Wollega district were selected. Two peasant associations (PAs) were selected from each district (one representing midland and one representing lowland) for a total of eight PAs from two zones (Table 1). In the study area, there is no environment which represents highland agroecology. The general weather condition of the study area at the Woreda level is depicted in Table 2.

2.2. Field Observation and Recording of a Flowering Plant. Continuous evaluations were performed to document when the plants flowered. Therefore, one monthly trip was made throughout the year to record with farmers and beekeepers in each survey area of the field to learn the local names of the plants. Then, to know the seasonal colony management of the year, continuously recorded plant flowering was grouped into four seasons, namely, season 1: September–November, season 2: December–February, season 3: March–May, and season 4: June–August.

2.3. Colony Establishment for Pollen and Honey Sample Collection. Four bee colonies were established at each location. Two were for pollen trapping used to analyze pollen samples, and the other two were used for honey harvesting to identify plant types from honey. For pollen collection, bee colonies entrances were fitted with pollen traps and pollen loads were collected every 7 days. After collection, it was placed in a clean paper bag and dried at room temperature for 24 hours. They were then grouped by color and weighted separately. This was carried out continuously throughout the year, and months that contained no pollen pellets were recorded as nonpollen-producing plants. Honey is typically harvested three times a year in the study area. At each month of harvest, honey samples were collected separately, directly from modern beehives at representative sites of agroecology. The botanical sources were then identified from bee pollen and honey samples in the Holeta Beekeeping Research Center.

2.4. Bee Pollen Analysis. Pollen grain samples were taken from representative pellets of each color, dissolved in water droplets, placed on glass slides, observed under a light microscope (400x magnification), and identified at the genus or species level [7]. In addition, reference slides were prepared from mature pollen grains collected from mature flower buds of ether-washed honey plants to support and validate the bee pollen source plant species in the study area.

2.5. Pollen Analysis from Honey. For laboratory analysis, two hives (two fresh honey samples) were used separately from each location for honey sample collection at different times of the year. Pollen analysis from honey was performed according to Louveaux et al. [7] to determine the botanical composition and abundance of pollen grains in honey. From each sample, 10 g of honey was dissolved in 20 ml of distilled water and the solution was centrifuged at 3000 rpm for 10–15 minutes and repeated as necessary. The sediment was transferred to a slide, examined under a 400x light microscope, and counted. Pollen types were identified by a comparison with reference slides of pollen collected directly from the plants in the study area. The percentage of pollen types in each honey sample was calculated based on the total number of pollen grains of different types counted in each sample. If more than 45% of pollen grains were counted, they were classified as primary pollen (monofloral honey), secondary pollen (16–45%), important minor pollen (3–15%), and minor pollen (<3%) which was used [7] and performed in the laboratory of the Holeta Bee Research Center.

2.6. Data Collection and Analysis. Data (means ± standard deviation) of agroecological bee pollen weight were calculated using SAS Software (SAS Institute, 2003; 14). For botanical origin analysis, pollen grain morphology in the agroecological and seasonal honey sample was counted from the slide microscopically and their percentage was calculated by dividing the single plant species pollen grain morphology over the total different plant pollen grain morphology and then multiplying by 100 by Microsoft Excel. Data from pollen trapping, honey sample, and field recording of the flowering plant were traced back to plant species, genera, and families' level with the help of reference books and pollen atlas [8] and prepared pollen reference slides.

3. Results and Discussion

3.1. Field Bee Flora Observation and Recording. Based on continuously recorded field observations, a total of 67 flowering bee plants and their flowering times were recorded in both study areas (Appendix 1 in Supplementary 1). Out of these, 59 and 63 plants were identified in the mid and lowlands, respectively. In the midland agroecology, 40.7% of the plants recorded were herbs, 32.2% were trees, 18.6% were

Table 1: Agroecology of the study site.

Zone	Woreda	Peasant association	Altitude (m)	Agro-ecology
West Wollega	Nejo	Lalisa iyesus	1490	Lowland
		Gida Kumbi	1880	Midland
	Gulisso	Maru	1421	Lowland
		Wara Dale	1562	Midland
Kellem Wollega	Dale Sedi	Hawetu birbir	1469	Lowland
		Belam	1775	Midland
	Sedi Chanka	Safara 5	1408	Lowland
		Kombo	1616	Midland

Table 2: General description of the weather of the study site at the Woreda level.

Woreda	Latitude	Longitude	Altitude (m)	Rainfall (mm)	Temperature
Nejo	10°18′15″–10°49′21″ N	35°28′10″–35°14′19″ E	1605–2000	1350 to 2300	18°C to 28°C
Gulisso	9°2′21″ to 9°21′41″ N	35°6′18″ to 35°33′28″ E	1420 to 1996	1240 to 1750	20 to 30°C
Dale Sedi	8°52′51″ N	35°13′18″ E to 35°23′48″	1400–2000	1000 to 1830	14°C to 30°C
Sedi Chanka	11°34′ N to 11°12′ N	37°33′ E to 38°11′ E	1100 to 1800	1100 to 1796	15.5°C to 34°C

shrubs, and 8.5% were climbing plants. Similarly, 36.5% herbs, 34.9% trees, 19.0% shrubs, and 7.9% climbers are present in the lowlands (Figure 1). In contrast to this study, Mululaem et al. [9] have demonstrated 58.06% of tree species, followed by herbs (57%) and shrubs (28.05%) from the high and lowlands of the Arsi Zone. This slight difference can be attributed to agroecology and geography.

In terms of plant habits, in the midland area, 72.4% of herbs bloom in season 1, 45.4% of shrubs in season 2, 84.6% of trees in season 3, and 33.3% of herbs in season 4 (Figure 2). In the lowlands, 65.5% of herbs bloom in season 1, 46.2% of shrubs in season 2, 86.6% of trees in season 3, and 16.6% in season 4 (Figure 3). This indicated that the predominant bee flora in the active period (season 1) is herbaceous, in season 2 is a shrub, and in season 3 is a tree. According to this finding, small plants bloomed following heavy rains, while trees bloomed following light rains.

3.2. Floral Calendar. Regarding the flowering period of the bee forage, the percentage of bee flora abundance was the highest in the midlands at 49.2% and in lowlands at 46.0% in season 1, 18.6% in midlands, and 20.6% in lowlands in season 2. Season 3 was 22.0% in the midlands and 23.8% in the lowlands, and season 4 was 10.2% in the midlands and 9.5% in the lowlands (Figure 4). In all study areas, almost/almost half (50%) of the flowering plants flowered in season 1, while fewer plants flowered in season 4. This is consistent with Mulualem et al. [9] who argued that the presence of many flowering plant species from September to November was due to the availability of water after the main rainy season from June to August, and the growth of herbaceous plants and crops reported to start flowering. In addition, Yirga and Teferi [10] reported that most bee plants flower after the main summer rainy season (June to early September). From this study, the second highest number of plant species flowering was recorded in season 3 (March to May) in all study areas. This agrees with the finding of Mululaem et al. [9] that the second flowering period occurs after a small rainy season starting in March-April.

