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Floral phenology and pollen potential of honey bee plants in North-East dry land areas of Amhara region, Ethiopia

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Abstract : *Beekeeping serves as a source of additional cash income for hundreds of thousands of farmer beekeepers in the country and plays a significant role in conserving the natural resources and contributes to the globe through environmental protection. Furthermore, even if the potential and success in beekeeping development is dependent first and foremost on the type and quantity of flora available, botanical composition of natural vegetation varies significantly. This study was conducted targeting identification and documentation of major honeybee floras, their phenology and pollen potential in the study area. For this, three representative agro-ecologies, respective sites and localities were selected using stratified random sampling procedures. A total of 120 Beekeepers were also purposively selected and interviewed to collect relevant information. Density and frequency of flowering plants was determined using appropriate vegetation determination techniques. Pollen was collected using pollen traps and was analyzed and verified for its traceability using appropriate mellissopalynological procedures and references. Trapped pollen analysis data were also traced back to plant species level. The study has revealed that the families diversity, directly attributed to the species diversity, in sample plots were generally higher in higher altitudes of the study area and deceasing towards lower altitudes. The density of the plant species per plot were higher for herbaceous plant species represented by plant families Pedaliaceae, Asteraceae and Papilionaceae. As a tip, 73.33% of the flowering plants identified from the trapped pollen were found to be propagated by their seeds indicating the point of entrance for rehabilitation. the highest amount of pollen was collected from those plants categorized as very good in their use to quality honey production (46.23%), in their acceptance by the bees (56.62%) and in their abundance (48.4%) comprising 22.22%, 26.67%, 31.11% and 28.89% of the total honey source plants identified throughout the study period respectively. Moreover, a total of 418.45gm of pollen (36.11%, 39.08% and 20.98% from herbaceous, shrub and tree species respectively) was collected by honeybees during the study period. It was found that 12 plant species (contributing 69.24% of the pollen) have been confirmed to be major pollen source plants of the area. Generally, we would like to recommend that wise use and rehabilitation of these potentially identified bee plant species shall be considered in attempting beekeeping development and environmental protection.*

Key words: *Bee plants, Phenology, Bee pollen, Trapped pollen, Honey bees, Pollen source, Mellissopalynology, Dry land Ethiopia.*

I. Introduction

Apiculture plays a significant role in the national economy of the country. It serves as a source of additional cash income for hundreds of thousands of farmer beekeepers in the country. Beekeeping plays a significant role in conserving the natural resources and contributes to the globe through environmental protection. Like all livestock species, bees require feeds for their production & reproduction (i.e. for colony size growth) (Fichtl R. and Admasu A., 1994). The honeybee plants provide pollen and nectar as main food sources for honeybees, while, flowering plants depend on bees as pollen vectors for their sexual reproduction and this interaction is particularly important in tropical ecosystems (Admasu et al., 1999; Araújo P.A., 2005). Bees usually forage mainly on pollen and nectar (being the later is major component in honey making).

The botanical composition of natural vegetation varies depending on the topography, climate and soil type. The potential for different hive products and success in beekeeping development is dependent first and foremost on the type and quantity of flora available (Amssalu B., 1999, 2004, 2007; Segeren P., 2004). Generally, because of the diversity of plant habitat and environmental conditions and distributions, flowering season vary from place to place (Tilahun A., 2003; Amha S., 2003). However, the study area, is the area in which the regional government has given great attention to boost beekeeping productivity, has suffered frequently from sever degradation, deforestation and low amount of rainfall and its erratic nature each year (Tilahun A., 2003) Which is much degraded and caused significant losses in vegetation cover and then number of honeybee colonies. This in turn resulted in shortage of bee forage plants to support the existing bee colony in the area (ILRI, 2000; Lakew et al., 2000). Therefore absconding and death of large number of honeybee colonies are common phenomena in the study area. This also has been amplified by the extensive loss of more than 6,000 honeybee colonies in 5 years (SWoA, 2006).

The presence of honey plants that provide pollen and nectar is very important for the existence, colony strength, production and productivity of the honeybee colony. Floral calendar of an area for beekeeping, for which it is dependent on, is a timetable that indicates the approximate durations of the blossoming (flowering) period of important bee plants and various information of the apiary (such as decision of different beekeeping managerial activities) (Amssalu B., 2004; Admasu et al., 2004). Phenology is the scientific study of periodic biological phenomena, such as the flowering of plants, in relation to climatic conditions, such as the number of days in flowering (length of flowering) (Amssalu B., 2007; FAO, 1987). Melissopalynological studies helps us to know the abundance, distribution, honey potential and phenological calendars of the vegetation in the area, when if combined beekeeping with plantations for producing high quality and quantity honey (Musarrat G., 2002). The analysis of honeybee pollen can further improve our knowledge of bee flora and vegetation.

Thus, identification and registration of honeybee flora in different agro-ecological zones, the value of different honey plants as sources of nectar and pollen or both, their life form, possible ways of propagation and their potential for honey production is a paramount importance (EARO, 2001). Moreover, beekeepers must have a working knowledge of flowering periods of both major and minor nectar and pollen producing plants in the vicinity of their apiaries for successful honey production to enable them determining when to carry out various management practices with their colonies (Francis G.S., 1990; Pearson W.D. and Braiden V., 1990).

II. Material and methods

Description of the study area

The study area (Fig. 1) represents three major and three sub agro-ecological zones (hot to warm sub-moist agro ecology having an altitude of <1500m, moderate or tepid sub-moist agro ecology having an altitude of 1500 - 1800m and cold sub-moist agro ecology of 1800 - 2200m altitude (MoA, 1998)). The majority (71.7 %) of the area lies in the moderate sub-moist agro ecology while hot to warm sub moist comprises about 27.1 % and cold sub-moist agro ecology occupies only 1.2 % of the area (MOA, 1998). The annual rainfall varies between 350 and 650 mm (AMAREW, 2006). Generally, the topography of the study area is rugged and chain of mountain terrains which limits seriously access to the various parts.

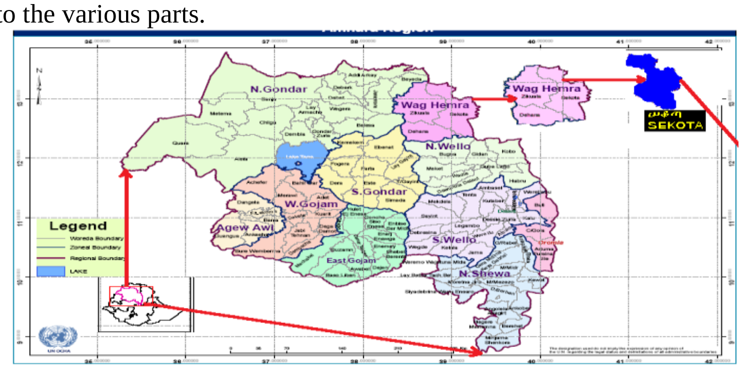

Figure 1: Administrative zones, districts and the study area in North-East Amhara, Ethiopia

III. Data collection

Bee flora inventory

Reconnaissance survey was employed to become familiar with the area, to get an insight on the vegetation distribution in the landscape, to observe and locate the possible traverses during the actual study. The study was conducted in three representative agro-ecologies of the study area representing lowland, which is <1500 masl, *the* midland, which is between 1500 and 1900 and highland, which is b/n 1900 and 2200 masl. With this, stratified random sampling procedure was followed to select the representative sites based on the strata made prior to the survey (i.e. agro-ecological representations) to exploit the different ecologies of the study area. Beekeeper farmers were also purposefully selected in order to collect the appropriate information on honey source plant lists, phenology (flowering period and duration), etc.