From this study, season 4 is the time when there are fewer flowers than in the other seasons. This season is the time of the main rainy season, and there is a shortage of bee flowers in the study area. This is supported by Mulualem et al. [9] who found that from June to August, which is the major rainy season nationwide, fewer flowering plants were observed, and plants produced more vegetative biomass than flowers. This is also reported by Addi and Lamessa [11] that during the rainy season, cold temperatures can inhibit flower production.

A total of 27 (Figure 5) and 26 (Figure 6) plant families were recorded in the lowland and midland, respectively. In lowland areas, the highest number of melliferous plant species was recorded for the Asteraceae family (23.7%) followed by Fabaceae (11.9%), Poaceae (10.2%), Combretaceae (6.8%), and Myrtaceae (5.1%), four botanical families were recorded 3.9%, and seventeen botanical families were recorded 1.7% (1 plant species).

Similarly, in the midland area, the Asteraceae family was the richest recorded (21.6%) followed by Fabaceae (13.3%), Poaceae (10.0%), Combretaceae (6.6%), Myrtaceae (5.0%), four botanical families were recorded 3.9%, and eighteen botanical families were recorded 1.6% (1 plant species). This finding is matching Mulualem et al [9] that out of the field observation and plant inventory Asteraceae family (38.5%) was the highest number of m*elliferous* plant species recorded followed by Fabaceae (24.6%).

3.3. Bee Pollen Collection. Trapped pollen was weighed from each agroecological site, and the mean was reported monthly throughout the year to obtain pollen abundance and flowering plant species (Figure 7). In the midland agroecology, small amounts (0.8 ± 0.2 g) were collected in August, increased until November (553.0 ± 57.5 g), and decreased in December (301.1 ± 5.4 g). Pollen-releasing plants were delayed in the lowlands compared to the midland, but the pollen load increased from no pollen in August to a peak of 499.3 ± 20.6 g in November and

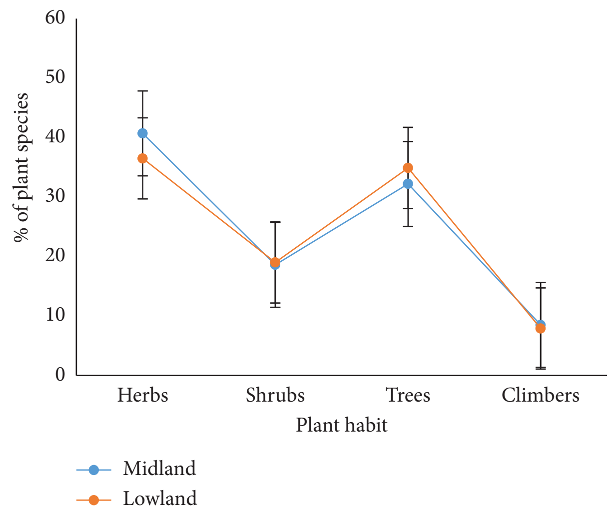


Figure 1: Flowering plant abundance based on their habit from field recorded flora.

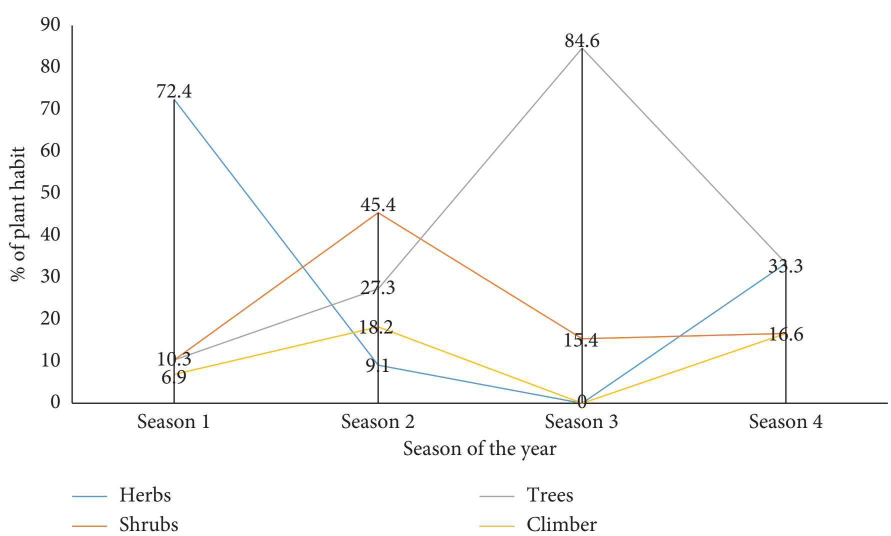


Figure 2: Dominance of plant habit based on season from field observed flora of the midland area.

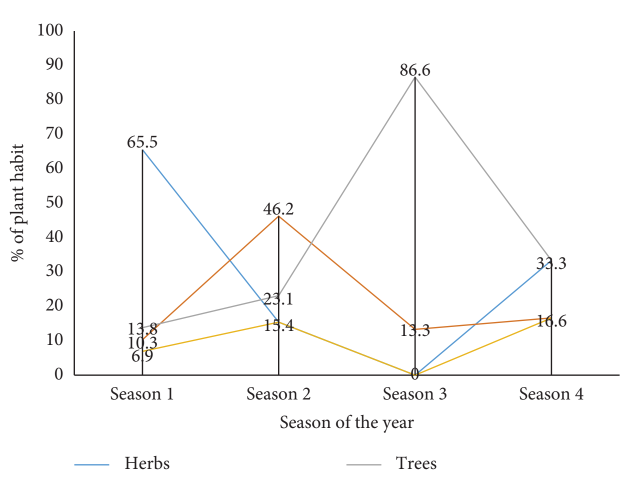


Figure 3: Dominance of plant habit based on the season from field observed flora of the lowland area.

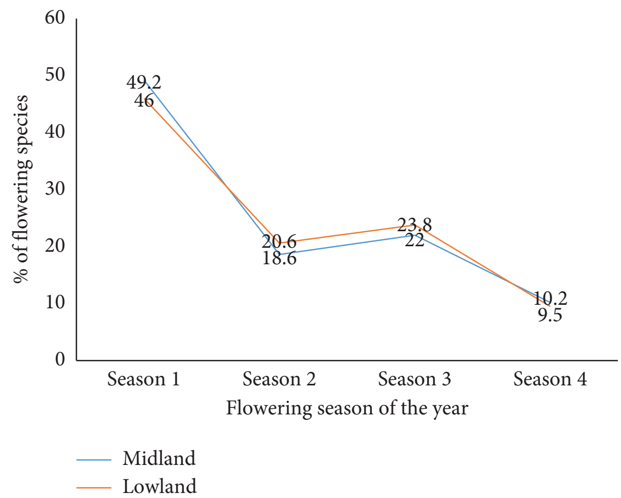


Figure 4: The flowering intensity of bee plants in agroecology.

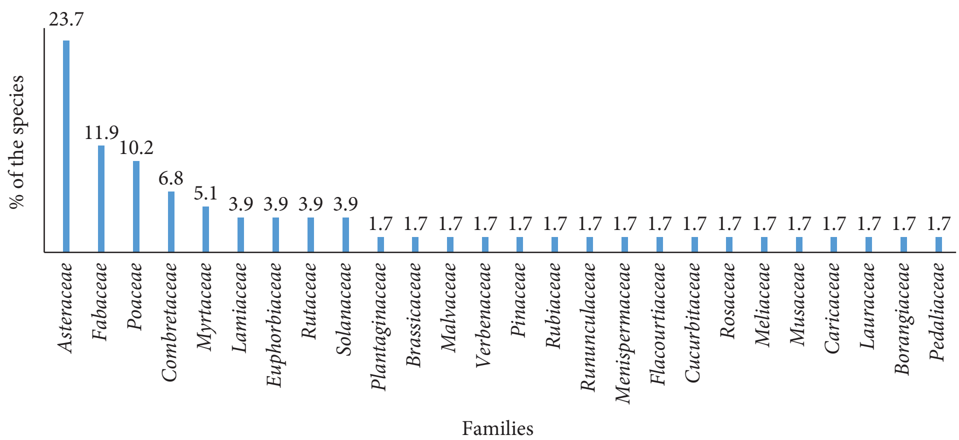


Figure 5: Number of dominant plant families from the lowland area.

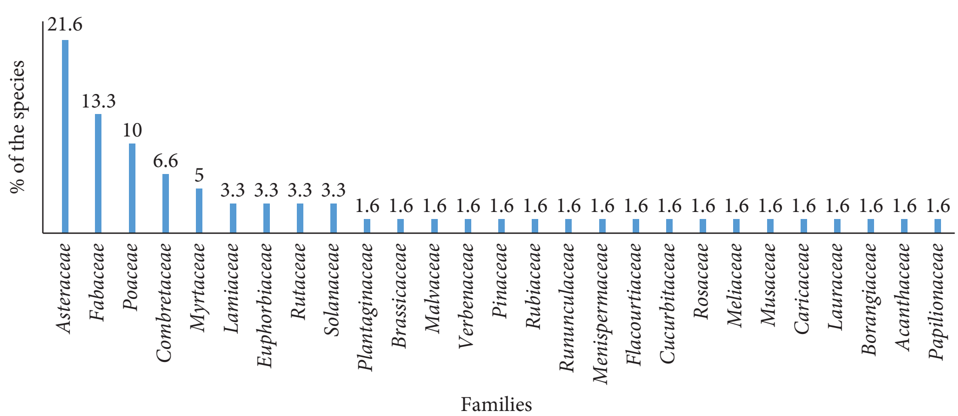


Figure 6: Number of dominant plant families from the midland area.

341.5 ± 41.5 in December. This result indicates that season 1 (September to November) can be regarded as the active season for the study area. In both agroecologies, March, July, and August are the months when pollen is not brought into the hive and can be during scarcity periods.

Throughout the year of pollen collection, more pollen was harvested from the midland (1430.8 ± 75.4 g) than from the lowlands (1291.8 ± 71.4 g) (Table 3). In the midland, the highest (1051.8 ± 56.4 g) and lowest (16.8 ± 6.3 g) were collected in seasons 1 and 4, respectively. Season 1 can be an

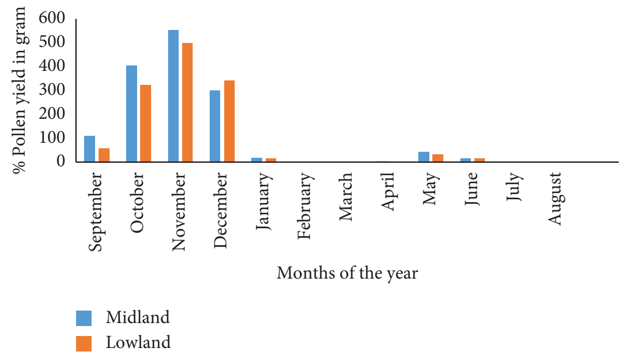


FIGURE 7: Monthly pollen trapped throughout the year in gram.

TABLE 3: Monthly pollen trapped throughout the year in gram.

Agroecology	Season of the year (mean ± SD)				Total
	Season 1	Season 2	Season 3	Season 4	
Midland	1051.8 ± 56.4	317.4 ± 7.9	44.82 ± 4.8	16.8 ± 6.3	1430.8 ± 75.4
Lowland	878.3 ± 18.3	357.0 ± 47.5	34.2 ± 3.8	15.6 ± 7.4	1291.8 ± 71.4

active time, with approximately 57.6% of the plants identified from bee pollen flowering during that season (Figure 8). In the lowland, the highest (878.3 ± 18.3 g) and lowest (15.6 ± 7.4 g) were demonstrated in seasons 1 and 4, respectively, and 55.7% of the plants were identified in season 1. In both agroecologies, more pollen was trapped following the main rainy season which is comparable with the finding by Wubie et al. [12], who suggested that the flowering period differs with different agroecologies based on their moisture contents and the highest volume of pollen was collected during the main rainy season (August through October). Furthermore, our results are consistent with Addi and Lamessa [11], where approximately 58.06% of bee plant species flower during the active season (September to November) and 8.67% during the heavy rain season (June to August). In our study, the midland begins flowering (pollen catch) earlier than the lowlands. This could be the difference in humidity. Midland regions get rain earlier than lowland agroecology.

3.4. Plant Identification from Trapped Bee Pollen. A total of 28 pollen source plant species were identified from the midland (Table 4). Most of the pollen collected was from *Bidens prestinaria* (572.0 g), *Bidens pilosa* (403.8 g), *Guizotia* spp (302.8 g), *Croton macrostachyus* (24.3 g), *Eucalyptus* spp (17.3 g), and *Lepidium sativum* (16.1 g) which accounted for 39.3%, 27.2%, 20.8%, 1.7%, 1.2%, and 1.1% of the total pollen collected, respectively. The top three of these are herbaceous plants that flowered in season 1 and were abundant. Among the identified plant species, *Asteraceae* and *Euphorbiaceae* are the major plant families of the midland (Table 5). 21.4% of the pollen plant species, accounting for 90.1% of pollen weight, were found in the *Asteraceae* family, whereas *Euphorbiaceae* accounted for 10.7% of the plant species, accounting for 1.8% of pollen weight.

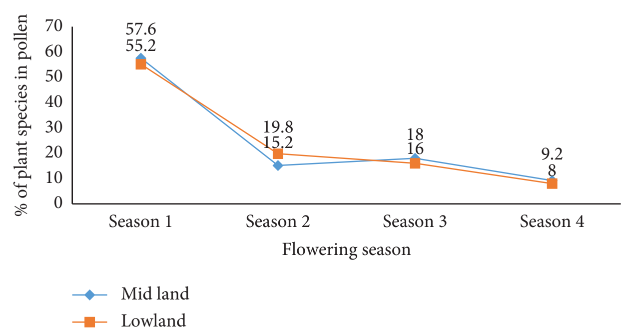


FIGURE 8: Percentage flowering intensity of bee plants from bee pollen collected.