Informal survey tools & structured questionnaire were also used to strengthen the data. A total of three localities and key informants were selected for local names identification of plants. Samples of matrix ranking based prioritized flora types during formal and informal surveys were collected for further analysis according to the National Herbarium Specimen Collection techniques. Plants, which were not identified, for their taxonomic names, in the field using the indigenous knowledge and other references were categorized as unidentified. The importance of each plant in beekeeping as minor, medium and major honey sources were also determined using the PRA ranking tools and laboratory evidences. Besides, pictures of bee plants were taken to use as an identification tool and documentation.

Honey plant density and frequency

The frequency and abundance of honey source plants were estimated using a 20m x 20m, 5m x 5m, 1m x1m quadrant for shrub and tree, herb and grass species respectively in a 2 km radius every 0.5 km distance from the hives, to understand forgeable area of honey plants by the representative bee colonies. The types of plants which were found in the quadrants were registered for their total number and local names. A total of 16 plots were recorded for each of the representative sites and the occurrence of each plant species in each of the plots was noted and density was calculated in hectare.

Pollen trapping and analysis

Six medium sized honeybee colonies were placed in each representative site of both agro-ecologies. Pollen loads, from in coming foragers, were trapped using pollen traps, fitted on the hive entrance. Trapped pollen pellets were then collected and labelled on daily basis for a total of 240 days and allowed to dry overnight at room temperature. Collected pollen pellets were also weighed for fresh and dry weight and sorted by colour. Each colour fractions were weighed independently and recorded.

Pollen grain samples from each colour representative pellets were taken and dissolved in a drop of water and mounted on a microscope slide and observed through a light microscope. On the other hand, reference slides were prepared from ripened pollen grains collected from ether washed honey plants' mature flower buds to support and verify bee pollen source plant species in the study area. Pollens which we couldn't identify botanically from both analyses techniques have been categorized as "*unidentified*".

Statistical data analysis

Data from pollen fresh and final weight, pollen weights collected per month, per plant family, per study sites and moisture content of honey were organized, verified, analysed and interpreted using JMP 5.0 (The Statistical Discovery Software SAS Institute Package, 2002) for ANOVA and Correlation. Data from pollen trapping were traced back to plant species level with the help of reference books, pollen atlas, and prepared pollen reference slides.

IV. Results and discussion

Honeybee flora inventory

Important flowering plants in the study area have been presented in local and scientific names with their respective families in table 1. Most of these plant species mentioned by respondents during the survey were similar to those identified through plant inventory and density analysis (Table 2). This has indicated that both results supported each other and indigenous knowledge of the farmers is dependable.

The bees obtain their food, and raw materials for all the hive products of interest to man such as honey, wax, and propolis directly or indirectly from plants. Among many factors, availability of potential flowering plants is the main parameter for an area to be considered as potential for honey production. According to the results of this survey, the honey bee plants of the study area comprised trees, shrubs, herbs, grasses and cultivated crops. Moreover, the species with their composition and population varies widely from area to area. Recent studies have revealed that the expansion of agriculture and rapid population growth resulted in dwindling of the forest into tiny leftovers, which are found around religious compounds and certain un-accessible escarpments of the region.

Consequently, shrubs, herbs and cultivated crops have largely replaced the previous forest vegetations which remained to be only 0.7% vegetation cover in the region (Azene *et al*., 1993). This shows that in the region in general and the study area in particular, there is high level of natural resources degradation which demands strong conservation and rehabilitation activities.

The diversity of families as a result of species diversity was higher in the higher altitude (28 species in18 Families) compared to mid altitude (24 species in 17 families) and lower altitude (22 species in 11 families) (Tables 3 - 5). This may be attributed to low and mid lands have low rainfall, and thus suppresses the growth of different plant species. However, this doesn't mean that areas with higher number of plant diversity are good for honey production, as honey production is more determined by plant density and abundance. As a result, the inventory result has showed that top 15 plant species of the study area which were found in 48.12% of the sample plots constituting 77.62% of the plant species counted.were considered as dominant (major) honey bee plants (Table 2).

Honey bee plant species *Guizotia abyssinica, Bidens spp., Echinops Spp., Vicia faba, Cynodon dactylon, Acacia seyal, Hypoestes trifolia, Becium grandiflorum, Acacia tortolis* and *Ocimum bacilicum* were the top 10 (more frequent) plants in most sample plots of the highland representative area where *Acacia asak, Sorghum bicolor, Sesamum indicum, Acacia mellifera, Acacia tortolis, Acacia seyal, Acacia brevispica, Bidens spp., grass spp.* and *Grewia bicolor* were the more frequent ones in the lowland while *Hypoestes trifolia, Ocimum bacilicum, Acacia tortolis, Becium grandiflorum, Bidens spp., Acacia seyal, Sorghum bicolor, Echinops spp., Vicia faba* and *Guizotia abyssinica* were the dominant ones in the midland altitude representation.

In this regard, higher plant frequencies are known to be the best indicators of adaptation to the area and local climates. For instance *Mimosaceae* was the most frequent family in sample quadrate due to its growing habit in degraded areas and harsh climate conditions. This result is in agreement with the findings of Amssalu B., (2001), which indicated that density value of the plant species per plots were higher for herbaceous plant species in higher altitudes represented by plant families *Pedaliaceae, Asteraceae* and *Papilionaceae.* In this study, we have found that *Asteraceae, Acanthaceae and Pedaliaceae* families were the plant families in higher densities in the highland , midland and lowland representing sample plots respectively (Tables 3 - 5). On the other hand tree and shrub densities were lower in the study area due to deforestation, perhaps.

Table 1: **List of honey bee plants in the study area given by the respondents (1=Very good, 2=Good, 3=Poor)**

No.	Local Name	Scientific Name	Family Name	Plant Abundance	Its use to quality Honey	Preference by the bees	Life Form	Food source	Flowering Time (Month)	No of days stayed during flowering	Means of Propagation
1	Echileqana	*Acacia brevispica*	*Mimosaceae*	1	2	2	Shrub	Pol/Nec	May	30	Seed
2	Gumarna	*Acacia mellifera*	*Mimosaceae*	1	1	1	Shrub	Pol/Nec	May	30	Seed
3	Tsalwa	*Acacia asak*	*Mimosaceae*	1	1	1	Tree	Pol/Nec	April	60	Seed
4	Key Girar	*Acacia seyal*	*Mimosaceae*	2	2	2	Tree	Pol/Nec	May	45	Seed
5	Abiqa	*Acacia tortolis*	*Mimosaceae*	1	2	1	Tree	Pol/Nec	May	60	Seed
6	Aluma	*Achyranthus spp.*	*Amaranthaceae*	3	3	2	Herb	Pol/Nec	September	10	Seed
7	Firtata	*Adansonia digitata*	*Bombacaceae*	3	3	3	Tree	Pol/Nec	June	25	Seed
8	Chiret	*Agave spp.*	*Agavaceae*	2	3	3	Shrub	Pol/Nec	September	30	Vegetative
9	Sibqana	*Albezia amara*	*Mimosaceae*	2	3	3	Tree	Pol/Nec	May	30	Seed
10	Malqoza	*Asparagus spp.*	*Liliaceae*	2	3	3	Shrub	Pol/Nec	March	45	Seed
11	Goza	*Balanite aegyptica*	*Balanitaceae*	1	2	2	Tree	Pol/Nec	April	45	Seed
12	Mentese	*Becium grandiflorum*	*Lamiaceae*	1	1	1	Shrub	Pol/Nec	July	90	Seed/Veg
13	Adey Abeba	*Bidens spp.*	*Asteraceae*	3	2	1	Herb	Pol/Nec	August	15	Seed
14	Shisha	*Boscia anguistifolia*	*Capparidaceae*	2	3	3	Tree	Pol/Nec	April	60	Seed
15	Gomen Zer	*Brassica spp.*	*Brassicaceae*	2	3	2	Herb	Pol/Nec	September	15	Seed
16	Wanza	*Cordia africana*	*Boraginaceae*	3	2	1	Tree	Pol/Nec	May	60	Seed
17	Serdo	*Cynodon dactylon*	*Poaceae*	2	3	3	Grass	Pollen	August	5	Seed/Veg

18	Wariat	*Digitaria abyssinica*	*Poaceae*	2	3	3	Grass	Pollen	August	5	Seed/Veg
19	Kushele	*Echinops spp.*	*Asteraceae*	1	1	1	Shrub	Nectar	September	25	Seed
20	Akrma	*Eluesine folicofolia*	*Poaceae*	3	3	2	Grass	Pollen	August	5	Seed/Veg
21	Bahir Zaf	*Eucalyptus camaldlensis*	*Myrtaceae*	2	2	1	Tree	Pol/Nec	May	30	Seed
22	Dedeho	*Euclea shimperi*	*Ebenaceae*	1	1	1	Shrub	Pol/Nec	March	45	Seed
23	Kulqual	*Euphorbia Spp.*	*Euphorbiaceae*	3	2	2	Shrub	Pol/Nec	March	15	Vegetative
24	Saha	*Grewia bicolor*	*Tiliaceae*	3	2	2	Shrub	Pol/Nec	June	21	Seed
25	Matta	*Grewia villosa*	*Tiliaceae*	2	2	1	Shrub	Pol/Nec	July	15	Seed
26	Nug	*Guizotia abyssinica*	*Asteraceae*	2	2	1	Herb	Pol/Nec	September	15	Seed
27	Yeferenj Suf	*Helianthus annuus*	*Asteraceae*	2	2	3	Herb	Pol/Nec	September	15	Seed
28	Senbelet	*Hyparrhenia rufa*	*Poaceae*	2	3	3	Grass	Pollen	August	5	Seed/Veg
29	Tej Matebia	*Hypoestes trifolia*	*Acanthaceae*	1	1	1	Herb	Pol/Nec	September	15	Seed
30	Mango	*Mangifera indica*	*Anacardiaceae*	3	3	3	Tree	Pol/Nec	April	25	Seed
31	Aba Timara	*Ocimum bacilicum*	*Lamiaceae*	1	1	1	Herb	Pol/Nec	August	21	Seed
32	Bahir Kulqual	*Opuntia Spp.*	*Cactaceae*	3	2	2	Shrub	Pol/Nec	June	45	Vegetative
33	Zeyitun	*Psidium guijava*	*Myrtaceae*	3	3	3	Tree	Pol/Nec	March	30	Seed
34	Kentafa	*Pterolobium stellatum*	*Caesalpiniaceae*	2	3	1	Shrub	Pol/Nec	March	30	Seed
35	Enbacho	*Rumex nervosus*	*Polygonaceae*	3	3	3	Shrub	Pol/Nec	March	30	Seed
36	Qundo Berberie	*Schinus molle*	*Anacardiaceae*	3	3	3	Tree	Pol/Nec	March	45	Seed
37	Selit	*Sesamum indicum*	*Pedaliaceae*	1	1	2	Herb	Pol/Nec	August	15	Seed
38	Mashila	*Sorghum bicolor*	*Poaceae*	1	1	1	Herb	Pollen	September	21	Seed
39	Dokima	*Syzygium guineens*	*Myrtaceae*	3	3	3	Tree	Pol/Nec	April	60	Seed
40	Ekima	*Terminalia glaucescens*	*Combretaceae*	3	1	2	Tree	Pol/Nec	April	15	Seed
41	Maget	*Trifolium Spp.*	*Papilionaceae*	2	3	2	Herb	Nectar	August	5	Seed/Veg
42	Sar	*Unidentified grass spp.*	*Poaceae*	2	3	3	Grass	Pollen	August	3	Seed/Veg
43	Tihuan Tila	*Verbena officinalis*	*Verbenaceae*	3	3	3	Herb	Pol/Nec	July	30	Seed
44	Girawa	*Vernonia Spp.*	*Asteraceae*	3	3	2	Shrub	Nectar	April	15	Seed
45	Bakiela	*Vicia faba*	*Papilionaceae*	1	2	2	Herb	Pol/Nec	September	15	Seed
46	Bekolo	*Zea mays*	*Poaceae*	3	3	3	Herb	Pollen	August	5	Seed
47	Giba	*Ziziphus spinachristi*	*Rhamnaceae*	2	2	2	Tree	Pol/Nec	September	45	Seed