Of the total 18 plant families consisting of 28 pollen source species, 57.57% was bloomed in season 1, 15.15% in season 2, 18.18% in season 3, and 9.09% in season 4. This is why more pollen was trapped in season 1, where *Bidens* and *Guizotia* spp were found in abundance and contributed to more pollen release. Our results suggest that water availability after the main rainy season from June to August induces the flowering of herbaceous plants and crops and makes the presence of a high number of flowering plants from September to November [9].

From lowland agroecology, a total of 24 plant species (Table 6) were screened from trapped bee pollen. Most of the pollen collected was *Bidens prestinaria* (522.2 g), *Bidens pilosa* (357.6 g), *Guizotia* spp (292.8 g), *Croton macrostachyus* (45.3 g), *Vernonia* spp (13.8 g), and *Lepidium sativum* (12.2 g), and they accounted for 39.4%, 26.9%, 22.1%, 3.4%, 1.0%, and 0.9% of the total pollen collected, respectively.

Among all the plants identified, *Asteraceae* is the most abundant plant family, with 25.0% of plant species accounting for 92% of total pollen weight (Table 7),

Table 4: Plant identified from bee pollen pellet in midland agroecology.

No.	Local name (in Afan Oromo)	Scientific name	Family name	Collecting time (month)	Pollen weight (gram)	Pollen weight (%)	Life form
1	Keelloo	*Bidens prestinaria*	Asteraceae	September–November	572.0	39.3	Herb
2	Maxxannee	*Bidens pilosa*	Asteraceae	July–October	403.8	27.8	Herb
3	Tuufoo/Nuugii	*Guizotia* spp	Asteraceae	September–November	302.8	20.8	Herb
4	Bakkanniisa	*Croton macrostachyus*	Euphorbiaceae	April-May	24.3	1.7	Tree
5	Baargamoo	*Eucalyptus* spp	Myrtaceae	October-November; February-March; and April-May	17.3	1.2	Tree
6	Feexoo	*Lepidium sativum*	Brassicaceae	September	16.1	1.1	Herb
7	Boqqolloo	*Zea mays*	Poaceae	August-September and May	14.2	1.0	Herb
8	Darguu	*Hypostes trifolia*	Acanthaceae	September-October	14	1.0	Herb
9	Eebicha	*Vernonia* spp	Asteraceae	January-February	13.8	0.9	Shrub
10	Siddisa	*Trifolium* spp	Fabaceae	August–October	12	0.8	Herb
11	Suufii	*Helianthus annuus*	Asteraceae	October–December	11	0.8	Herb
12	Buna	*Coffee arabica*	Rubiaceae	January-February	10.4	0.7	Shrub
13	Raafuu	*Brassica abyssinica*	Brassicaceae	September	9.3	0.6	Herb
14	Baallammii	*Andropogon abyssinicus*	Asteraceae	October	7.1	0.5	Herb
15	Bishingaa	*Sorghum bicolor*	Poaceae	September	5.3	0.4	Herb
16	Waddeessa	*Cordia africana*	Boraginaceae	August–October	5.2	0.4	Tree
17	Baddeessaa	*Syzygium guineense*	Myrtaceae	March-April	2.9	0.2	Tree
18	Dabaqqaa	*Terminalia glaucescens*	Combretaceae	February-March	2.6	0.2	Tree
19	Qundabarbarree	*Schinnus molle*	Anacardiaceae	January–March	2.1	0.1	Tree
20	Dhangaggoo	*Rumex nervosus*	Polygonaceae	September	1.9	0.1	Shrub
21	Abbayyii	*Measa lanceolata*	Primulaceae	August-September	1.3	0.09	Shrub
22	Qobboo faranjii	*Ricinus communis*	Euphorbiaceae	February-March	1.2	0.08	Shrub
23		*Opertia ficus-indica*	Cactaceae	November	1.0	0.07	Shrub
24		*Polyscias* spp	Araliaceae	January	0.8	0.06	Shrub
25	Hiddii	*Solanum anguivi*	Solanaceae	September-October	0.7	0.05	Herb
26	Incinnii	*Hibiscus micranthus*	Malvaceae	September	0.4	0.04	Herb
27		*Acalypha indica*	Euphorbiaceae	February	0.2	0.01	Herb
28	Baaqalaa	*Vicia faba*	Papilionaceae	September	0.1	0.007	Herb

Table 5: Plant diversity with pollen weight in a family from bee pollen collected in midland agroecology.

No.	Family name	Plant species		Bee pollen weight	
		In number	In percentage	In gram	In percentage
1	Asteraceae	6	21.4	1310.5	90.1
2	Euphorbiaceae	3	10.7	26.0	1.8
3	Brassicaceae	2	7.1	25.4	1.7
4	Myrtaceae	2	7.1	20.2	1.4
5	Poaceae	2	7.1	20.0	1.4
6	Fabaceae	1	3.6	12.0	0.8
7	Acanthaceae	1	3.6	14.0	0.9
8	Rubiaceae	1	3.6	10.4	0.7
9	Boraginaceae	1	3.6	5.2	0.3
10	Combretaceae	1	3.6	2.6	0.2
11	Anacardiaceae	1	3.6	2.1	0.1
12	Polygonaceae	1	3.6	1.9	0.1
13	Primulaceae	1	3.6	1.3	0.08
14	Cactaceae	1	3.6	1.0	0.06
15	Araliaceae	1	3.6	0.8	0.05
16	Solanaceae	1	3.6	0.7	0.04
17	Malvaceae	1	3.6	0.4	0.02
18	Papilionaceae	1	3.6	0.1	0.006

Euphorbiaceae (8.3% plant species for 3.0% pollen weight), and *Poaceae* (8.3% plant species for 0.9% total pollen weight). Wubie et al. [12] stated that *Asteraceae* is the major pollen source family, contributing 19.95% of all pollen collected. Comparing the seasons, 55.2% of the flowers bloomed in season 1, 13.8% in season 2, 17.2% in season 3, and 13.8% in season 4 (Figure 8). For this reason, more pollen was trapped in season 1.

3.5. Harvest Time of Honey and Its Floral Source. In both agroecologies, honey is harvested three times a year. However, from the lowlands, it is harvested a month after the honey is harvested from the midlands. Although the sources of honey plants were almost the same in both agroecologies, bee plants flowered 1-2 months earlier in the midlands than in the lowland areas. The microscopic pollen grain morphology of floral source of honey plants from honey samples was demonstrated in Figure 9.

3.6. Honey in Midland Agroecology

3.6.1. Honey Harvested in November. A total of 16 honey source plants were identified from the honey samples and designated as *Guizotia* species honey type (monofloral honey) because they had pollen content grades greater than 45% and fell into the predominant pollen type (62.4%) (Table 8). Of the total number of confirmed plants, herbaceous plants accounted for 68.75%, followed by trees (25%) and shrubs (6.25%). Of the 13 plant families identified, the highest number of plant species was found within the *Asteraceae* family (23.07% of all plant species recorded) accounting for 69% of the total pollen grains counted. Plant abundance in this family was also observed, comparable to pollen trap analyses performed in season 1 of midland. After the main rainy season (June to August), herbaceous plants, especially *Guzotia* and *Bidens*, bloomed abundantly and their honey is synthesized by bees. Similarly, information from Tesfaye et al. [13] found that *Guizotia* from honey harvested in October-November accounted for 87% of total pollen counts. Our results are similar to Addi and Bareke [14], where *G. scarba* produced single-flower honey as it grows abundantly in different habitats, cultivated land, forest edges, and open grasslands.