Table 2: Density and frequency of honey plants in sample quadrants

No.	Scientific Names	Family Names	Plant Count	Plant Density Per ha	No. of Plots of Observation
1	*Guizotia abyssinica*	*Asteraceae*	139	3475	1
2	*Bidens spp.*	*Asteraceae*	117	2925	11
3	*Acacia tortolis*	*Mimosaceae*	84	2100	8
4	*Becium grandiflorum*	*Lamiaceae*	82	2050	5
5	*Hypoestes trifolia*	*Acanthaceae*	78	1950	7
6	*Vicia faba*	*Papilionaceae*	77	1925	6
7	*Sorghum bicolor*	*Poaceae*	75	1875	13
8	*Acacia asak*	*Mimosaceae*	73	1825	11
9	*Vernonia Spp.*	*Asteraceae*	70	1750	2
10	*Acacia mellifera*	*Mimosaceae*	68	1700	6
11	*Sesamum indicum*	*Pedaliaceae*	66	1650	10
12	*Acacia seyal*	*Mimosaceae*	65	1625	13
13	*Ocimum bacilicum*	*Lamiaceae*	64	1600	13
14	*Brassica spp.*	*Brassicaceae*	63	1575	2
15	*Echinops spp.*	*Asteraceae*	61	1525	7
16	*Un-Identified grass spp.*	*Poaceae*	60	1500	5
17	*Acacia brevispica*	*Mimosaceae*	59	1475	6
18	*Albezia amara*	*Mimosaceae*	58	1450	5
19	*Hyparrhenia rufa*	*Poaceae*	55	1375	8
20	*Grewia bicolor*	*Tiliaceae*	52	1300	3
29	*Euclea shimperi*	*Ebenaceae*	52	1300	7
21	*Cyperus spp.*	*Cyperaceae*	51	1275	5
22	*Eluesine floccifolia*	*Poaceae*	49	1225	6
30	*Aloe berhana*	*Liliaceae*	48	1200	4
24	*Opuntia Spp.*	*Cactaceae*	47	1175	6
25	*Cynodon dactylon*	*Poaceae*	45	1125	13
31	*Eucalyptus camaldlensis*	*Myrtaceae*	27	675	4
32	*Ziziphus spinachristi*	*Rhamnaceae*	25	625	4
27	*Rumex nervosus*	*Polygonaceae*	23	575	4
33	*Euphorbia Spp.*	*Euphorbiaceae*	17	425	3
36	*Balanite aegyptica*	*Balanitaceae*	17	425	4
34	*Achyranthus spp.*	*Amaranthaceae*	15	375	8
40	*Pterolobium stellatum*	*Caesalpiniaceae*	13	325	1
35	*Agave sisalana*	*Agavaceae*	9	225	5
23	*Cordia africana*	*Boraginaceae*	8	200	1
26	*Helianthus annus*	*Asteraceae*	7	175	1
28	*Digitaria abyssinica*	*Poaceae*	5	125	1
37	*Grewia villosa*	*Tiliaceae*	5	125	4
43	*Asparagus spp.*	*Liliaceae*	5	125	6
38	*Boscia anguistifolia*	*Capparidaceae*	4	100	4
41	*Terminalia glaucescens*	*Combretaceae*	4	100	1
42	*Carica papaya*	*Caricaceae*	3	75	3
39	*Cadaba farinosa*	*Capparidaceae*	2	50	2

Table 3: Honey plant families and their frequency of occurrence in the highlands

Family Name	Plant Count	Plant Density per ha	No. of Species
Asteraceae	504	700.0	5
Papilionaceae	100	416.7	1
Lamiaceae	149	206.9	2
Acanthaceae	44	157.1	1
Mimosaceae	114	135.7	2
Poaceae	198	130.3	5
Tiliaceae	14	116.7	1
Cyperaceae	20	100.0	1
Polygonaceae	16	100.0	1
Ebenaceae	27	96.4	1
Brassicaceae	17	85.0	1
Cactaceae	17	70.8	1
Agavaceae	9	45.0	1
Boraginaceae	7	43.8	1
Euphorbiaceae	4	33.3	1
Myrtaceae	5	31.3	1
Caesalpiniaceae	1	25.0	1
Caricaceae	2	16.7	1

Table 4: Honey plant families and their frequency of occurrence in the midlands

Family Name	Plant Count	Plant Density per ha	No. of Species
Acanthaceae	113	256.8	1
Cyperaceae	24	200.0	1
Lamiaceae	152	181.0	2
Mimosaceae	132	165.0	2
Papilionaceae	32	160.0	1
Asteraceae	132	137.5	4
Brassicaceae	9	112.5	1
Polygonaceae	7	87.5	1
Poaceae	104	81.3	4
Cactaceae	16	80.0	1
Myrtaceae	10	41.7	1
Boraginaceae	1	25.0	1
Combretaceae	1	25.0	1
Ebenaceae	2	25.0	1
Euphorbiaceae	3	25.0	1
Liliaceae	6	25.0	1

Table 5: Honey plant families and their frequency of occurrence in the lowlands

Family Name	Plant Count	Plant Density per ha	No. of Species
Pedaliaceae	160	400.0	1
Mimosaceae	591	378.8	6
Poaceae	224	350.0	3
Asteraceae	69	123.2	2
Rhamnaceae	15	93.8	1
Cactaceae	11	91.7	1
Tiliaceae	21	87.5	2
Amaranthaceae	15	46.9	1
Balanitaceae	7	43.8	1
Liliaceae	13	32.5	2
Capparidaceae	6	25.0	2

Honey plant phenology (flowering period)

The phenological picture of total flowering, defines the changes in the seasonal landscape over the study area (Figure 2). Honey plants flower throughout the study period except in June, July and October in midland, highland and lowland representative sites respectively. However, the highest proportion of honey plants flowers during August through October, with the peak in August and September and March to May with their peak in March (Figure 2). This has explained that August to October is the major and March to May is the minor honey flow periods of the study area. This may explain the reason why flowering period differ also in each agro-ecologies of the study area. Thus honey plant phenology in the study area is considered to be biphasic. However, the minor honey flow period of the area is preceded by the short rainy season (*'Belg'*), mostly which is not frequent.

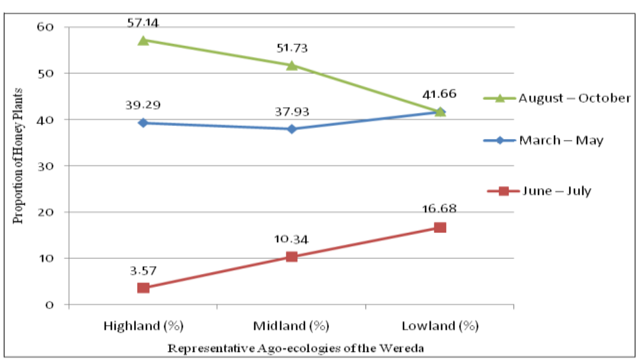

Figure 2: Flowering periods of honey plants

As it is explained by Hepburn & Radloff (1998) and we understood, the major rains occur in summer (*'Kiremt'*) following which flowering intensity reaches a peak in autumn, flowering phenology characteristic of the herbaceous flora throughout the country at large and the study area in particular is highly boosted.

Trapped pollen analysis

From the trapped pollen analysis, we have found that pollens of 27 plant families comprised of 45 species of plants were collected by honey bees of which 8.89%, 31.11 %, 35.56% and 24.44 % were grasses, herbs, shrubs and trees respectively (Table 6). In this study, the honey bees have collected pollen for a total of 207 days in the highland, 193 days in the midland and 196 days in the lowland areas.

Table 6: Nature of honey plants

Site	No. of Plant Species	No. of Families	Grasses	%	Herbs	%	Shrubs	%	Trees	%
Highland	28	16	2	7.1	8	28.6	10	35.7	8	28.6
Midland	29	17	3	10.3	9	31.0	10	34.5	7	24.1
Lowland	24	15	1	4.2	6	25.0	7	29.2	10	41.7

As suggested by Diaz L. *et al.*, (1998) from a study conducted in Italy that pollen composition from beehives showed the different characteristics of local vegetations. This also showed that the local floras have characteristic plant associations that are reflected in the corresponding spectrum of pollen types represented in the local honeys and honey carries its certificates of origin (Nuru A. *et at.,* 2001; Nuru A., 2007).

When we see the food sources obtained by honeybees from bee plants of the area, all grass species were only pollen source plants. Whereas, among a total of 14 herb species, 12 of them provided both pollen and nectar and 1 species is a nectar source and the remaining 1 is a pollen source plant. 14 species out of 16 shrubs provided pollen and nectar and only 2 are nectar sources. However all tree species identified was found to be both a pollen and nectar source plants (Table 7).

Table 7: Food sources of honey plants

Site	No. of Plant Species	No. of Families	Pollen Source Plants	%	Pollen and Nectar Source Plants	%	Nectar Source Plants	%
Highland	28	16	0	0.0	25	89.3	3	10.7
Midland	29	17	1	3.4	25	86.2	3	10.3
Lowland	24	15	0	0.0	22	91.7	2	8.3

The identification of bee-collected pollen loads from pollen traps indicated not only the plants from which the honeybees had collected the pollen but it also showed the relative importance of each plant species as a pollen source. The total amount of pollen collection from lower altitude representations was lower in quantity. This may be attributed to high temperature, insufficient moisture and erratic rainfall enforcing the flowering plants to bloom for short period of time while the flowering periods of the plants in the higher altitudes extends up to end of October enhancing longer period of blooming which has resulted in higher amounts of pollen collections.

Even if there are 250,000 species of plants throughout the world visited by honeybees of which 4000 are considered to be the most important honey source plants (Irene, 2005), at least 45 species of bee plants have been visited by honeybees in the study area. However, a final perspective should be gained by considering the relative breadth and depth of plant species utilization by honeybees. Although honeybees are considered as florally promiscuous, studies on pollen source plant species uniformly demonstrated that a narrow band of species in a wide spectrum of floral choices was actually used at a significant level in the study area.

As explained by various studies, the trait of flower constancy has gone a long way in explaining selectivity of honeybees in pollen foraging. Likewise, the temporal periodicity of available pollen in bee plants further modified a final account of pollen utilization over the seasons (Amssalu B., 1999).

Even though honeybees frequently are making use of the floral resources available closer to the beehives, the presence of a specific combination of pollen types in a sample has indicated their botanical and geographical origins (Diaz L. *et al.*, 1998). Furthermore, as it has been observed in this study, this has indicated the width and breadth of floral resources in the area. However, Amssalu B. (2001) reported that even if different types of honey bee plants were observed in the highlands of Ethiopia, the broad generalizations relating honeybee colony cycles to the phenology of flowering and climate do not reflect the collection of pollen by honeybees with regard to seasonal plant species diversity.

As it was evidenced by respondents, very good, good and poor bee plants in different parameters have showed a significant difference in pollen yield among themselves. Consequently, very good plants in their use to quality honey production, in preference by the honey bees and in abundance have provided the highest pollen yield (46.23%, 56.62% and 48.40% respectively) Table 8. However, the amount of pollen collected by honeybees varied over the seasons. This result has also showed that in the absence of pollen analysis, use of experienced beekeeper farmers could be worthy enough to identify the potential honey source plants in a given area.

Table 8: Criteria of selection of bee plants and their contribution to total pollen yield.

Criteria of Selection	Grades Given	No. of Plant Species	%	Total Pollen Yield (gm)	% Contribution
Its Use to Quality Honey Production	Very good	12	26.67	193.43	46.23
	Good	10	22.22	123.86	29.60
	Poor	23	51.11	101.16	24.17
Preference by the bees	Very good	14	31.11	236.93	56.62
	Good	18	40.00	136.44	32.61
	Poor	13	28.89	45.08	10.77
Plant Abundance	Very good	13	28.89	202.52	48.40
	Good	15	33.33	120.94	28.90
	Poor	17	37.78	94.99	22.70

Furthermore, the respondents have indicated that 73.33% of the flowering plants identified from the trapped pollen are propagated by their seeds only, 15.56% by their seeds and vegetative means, and 8.89% by vegetative means only (Table 9).

Table 9: Methods of propagation of bee plants

Site	No. of Plant Species	No. of Families	Seed	%	Seed/Vegetative	%	Vegetative	%
Highland	28	16	21	75.0	4	14.3	3	10.7
Midland	29	17	21	72.4	4	13.8	4	13.8
Lowland	24	15	20	83.3	1	4.2	3	12.5

Major pollen source plant species identified in the trapped pollen analysis were varied across sampling areas of the study area which has confirmed that the type of vegetation reflects the agro-ecologies of the area. In this study, a higher quantity of pollen (183.43gm) was collected from the highland representations than the midland (145.92gm) and lowland (91.22gm) areas (Tables 10 – 12). More specifically, 65.94%, 67.52% and 56.44% of the total pollen collected was from 7, 8 and 10 plant species in the mid, lower and higher altitudes of the study area respectively. This has implied that species diversity of honey bee plants was higher in the highland sites. In fact, this is attributed to the higher moisture in the highland has favoured the growth and flowering of various bee plants compared to the lowland and midland representatives. Meanwhile, *Acacia tortolis (*7.74%*), Ocimum bacilicum (*6.99%*), Becium grandiflorum (*6.45%*), Hypoestes trifolia (*6.44%*), Sorghum bicolor (*6.10%*), Bidens spp. (*5.85%*)* and *Guizotia abyssinica (*5.69%*)* were the major contributors (about 45.26%) of pollen income in the study area (Table 13). Even though honeybees collected pollen from 27 plant families in this study, the major pollen source bee plant families were *Asteraceae*, *Mimosaceae*, *Lamiaceae*, *Poaceae*, *and Acanthaceae* contributing 19.95%, 15.19%, 14.33%, 9.74% and 7.24% of the total pollen collection respectively (Table 14).