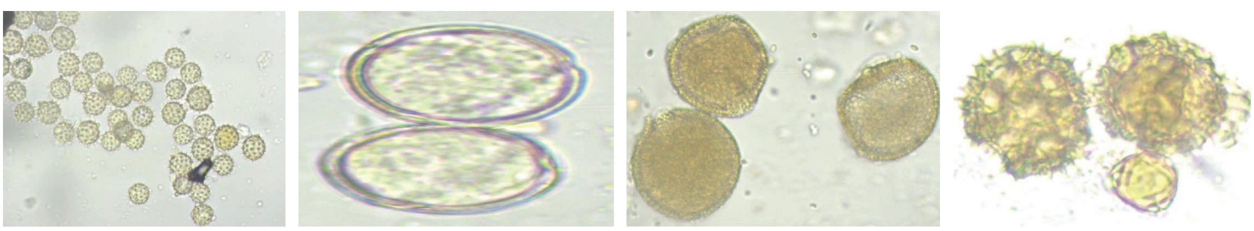
3.6.2. Honey Harvested in February. A total of 23 honey-source plants were identified from the honey samples (Table 8) and categorized under multifloral honey. Out of these, *C. arabica* and *Vernonia* which contributed 42.9% and 23.46% of the total number of pollen grains, respectively, were assigned to secondary pollen types. Shrubs accounted for 40.9% of the total number of confirmed plants, followed by trees (31.81%) and herbs (27.27%). Out of the 15 plant families identified, the highest number of melliferous plant species was found in *Asteraceae* (26.66% of all recorded plant species), followed by *Fabaceae* (20%), *Rubiaceae* (13.13%), and *Acanthaceae* (13.13%). However, for the total number of pollen grains, Rubiaceae accounted for 43.43%, followed by *Asteraceae* (33.01%), *Acanthaceae* (1.57%), and *Fabaceae* (0.18%). The flowering period of *C. arabica* in the study area depends on the rain condition. It flowered mostly from the mid of January to March following the rain condition and stays a maximum of 10 days on flowering. This plant is widely cultivated for its fruits and is a much-known cash crop in the study area. When flowered, it is abundantly available for the forager bees and releases plenty of nectar and pollen. Its honey is harvested from February to March depending on the rain. *Vernonia* spp is the second predominant plant which is propagated in a coffee plant primarily for shedding. Similarly, Tesfaye et al. [13] demonstrated that from honey samples harvested in January through February, 46% and 20% of pollen were counted by *C. arabica* and *V. amygdalina* of the study area which could

Table 6: Plant identified from bee pollen pellet in lowland agroecology.

No.	Local name (in Afan Oromo)	Scientific name	Family name	Collecting time (month)	Pollen weight (gram)	Pollen weight (%)	Life form
1	Keelloo	*Bidens prestinaria*	Asteraceae	October-November	522.2	39.4	Herb
2	Maxxannee	*Bidens pilosa*	Asteraceae	August–November	357.6	26.9	Herb
3	Tuufoo	*Guizotia* spp	Asteraceae	October–November	292.8	22.1	Herb
4	Bakkanniisa	*Croton macrostachyus*	Euphorbiaceae	April-May	45.3	3.4	Tree
5	Eebicha	*Vernonia* spp	Asteraceae	January-February	13.8	1.0	Shrub
6	Feexoo	*Lepidium sativum*	Brassicaceae	September	12.2	0.9	Herb
7	Boqqolloo	*Zea mays*	Poaceae	September and May	11.2	0.8	Herb
8	Suufii	*Helianthus annuus*	Asteraceae	October–December	10.0	0.7	Herb
9	Siddisa	*Trifolium* spp	Fabaceae	September-October	9.1	0.7	Herb
10	Buna	*Coffee arabica*	Rubiaceae	January-February	8.4	0.6	Shrub
11	Darguu	*Hypostes trifolia*	Acanthaceae	September-October	7.1	0.5	Herb
12	Baargamoo	*Eucalyptus* spp	Myrtaceae	October-November; February-March; April-May	6.3	0.5	Tree
13	Dabaqqaa	*Terminalia glaucescens*	Combretaceae	February-March	5.6	0.4	Tree
14	Baallammii	*Andropogon abyssinicus*	Asteraceae	October	5.1	0.3	Herb
15	Muuzii	Musa acuminata	Musaceae	Throughout the year	4.0	0.3	Shrub
16	Bishingaa	*Sorghum bicolor*	Poaceae	September	3.6	0.3	Herb
17	Waddeessa	*Cordia africana*	Boraginaceae	August–October	2.3	0.2	Tree
18	Dhangaggoo	*Rumex nervosus*	Polygonaceae	September	1.9	0.1	Shrub
19	Baddeessaa	*Syzygium guineense*	Myrtaceae	March-April	1.8	0.1	Tree
20	Qobboo faranjii	*Ricinus communis*	Euphorbiaceae	February-March	1.2	0.09	Shrub
21	Abbayyii	*Measa lanceolata*	Primulaceae	August-September	1.3	0.09	Shrub
22	Qundabarbarree	*Schinnus molle*	Anacardiaceae	January–March	1.1	0.08	Tree
23	Hiddii	*Solanum anguivi*	Solanaceae	September-October	0.6	0.04	Herb
24	Incinnii	*Hibiscus micranthus*	Malvaceae	September	0.3	0.02	Herb

Table 7: Plant diversity and pollen weight in a family from bee pollen collected in lowland agroecology.

No.	Family name	Plant species		Bee pollen weight	
		In number	In percentage	In gram	In percentage
1	Asteraceae	6	25.0	1401.5	91.9
2	Euphorbiaceae	2	8.3	46.5	3.0
3	Poaceae	2	8.3	14.8	0.9
4	Brassicaceae	1	4.2	12.2	0.8
5	Fabaceae	1	4.2	9.1	0.6
6	Rubiaceae	1	4.2	8.4	0.5
7	Myrtaceae	2	8.3	8.1	0.5
8	Acanthaceae	1	4.2	7.1	0.4
9	Combretaceae	1	4.2	5.6	0.3
10	Musaceae	1	4.2	4.0	0.3
11	Boraginaceae	1	4.2	2.3	0.2
12	Polygonaceae	1	4.2	1.9	0.1
13	Anacardiaceae	1	4.2	1.1	0.07
14	Primulaceae	1	4.2	1.3	0.08
15	Solanaceae	1	4.2	0.6	0.04
16	Malvaceae	1	4.2	0.3	0.02



(a) (b) (c) (d)

Figure 9: Pollen grain morphology of major honey plants from honey samples. (a) *Guizotia* pollen grain, (b) *C. arabica* pollen grain, (c) *C. macrostychus* pollen grain, and (d) Vernonia pollen grain.

be comparable with the current finding. Furthermore, Addi and Bareke [14] identified *C. arabica* monofloral honey (55% pollen count) with a mixture of *V. amygdalina* (15%), *Rumex* spp (11%), and *V. auriculifera* (19%), and *C. arabica* honey is mostly harvested from February to March. In contrary with the honey harvested in November, honey in February is mostly harvested from shrub plants in *Rubiaceae*.