Table 10: Identified bee plant species from trapped pollen in the midland

Local Name	Scientific Name	Family Name	Pollen Weight (gm)	Life Form	Food source	Flowering Time (Month)	No of days stayed during flowering	Means of Propagation
Tej Matebia	*Hypoestes trifolia*	*Acanthaceae*	18.32	Herb	Pol/Nec	September	15	Seed
Mentese	*Becium grandiflorum*	*Lamiaceae*	17.11	Shrub	Pol/Nec	July	90	Seed/Veg
Aba Timara	*Ocimum bacilicum*	*Lamiaceae*	15.69	Shrub	Pol/Nec	August	21	Seed
Abiqa	*Acacia tortolis*	*Mimosaceae*	13.89	Tree	Pol/Nec	May	60-75	Seed
Kushele	*Echinops spp.*	*Asteraceae*	10.72	Shrub	Nectar	September	25	Seed
Nug	*Guizotia abyssinica*	*Asteraceae*	10.52	Herb	Pol/Nec	October	15	Seed
Mashila	*Sorghum bicolor*	*Poaceae*	8.57	Herb	Pol/Nec	September	21	Seed
Gomen Zer	*Brassica spp.*	*Brassicaceae*	5.36	Herb	Pol/Nec	September	15	Seed
Adey Abeba	*Bidens spp.*	*Asteraceae*	4.85	Herb	Pol/Nec	August	10	Seed
Sar	*Un Identified spp.*	*Poaceae*	4.23	Grass	Pollen	August	5	Seed/Veg
Bahir zaf	*Eucalyptus camaldulensis*	*Myrtaceae*	3.99	Tree	Pol/Nec	April	90-120	Seed
Bakiela	*Vicia faba*	*Papilionaceae*	3.45	Herb	Pol/Nec	August	25	Seed
Saha	*Grewia bicolor*	*Tiliaceae*	2.93	Shrub	Pol/Nec	June	21	Seed
Eriet	*Aloe berhana*	*Liliaceae*	2.82	Shrub	Pol/Nec	September	45	Vegetative
Kentafa	*Pterolobium spp.*	*Caesalpiniaceae*	2.72	Shrub	Pol/Nec	September	30	Seed
Giba	*Ziziphus spinachristi*	*Rhamnaceae*	2.58	Tree	Pol/Nec	September	45	Seed

Girawa	*Vernonia Spp.*	*Asteraceae*	2.45	Shrub	Nectar	April	15	Seed
Bahir Kulqual	*Opuntia Spp.*	*Cactaceae*	2.41	Shrub	Pol/Nec	May	30	Vegetative
Qundo Berbere	*Schinus molle*	*Anacardiaceae*	1.90	Tree	Pol/Nec	March	45	Seed
Maget	*Trifolium Spp.*	*Papilionaceae*	1.62	Herb	Nectar	July	15	Seed
Tirunba Abeba	*Zantadescha aethiopica*	*Araceae*	1.56	Herb	Pol/Nec	September	15	Seed
Suf	*Helianthus annuus*	*Asteraceae*	1.44	Herb	Pol/Nec	September	15	Seed
Bekolo	*Zea mays*	*Poaceae*	1.34	Herb	Pollen	August	5	Seed
Feto	*Lepidium sativum*	*Brassicaceae*	1.13	Herb	Pol/Nec	September	15	Seed
Sensel	*Justicia shimeriana*	*Acanthaceae*	1.04	Shrub	Pol/Nec	August	15	Seed/Veg
Kulqual	*Euphorbia Spp.*	*Euphorbiaceae*	0.80	Shrub	Pol/Nec	October	45	Vegetative
Gumero	*Capparis micrantha*	*Capparidaceae*	0.36	Shrub	Pol/Nec	June	25	Seed/Veg

Table 11: Identified bee plant species from trapped pollen in the lowland

Local Name	Scientific Name	Family Name	Pollen Weight (gm)	Life Form	Food Source	Flowering Time (Month)	No. of days stayed during flowering	Means of Propagation
Tsalwa	*Acacia asak*	*Mimosaceae*	10.17	Tree	Pol/Nec	April	60	Seed
Gumarna	*Acacia mellifera*	*Mimosaceae*	9.44	Shrub	Pol/Nec	May	30	Seed
Key Girar	*Acacia seyal*	*Mimosaceae*	8.05	Tree	Pol/Nec	May	30	Seed
Abiqa	*Acacia tortolis*	*Mimosaceae*	7.90	Tree	Pol/Nec	May	60	Seed
Selit	*Sesamum indicum*	*Pedaliaceae*	7.84	Herb	Pol/Nec	August	15	Seed
Mashila	*Sorghum bicolor*	*Poaceae*	7.42	Herb	Pol/Nec	September	15	Seed
Adey Abeba	*Bidens spp.*	*Asteraceae*	5.43	Herb	Pol/Nec	August	15	Seed
Bahir Kulqual	*Opuntia Spp.*	*Cactaceae*	5.34	Shrub	Pol/Nec	July	30	Vegetative
Eriet	*Aloe spp.*	*Liliaceae*	4.38	Shrub	Pol/Nec	September	20	Vegetative
Saha	*Grewia bicolor*	*Tiliaceae*	4.26	Shrub	Pol/Nec	September	10	Seed
Giba	*Ziziphus spinachristi*	*Rhamnaceae*	4.19	Tree	Pol/Nec	September	45	Seed
Echileqana	*Acacia brevispica*	*Mimosaceae*	3.52	Shrub	Pol/Nec	May	30	Seed
Kulqual	*Euphorbia Spp.*	*Euphorbiaceae*	3.12	Shrub	Pol/Nec	March	15	Vegetative
Sar	*Un-Identified spp.*	*Poaceae*	3.12	Grass	Pollen	August	3	Seed/Veg
Girawa	*Vernonia Spp.*	*Asteraceae*	3.11	Herb	Nectar	August	25	Seed
Goza	*Balanite aegyptica*	*Balanitaceae*	1.77	Tree	Pol/Nec	April	45	Seed
Aluma	*Achyranthus spp.*	*Amaranthaceae*	1.67	Herb	Pol/Nec	September	10	Seed
Maget	*Trifolium Spp.*	*Papilionaceae*	0.31	Herb	Nectar	August	3	Seed
Gorteb	*Plantago spp.*	*Plantaginaceae*	0.18	Grass	Pollen	August	10	Seed