3.6.3. Honey Harvested in May. A total of nine honey source plants were identified from the honey samples (Table 8). A 47.42% of pollen grains counted were from *C. macrostachyus*, the dominant pollen type (monofloral honey), and secondary pollen types from *S. guineense* (24.03%) and other important minor and minor pollen types. Of the total number of plants identified, most were trees, accounting for 44.44%, followed by shrubs (33.33%) and herbs (22.22%). Of the 6 plant families identified, the highest number of melliferous plant species were found under *Myrtaceae* (50.0% of total plant species recorded) that contributed a cumulative 53.41% of the total pollen grain weighed, while *Asteraceae* is the second rich plant family (33.3%) but least cumulative pollen trapped (0.19%). Comparable information was reported by Addi and Bareke [14] in the Gera forest, 60% of the pollen was counted from *C. macrostachyus* honey harvested at the end of the small rainy season in June. The dominance of a monofloral species from a honey source in honey samples is determined by its abundance, nectar potential, and flowering schedule of the plant [15].

3.7. Honey in Lowland Agroecology

3.7.1. Honey Harvested in December. A total of 11 honey-source plants were identified from the honey samples (Table 9). From these plants, 52.85% of the counted pollen grains were derived from the *Guzotia* spp, which fell into the predominant pollen types and could be called the *Guzotia* honey type. From the total number of plants identified, herb plant accounts for 81.81%, trees (25%), and no shrub plant contributed in the season. From 13 plant families identified, the highest number of melliferous plant species were found under *Asteraceae* (18.2% of total plant species recorded) which accounted for 65.34% and *Poaceae* with 18.2% of total plant species produced 6.16% of the total pollen grain counted. The plant richness of this family is also observed and comparable to pollen trapped analysis assigned in season 1 midland agroecology. After the main rainy season (June-August), herbaceous plants especially *Guzotia* and *Bidens* spp, flowered abundantly and their honey is synthesized by the bees. A similar finding by Tesfaye et al. [13] stated that 87% of the total pollen grain was cropped by *Guizotia* spp from the study area. Furthermore, Addi and

Table 8: The characteristics of identified honey plants with their pollen frequency class from midland honey type.

Harvesting time	No.	Scientific name	Family name	Vernacular name (Afan Oromo)	Life form	Resources for bees	Pollen grain counted (%)	Frequency class	Honey type
November	1	Guizotia spp	Asteraceae	Tuufoo/nuugii	Herb	P & N	62.4	PP	Monofloral *Guizotia* spp honey
	2	Bidens spp	Asteraceae	Maxxannee	Herb	P & N	6.4	IMP	
	3	Trifolium spp	Fabaceae	Siddisa	Herb	P & N	6.1	IMP	
	4	Eucalyptus spp	Myrtaceae	Baargamoo	Tree	P & N	4.7	IMP	
	5	Grass type	Poaceae	Gosa margaa	Herb	P & N	4.0	IMP	
	6	Plantago lanceolate	Plantaginaceae	Qorxobbii	Herb	P	2.7	MP	
	7	Clausena anisata	Rutaceae		Shrub	P & N	2.4	MP	
	8	Terminalia brown	Combretaceae	Dabaqqaa	Tree	P & N	2.3	MP	
	9	Sesamum indicum	Pedaliaceae	Saalixa	Herb	P & N	1.9	MP	
	10	Cassipourea celastroides	Rhizophoraceae		Tree	P & N	1.9	MP	
	11	Allophylus abyssinicus	Sapindaceae	Sarara	Tree	P & N	1.7	MP	
	12	Vicia faba	Papilionaceae	Baaqelaa	Herb	P & N	1.1	MP	
	13	Lipidium sativum	Brassicaceae	Feexoo	Herb	P & N	1.6	MP	
	14	Vernonia spp	Asteraceae	Eebicha	Shrub	P & N	0.2	MP	
	15	Brassica carinata	Brassicaceae	Raafuu	Herb	P & N	0.2	MP	
	16	Satureja paradoxa	Lamiaceae	Xinaaddama	Herb	P & N	0.05	MP	
February	1	Coffee arabica	Rubiaceae	Buna	Shrub	P & N	42.90	SP	Multifloral honey
	2	Vernonia spp	Asteraceae	Gosa eebichaa	Shrub	P & N	23.46	SP	
	3	Terminalia spp	Combretaceae	Dabaqqaa	Tree	P & N	14.16	IMP	
	4	Guizotia spp	Asteraceae	Tuufoo	Herb	P & N	6.67	IMP	
	5	Ehertia cymosa	Boraginaceae		Tree	P & N	3.06	IMP	
	6	Apodytes dimidiata	Icacinaceae	Qumbaala	Tree	P & N	2.15	MP	
	7	Bidens spp	Asteraceae	Keelloo	Herb	P & N	1.57	MP	
	8	Sphaeranthus ukambensis	Asteraceae		Herb		1.31	MP	
	9	Clausena anisata	Rutaceae		Shrub	P & N	1.29	MP	
	10	Eucalyptus spp	Myrtaceae	Baargamoo	Tree	P & N	1.00	MP	
	11	Hypoested trifolia	Acanthaceae	Darguu	Herb	P & N	1.22	MP	
	12	Plantago lanceolate	Plantaginaceae	Qorxobbii	Herb	P & N	0.60	MP	
	13	Galiniera saxifraga	Rubiaceae	Mixoo	Shrub	P & N	0.53	MP	
	14	Justicia schimperiana	Acanthaceae	Dhummuuggaa	Shrub	P & N	0.35	MP	
	15	Bersama abyssinica	Melianthaceae	Lolchiisaa	Tree	P & N	0.35	MP	
	16	Trichocladus ellipticus	Hamamelidaceae		Shrub	P & N	0.31	MP	
	17	Rumex nervosus	Polygonaceae	Dhangaggoo	Shrub	P & N	0.15	MP	
	18	Euphorbia ampliphylla	Euphorbiaceae	Adaamii	Tree	P & N	0.13	MP	
	19	Trifolium spp	Fabaceae	Siddisa	Herb	P & N	0.08	MP	
	20	Melilotus alba	Fabaceae		Herb	P & N	0.06	MP	
	21	Crotolaria loburnifolia	Fabaceae		Shrub	P & N	0.04	MP	
	22	Dobiya torida	Sterculiaceae	Daannisa	Tree	P & N	0.04	MP	

Table 8: Continued.

Harvesting time	No.	Scientific name	Family name	Vernacular name (Afan Oromo)	Life form	Resources for bees	Pollen grain counted (%)	Frequency class	Honey type
May	1	Croton macrostychpous	Euphorbiaceae	Bakkanniisa	Tree	P & N	47.42	PP	*Croton macrostachyus* honey
	2	Syzium guineense	Myrtaceae	Baddeessaa	Tree	P & N	24.03	SP	
	3	Eucalyptus spp	Myrtaceae	Baargamoo	Tree	P & N	16.57	IMP	
	4	Acacia spp	Myrtaceae	Laaftoo	Tree	P & N	13.81	IMP	
	5	Justicia schimperiana	Acanthaceae	Dhummuuggaa	Shrub	P & N	0.55	MP	
	6	Rumex nervosus	Polygonaceae	Dhangaggoo	Shrub	P & N	0.38	MP	
	7	Coffee arabica	Rubiaceae	Buna	Shrub	P & N	0.27	MP	
	8	Guizotia spp	Asteraceae	Tuufoo	Herb	P & N	0.16	MP	
	9	Bidens spp	Asteraceae	Keelloo	Herb	P & N	0.03	MP	

P: pollen, N: nectar, PP: predominant pollen, SP: secondary pollen, IMP: important minor pollen, and MP: minor pollen.

Table 9: The characteristics of identified honey plants with their pollen frequency class from lowland honey type.

Harvesting time	No.	Scientific name	Family name	Vernacular name (Afan Oromo)	Life form	Resources for bees	Pollen grain counted (%)	Frequency class	Honey type
December	1	Guizotia spp	Asteraceae	Tuufoo/nuugii	Herb	P & N	51.85	PP	Monofloral
	2	Bidens spp	Asteraceae	Keelloo	Herb	P & N	13.49	IMP	
	3	Trifolium spp	Fabaceae	Siddisa	Herb	P & N	12.27	IMP	
	4	Sesamum indicum	Pedaliaceae	Saalixii	Herb	P & N	8.12	IMP	
	5	Grass type	Poaceae	Gosa margaa	Herb	P & N	5.95	IMP	
	6	Eucalyptus spp	Myrtaceae	Baargamoo	Tree	P & N	4.62	IMP	
	7	Lepidium sativum	Brassicaceae	Feexoo	Herb	P & N	1.32	MP	Guizotia spp honey
	8	Parkinsonia aculeata	Combretaceae	Dabaqqaa	Tree	P & N	1.22	MP	
	9	Vicia faba	Papilionaceae	Baaqelaa	Herb	P & N	0.63	MP	
	10	Plectranthus punctatus	Lamiaceae	Motijo	Herb	P & N	0.26	MP	
	11	Andropogon abyssinicus	Poaceae	Sarara	Tree	P & N	0.21	MP	
March	1	Coffee arabica	Rubiaceae	Buna	Shrub	P & N	55.22	PP	
	2	Vernonia spp	Asteraceae	Gosa eebichaa	Shrub	P & N	24.44	SP	
	3	Guizotia spp	Asteraceae	Tuufoo/hadaa	Herb	P & N	10.84	IMP	
	4	Sphaeranthus ukambensis	Asteraceae		Herb	P & N	2.00	MP	
	5	Bidens spp	Asteraceae	Keelloo	Herb	P & N	1.55	MP	
	6	Eucalyptus spp	Myrtaceae	Baargamoo	Tree	P & N	1.32	MP	
	7	Plantago lanceolate	Plantaginaceae	Qorxobbii	Herb	P & N	0.91	MP	
	8	Hypoested trifolia	Acanthaceae	Darguu	Herb		0.91	MP	Coffee arabica honey
	9	Clausena anisata	Rutaceae		Shrub	P & N	0.77	MP	
	10	Terminalia spp	Combretaceae	Birdheessa/dabaqqa	Tree	P & N	0.57	MP	
	11	Justicia spp	Acanthaceae	Sensel	Shrub	P & N	0.54	MP	
	12	Brassica carinata	Brassicaceae	Raafuu	Herb	P & N	0.33	MP	
	13	Rumex nervosus	Polygonaceae	Dhangaggoo	Shrub	P & N	0.20	MP	
	14	Euphorbia ampliphylla	Euphorbiaceae	Adaamii	Tree	P & N	0.13	MP	
	15	Trifolium spp	Fabaceae	Siddisa	Herb	P & N	0.10	MP	
	16	Melilotus albus	Fabaceae		Herb	P & N	0.10	MP	
June	1	Croton macrostachyus	Euphorbiaceae	Bakkanniisa	Tree	P & N	50.42	PP	
	2	Syzium guineense	Myrtaceae	Baddeessaa	Tree	P & N	21.03	SP	
	3	Eucalyptus spp	Myrtaceae	Baargamoo	Tree	P & N	16.57	SP	
	4	Acacia spp	Myrtaceae	Laaftoo	Tree	P & N	13.81	IMP	
	5	Justicia heterocarpa	Acanthaceae	Sensel	Herb	P & N	0.55	MP	*Croton macrostachyus* honey
	6	Rumex nervosus	Polygonaceae	Dhangaggoo	Shrub	P & N	0.38	MP	
	7	Coffee arabica	Rubiaceae	Buna	Shrub	P & N	0.27	MP	
	8	Guizotia spp	Asteraceae	Tuufoo	Herb	P & N	0.16	MP	
	9	Bidens spp	Asteraceae	Keelloo/maxxannee	Herb	P & N	0.03	MP	

P: pollen, N: nectar, PP: predominant pollen, SP: secondary pollen, IMP: important minor pollen, and MP: minor pollen.

Bareke [14] indicated that *G. scarba* provided monofloral honey due to its growing in abundance in a wide range of habitats: cultivated fields, forest margins, and open grasslands.

3.7.2. Honey Harvested in March. A total of 16 honey source plants were identified from the honey samples and termed as *C. arabica* honey types. It accounts for 55.22% of the total pollen grains counted and is classified as the predominant pollen type (Table 9). In addition, for the *Vernonia* spp, 24.44% of the total number of pollen grains are assigned to secondary pollen types. Of the total number of plants identified, shrubs accounted for 47.05%, followed by trees (17.64%) and herbs (35.29%). Among the 15 identified plant families, *Asteraceae* (23.5% of all recorded plant species) had the highest number of plant species. Although *Asteraceae* was rich in plant species, its total number of pollen grains (38.83%) was lower than that of *Rubiaceae* (55.22%). The current findings are consistent with Tesfaye et al. [13] who found that for honey samples harvested from January to February, 46% and 20% of pollen grain were recorded from *C. arabica* and *V. amygdalina,* respectively, in the study area. Furthermore, Addi and Bareke [14] found that *C. arabica* monofloral honey (pollen count 55%) contained a mixture of *V. amygdalina* (15%), Rumex spp (11%), and *V. auricullifera* (19%), and *C. arabica* honey was harvested mainly in February to March. Unlike honey harvested in November, February honey is primarily harvested from rubiaceous shrubs.