Table 12: Identified bee plant species from trapped pollen in the highland

Local Name	Scientific Name	Family Name	Pollen Weight (gm)	Life Form	Food Source	Flowering Time (Month)	No of days stayed during flowering	Means of Propagation
Adey Abeba	*Bidens spp.*	*Asteraceae*	14.18	Herb	Pol/Nec	September	15	Seed
Aba Timara	*Ocimum bacilicum*	*Lamiaceae*	13.54	Shrub	Pol/Nec	August	25	Seed
Nug	*Guizotia abyssinica*	*Asteraceae*	13.31	Herb	Pol/Nec	September	15	Seed
Abiqa	*Acacia tortolis*	*Mimosaceae*	10.60	Tree	Pol/Nec	April	30	Seed
Mentese	*Becium grandiflorum*	*Lamiaceae*	9.86	Shrub	Pol/Nec	August	60	Seed/Veg
Mashila	*Sorghum bicolor*	*Poaceae*	9.54	Herb	Pol/Nec	September	35	Seed
Girawa	*Vernonia Spp.*	*Asteraceae*	9.25	Shrub	Nectar	August	15	Seed
Tej Matebia	*Hypoestes trifolia*	*Acanthaceae*	8.63	Herb	Pol/Nec	September	15	Seed
Bahir Zaf	*Eucalyptus camaldlensis*	*Myrtaceae*	7.47	Tree	Pol/Nec	May	30	Seed
Kushele	*Echinops Spp.*	*Asteraceae*	7.15	Shrub	Nectar	October	60	Seed
Wanza	*Cordia africana*	*Boraginaceae*	6.70	Tree	Pol/Nec	March	21	Seed
Saha	*Grewia bicolor*	*Tiliaceae*	6.62	Shrub	Pol/Nec	June	21	Seed

Gomen Zer	*Brassica spp.*	*Brassicaceae*	6.29	Herb	Pol/Nec	September	15	Seed
Kulqual	*Euphorbia Spp.*	*Euphorbiaceae*	5.02	Shrub	Pol/Nec	October	25	Vegetative
Kentafa	*Pterolobium stellatum*	*Caesalpiniaceae*	4.59	Shrub	Pol/Nec	March	30	Seed
Bakiela	*Vicia faba*	*Papilionaceae*	4.18	Herb	Pol/Nec	September	15	Seed
Eriet	*Aloe berhana*	*Liliaceae*	4.05	Shrub	Pol/Nec	September	15	Vegetative
Yefyel Gomen	*Plectranthus spp.*	*Lamiaceae*	3.76	Herb	Pol/Nec	August	15	Seed
Feto	*Lepidium sativum*	*Brassicaceae*	3.52	Herb	Pol/Nec	September	15	Seed
Akrma	*Eluesine folicofolia*	*Poaceae*	3.38	Grass	Pollen	August	5	Seed/Veg
Giba	*Ziziphus spinacristi*	*Rhamnaceae*	3.32	Tree	Pol/Nec	September	45	Seed
Sar	*Un-Identified spp.*	*Poaceae*	3.15	Grass	Pollen	August	5	Seed/Veg
Maget	*Trifolium Spp.*	*Papilionaceae*	2.35	Herb	Nectar	August	5	Seed/Veg
Enbacho	*Rumex nervosus*	*Polygonaceae*	2.34	Shrub	Pol/Nec	March	30	Seed
Sensel	*Justicia spp.*	*Acanthaceae*	2.32	Shrub	Pol/Nec	August	15	Seed/Veg
Tirunba Abeba	*Zantadescha spp.*	*Araceae*	2.19	Herb	Pol/Nec	September	15	Seed
Bahir Kulqual	*Opuntia Spp.*	*Cactaceae*	2.04	Shrub	Pol/Nec	May	25	Vegetative
Gicha	*Cyperus spp.*	*Cyperaceae*	1.92	Grass	Pollen	August	5	Seed/Veg
Mango	*Mangifera indica*	*Anacardiaceae*	1.92	Tree	Pol/Nec	April	25	Seed
Gumero	*Capparis micrantha*	*Capparidaceae*	1.74	Shrub	Pol/Nec	June	25	Seed/Veg
Chiret	*Agave sisalana*	*Agavaceae*	1.59	Shrub	Pol/Nec	September	30	Vegetative
Qundo Berberie	*Schinus molle*	*Anacardiaceae*	1.39	Tree	Pol/Nec	April	30	Seed
Aluma	*Achyranthus aspera*	*Amaranthaceae*	1.25	Herb	Pol/Nec	September	10	Seed
Teketila	*Tapinanthus aurantias*	*Loranthaceae*	1.22	Shrub	Pol/Nec	September	25	undefined
Dokima	*Syzygium guineens*	*Myrtaceae*	1.11	Tree	Pol/Nec	April	45-75	Seed
Suf	*Helianthus annuus*	*Asteraceae*	1.09	Herb	Pol/Nec	October	15	Seed
Ekima	*Terminalia glaucescens*	*Combretaceae*	0.85	Tree	Pol/Nec	April	15	Seed

Table 13: Bee plant species of the study area identified from the trapped pollen analysis

Scientific Name	Family Name	Pollen Weight (gm)	%
Acacia tortolis	*Mimosaceae*	32.39	7.74
Ocimum bacilicum	*Lamiaceae*	29.23	6.99
Becium grandiflorum	*Lamiaceae*	26.97	6.45
Hypoestes trifolia	*Acanthaceae*	26.95	6.44
Sorghum bicolor	*Poaceae*	25.53	6.10
Bidens spp.	*Asteraceae*	24.46	5.85
Guizotia abyssinica	*Asteraceae*	23.83	5.69
Echinops Spp.	*Asteraceae*	17.87	4.27
Vernonia Spp.	*Asteraceae*	14.81	3.54
Grewia bicolor	*Tiliaceae*	13.81	3.30
Brassica spp.	*Brassicaceae*	11.65	2.78
Eucalyptus camaldulensis	*Myrtaceae*	11.46	2.74
Aloe berhana	*Liliaceae*	11.25	2.69
Un-Identified spp.	*Poaceae*	10.50	2.51
Acacia asak	*Mimosaceae*	10.17	2.43
Ziziphus spinachristi	*Rhamnaceae*	10.09	2.41
Opuntia Spp.	*Cactaceae*	9.79	2.34
Acacia mellifera	*Mimosaceae*	9.44	2.26
Euphorbia Spp.	*Euphorbiaceae*	8.94	2.14
Acacia seyal	*Mimosaceae*	8.05	1.92
Sesamum indicum	*Pedaliaceae*	7.84	1.87
Vicia faba	*Papilionaceae*	7.63	1.82
Pterolobium stellatum	*Caesalpiniaceae*	7.31	1.75
Cordia africana	*Boraginaceae*	6.70	1.60
Lepidium sativum	*Brassicaceae*	4.65	1.11
Trifolium Spp.	*Papilionaceae*	4.28	1.02
Plectranthus spp.	*Lamiaceae*	3.76	0.90
Zantadescha spp.	*Araceae*	3.75	0.90
Acacia brevispica	*Mimosaceae*	3.52	0.84
Eluesine folicofolia	*Poaceae*	3.38	0.81
Justicia spp.	*Acanthaceae*	3.36	0.80
Schinus molle	*Anacardiaceae*	3.29	0.79
Achyranthus aspera	*Amaranthaceae*	2.92	0.70
Helianthus annuus	*Asteraceae*	2.53	0.60
Rumex nervosus	*Polygonaceae*	2.34	0.56
Capparis micrantha	*Capparidaceae*	2.10	0.50
Cyperus spp.	*Cyperaceae*	1.92	0.46
Mangifera indica	*Anacardiaceae*	1.92	0.46
Balanite aegyptica	*Balanitaceae*	1.77	0.42
Agave sisalana	*Agavaceae*	1.59	0.38

Zea mays	*Poaceae*	1.34	0.32
Tapinanthus aurantias	*Loranthaceae*	1.22	0.29
Syzygium guineens	*Myrtaceae*	1.11	0.27
Terminalia glaucescens	*Combretaceae*	0.85	0.20
Plantago spp.	*Plantaginaceae*	0.18	0.04
		418.45	

Table 14: Identified bee plant families from trapped pollen analysis

No.	Family Name	Pollen dry Weight (gm)	%	No. of Plant Spp. Included
1	*Asteraceae*	83.50	19.95	5
2	*Mimosaceae*	63.57	15.19	5
3	*Lamiaceae*	59.96	14.33	3
4	*Poaceae*	40.75	9.74	4
5	*Acanthaceae*	30.31	7.24	2
6	*Brassicaceae*	16.30	3.90	2
7	*Tiliaceae*	13.81	3.30	1
8	*Myrtaceae*	12.57	3.00	2
9	*Papilionaceae*	11.91	2.85	2
10	*Liliaceae*	11.25	2.69	1
11	*Rhamnaceae*	10.09	2.41	1
12	*Cactaceae*	9.79	2.34	1
13	*Euphorbiaceae*	8.94	2.14	1
14	*Pedaliaceae*	7.84	1.87	1
15	*Caesalpiniaceae*	7.31	1.75	1
16	*Boraginaceae*	6.7	1.60	1
17	*Anacardiaceae*	5.21	1.25	2
18	*Araceae*	3.75	0.90	1
19	*Amaranthaceae*	2.92	0.70	1
20	*Polygonaceae*	2.34	0.56	1
21	*Capparidaceae*	2.1	0.50	1
22	*Cyperaceae*	1.92	0.46	1
23	*Balanitaceae*	1.77	0.42	1
24	*Agavaceae*	1.59	0.38	1
25	*Loranthaceae*	1.22	0.29	1
26	*Combretaceae*	0.85	0.20	1
27	*Plantaginaceae*	0.18	0.04	1

In general, 31 families comprising 59 species of bee plants were identified in the study area from the survey, inventory and trapped pollen analyses. About 27.12% of the identified plants were herbaceous species while 33.9% and 27.12% were shrubs and trees respectively. The rest proportion of these plants was grass species (Table 15).

Table 15: Pollen collection by life form of the honey plants identified in the wereda

Life Form	No. of Species	%	Pollen Weight	%
Grasses	7	11.86	15.98	3.82
Herbs	16	27.12	151.12	36.11
Shrubs	20	33.90	163.55	39.08
Trees	16	27.12	87.8	20.98
Total	**59**	**100.00**	**418.45**	**100.00**

As a result, a total of 418.45 gm of pollen was collected by honey bees during the study period from herbaceous species (36.11%), shrubs (39.08%) and trees (20.98%) which further explained that the value or the contribution of honey plant species was not mainly depending on the number of species and the abundance and density of the plant species are the main determinant factors. Generally, the total pollen collected by bees from the different life forms was in agreement with the result obtained from sample quadrant plot analysis in this study. Moreover, the numbers of shrub plant species identified in trapped pollen were accounting 39.53% of the inventoried plant species while 25.58% and 20.93% of the plant species in trapped pollen were trees and herbaceous plant species respectively and the rest the grass species.

Regarding pollen collection by flowering months, because of the reason that flowering period differs with different agro-ecologies based on their moisture contents, the highest volume of pollen (74.64%) was collected during the main rainy season (August through October) with peak in September (37.58%). Among flowering periods of the year, the lowest amount of pollen was collected in November (2.06%) and May (3.83%) (Table 16). The daily mean pollen collection was 2.32 ± 0.0378gm while the maximum was 5.34gm throughout the study period.

Table 16: Pollen collection by months during the study period

Month	Pollen Weight	%
September	157.24	37.58
October	68.13	16.28
November	8.62	2.06
May	16.04	3.83
June	49.04	11.72
July	40.81	9.75
August	78.57	18.78

The number of plant species included in a family for the computation of pollen dry weight by plant families identified has showed a significant difference (P≈0.01). Consequently, *Asteraceae*, *Mimosaceae* and *Lamiaceae* were the major pollen source families in the study area contributed 19.95%, 15.19% and 14.33% of the total pollen collected respectively while *Plantaginaceae* was the least pollen contributor (0.04%).

V. Conclusion

The study has confirmed that criterion set by respondents in prioritizing honey bee plants was in agreement with the amount of pollen collection. Thus, very good plants in each of the criterion have provided the highest pollen for the bees as a food.

The appropriate implementation of mellissopalynological methods have confirmed that the local floras are reflected in the corresponding spectrum of pollen types represented in the collected pollen pellets. This further explained the importance of apiculture for vegetation characterization and identification of geographical origins. Of course, a final perspective could be obtained by considering the relative breadth and depth of plant species utilization by honey bees.

Although a narrow group of species in a wide spectrum of floral choices is truly used at significant levels, fewer number of flowering plant species out of the numerous flora of the country were visited by the honey bees in the study area.

Consequently, based on the techniques that we have employed, *Acacia tortolis, Ocimum bacilicum, Becium grandiflorum, Hypoestes trifolia, Sorghum bicolor, Bidens spp., Guizotia abyssinica, Echinops Spp., Vernonia Spp., Grewia bicolor, Brassica spp., Eucalyptus camaldlensis, Aloe berhana, Un-Identified spp., Acacia asak, Ziziphus spinacristi, Opuntia Spp., Acacia mellifera, Euphorbia Spp.* and *Acacia seyal* have been found to be the dominant (major) honey bee plants of the study area. However, as compared to honey production potential of the area, only few numbers of pollen source plant species were identified due to time constraint.

Furthermore, the strong relationships between pollen yields collected from abundant bee plant species have essentially disproved the hypothesis stating that the availability of bee flora and beekeeping are independent in the study area. This in turn has led us to conclude that beekeeping productivity is strictly dependent on the availability of floral resources in the study area. Thus, in-depth analysis of bee plants throughout the year, determination of total carrying capacity, propagation, wise use and conservation of floral vegetation shall take a considerable attention for better integration of the sector with phenological flow and potential of flowering plants in the area. In this regard, the community should be supported with different conservation programs running in the area for better achievements. Furthermore, as most honey bee plants investigated in the study area are propagated by their seeds; collection, management and conservation of plant seeds should not be a sidelined activity.

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