3.7.3. Honey Harvested in June. A total of nine honey source plants were identified from the honey samples (Table 9). *C. macrostachyus* is the dominant plant, accounting for 52.42% of the total pollen grains and the predominant pollen type (monofloral honey). This type of honey was contributed by a secondary type, namely, *S. guineense* and *Eucalyptus* spp, and they contribute 21.03% and 16.57% of pollen grains, respectively. Of the total number of plants identified, most were trees, accounting for 44.44%, followed by shrubs (33.33%) and herbs (22.22%). Comparable information was reported by Bareke and Addi [15]. In the Gera forest, 60% of the pollen was counted from *C. macrostachyus* honey harvested at the end of the small rainy season in June. The dominance of monofloral species from a honey source in honey samples is determined by the abundance of the plant, nectar potential, and flowering schedule [15].

4. Conclusion

From the field recorded result, a total of 59 and 63 plants were identified in the midland and lowlands, respectively. In the midland agroecology, small amounts (0.8 ± 0.2 g) were collected in August, increased until November (553.0 ± 57.5 g), and decreased in December (301.1 ± 5.4 g). In the lowland, the pollen load increased from no pollen in August to a peak of 499.3 ± 20.6 g in November and decreased (341.5 ± 41.5 g) in December. In both agroecologies, February, March, July, and August are the months when pollen is not brought into the hive. Season 1 had the highest pollen yields, ranging from 11051.8 ± 56.4 g (midlands) to 878.3 ± 18.3 g (lowlands), while season 4 had the lowest ranging from 16.8 ± 6.3 g (midlands) to 15.6 ± 7.4 g (lowlands) and had the lowest pollen yield season. In both regions, February, March, July, and August are the months when pollen is not brought into the hive and can be used as dearth periods. A total of 1430.8 ± 75.4 and 1291.8 ± 71.4 g of bee pollen/hive were collected throughout the year in midland and lowland, respectively. In addition, *Asteraceae* was the richest family contributing around 90% of pollen weight, and more than 50% are herbaceous plant and flowered in season 1.

In both agroecologies, honey is harvested three times a year. In the midland, monofloral honey, *Gizotia* (64.42%), and *C. macrostychus* (47.42%) were harvested in November and May, respectively, and secondary dominant plants were harvested in February from *C. arabica* (42.9%) and *Vernonia* spp. (23.46%). Similarly, in the lowlands, monofloral honey of *Guizotia* (51.85%), *C. arabica* (55.22%), and *C. macrostychus* (50.42%) were harvested in December, March, and June, respectively. Based on filed observation, bee, and honey pollen analysis, *B. prestinaria*, *B. pilosa*, *Guizotia* spp, *C. macrostachyus*, *Eucalyptus* spp, *L. sativum*, *Z. mays*, *H. trifolia*, *Vernonia* spp, *Trifolium* spp, *H. annuus*, *C. arabica*, *B. abyssinica*, *A. abyssinicus*, *S. bicolor*, *C. africana*, *S. guineense*, and *T. glaucescens* are major bee plants. The current finding concluded and recommended that season 1 (September to November) is the active period, and hence, swarm control and hive supering are required. On the other side, February, March, July, and August are a dearth period, and hence, providing supplementary feeding and hive reduction is recommended.

Data Availability

The datasets used and/or analyzed during the current study are available upon reasonable request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

We would like to thank the Oromia Agricultural Research Institute for financial support and the Holota Apiculture Research Center. We would also like to thank the botany laboratory technician for assisting in the melissopalynological analysis.

Supplementary Materials

Appendix 1: field observation and list of the registered flowering plant species and time of flowering in the study area. (*Supplementary Materials*)

References

[1] T. Jamir, H. K. Singh, A. Chauhan, S. Banik, and S. P. Kanaujia, "Studies on Impact of Stingless Bee

(Tetragonula Iridipennis) Pollination in Watermelon (Citrullus lanatus)," *The Pharma Innovation Journal 2022*, vol. 11, no. 7, pp. 4801–4804, 2022.

[2] A. Bezabeh, *Identification of Major Pollen Sources of Honey Plants Around Holetta Bee Research center*, Oromiya Agricultural Development Bureau, Oromia, Ethiopia, 2000.

[3] A. Addi, D. Lamessa, and A. Bezabeih, "Botanical inventory and phenology of bee plants in rift valley regions of East Showa Zone," *ESAP Proceedings*, vol. 31, 2005.

[4] H. R. Hepburn and S. E. Radloff, "Biogeography of the dwarf honeybees, Apis andreniformis and Apis florea," *Apidologie*, vol. 42, no. 3, pp. 293–300, 2011.

[5] T. Mulualem, E. Adgo, D. T. Meshesha et al., "Exploring the variability of soil nutrient outflows as influenced by land use and management practices in contrasting agroecological environments," *Science of the Total Environment*, vol. 786, Article ID 147450, 2021.

[6] A. Bezabeh, "Nature and phenology of honey plants in central highlands of Ethiopia," in *Proceedings of the 12th National Annual Conference of Ethiopian Society of Animal production*, Oromia, Ethiopia, November 2004.

[7] J. Louveaux, A. Maurizio, and G. Vorwohl, "Methods of melissopalynology," *Bee World*, vol. 59, no. 4, pp. 139–157, 1978.

[8] N. Adgaba, *Atlas of Pollen Grains of Major Honey Bee Flora of Ethiopia*, Holeta Bee Research Centre, Commercial Printing Enterprise, Addis Ababa, Ethiopia, 2007.

[9] A. Mulualem, A. Admasu, S. Fekadu, W. Mezgeb, and B. Amsalu, "Identification of bee floral diversity and abundance in selected districts of Arsi zone," *International Journal of Botany Studies*, vol. 6, no. 3, pp. 605–610, 2021.

[10] G. Yirga and M. Teferi, "Participatory technology and constraints assessment to improve the livelihood of beekeepers in Tigray Region, northern Ethiopia," *Momona Ethiopian Journal of Science*, vol. 2, no. 1, 2010.

[11] A. Addi and D. Lamessa, "Bee plant inventory and the pollen potentiality of Menagesha Suba State Forest for beekeeping utilization," *Ethiopian Journal of Biological Sciences*, vol. 8, no. 2, 2009.

[12] A. J. Wubie, A. Bezabeh, and K. Kebede, "Floral phenology and pollen potential of honey bee plants in North-East dry land areas of Amhara region, Ethiopia," *IOSR Journal of Agriculture and Veterinary Science*, vol. 7, no. 5, pp. 36–49, 2014.

[13] O. Tesfaye, E. Mekonen, and A. Disa, "Botanical origin and physicochemical composition of Apis mellifera L. Honey from western Oromia, Ethiopia," *Asian Journal of Bio Science*, vol. 16, no. 1, pp. 40–51, 2023.

[14] A. Addi and T. Bareke, "Review: floral resources diversity and vegetation types important for honeybees in Ethiopia," *Asian Journal of Forestry*, vol. 3, no. 2, 2019.

[15] T. Bareke and A. Addi, "Honeybee flora resources of Guji zone, Ethiopia," *Journal of Biology, Agriculture and Healthcare*, vol. 8, no. 21, pp. 1–9, 2018.