

Identification and Establishing Floral calendar in, Jimma zone of Oromia Ethiopia

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Abstract

Honeybee colony performance as well as production of honey and other hive products depends on bee forages. The study was designed with objective to identify and establish flowering Calendar of bee plants for multiple honey production. Bee forage inventory was made in a plot size of 20mx20, for woody plants and 2mx2m for herbaceous bee forages. Based on the inventory of bee forages, pollen load collection and honey pollen analysis, 103 plant species were identified as source of nectar and pollen for honeybees. From identified plant species *Ageratum conizoides*, *Guizotia scabra*, *Cordia africana*, *Datura arborea*, *Plantago lanceolatum*, *Rumex nervosus*, and *Justicia schimperina*, were the major honey source plants in the area. The fresh weight of pollen collected at different months of the year indicated that significant amount of pollen was collected during September, October to November but decline of incoming pollen weight was recorded during, March and July. The major honey flow period of the area occurred during November and extends early December and late February. The minor honey flow also resulted May-June. The pollen analysis of honey samples revealed that three monofloral honey types were identified which include *Guizotia*, *Vernonia* and *Croton* monofloral honey types comprising the pollen frequency ranging from 45% to 100%. The study concluded that floral calendar of bee forages strictly dependent on the seasonal availability of food sources and beekeepers should get awareness on management of honeybee colonies with the flowering calendar in the area to increase frequency of honey production.

Keywords: Floral calendar, Pollen analysis, abundance, monofloral honey, Honey flow period

Introduction

Ethiopia has diverse climatic conditions and topography which favors for the growth of wide range of plants having different flowering pattern which result in availability of different honey flow periods which is entirely depend on flowering calendar of the area [1]. The floral calendar of bee plant is a timetable to indicate the date and duration of flowering of important bee plant species in an area. It is an important tool that informs the availability of certain bee forage for particular area, to predict time of honey flow period and their values to honeybees [2]. There are strong associations between floral calendar of bee plants and the seasonal cycles of honeybee colonies as it is affected by weather condition of the area [3]. The variations in rainfall and temperature can have influential effects on the onset & duration of the major bee plants, that can be coincide with management activities to increase yield of honey [4].

In the country the maximum flowering occurs after the main rainy season, followed immediately by dry season and small rainy season even though many species exhibit multiple flowering patterns within a year [5]. The length and intensity of rainfall influences the flowering of bee plants affecting the availability and quality of nectar and pollen. The well-defined sequences of colony events form a linear chain of relationship with rainfall: peak rainfall→ peak flowering→ maximum brood rearing→reproductive swarming [6] and [7]. Therefore the timing of management operations corresponding to flowering pattern of bee plants which is critical in building up colony populations before the main nectar flow following the rainfall pattern of the area [8]. Even though honeybees naturally build up their population during periods when resources are available, the beekeeper must ensure that peak population is reached before or during the nectar flow. In Jimma zone, the area receives high rainfall for about 9 months as result, plants have extended flowering period and exhibit different flowering pattern [8]. As the result of this variation, beekeepers lack adequate information about appropriate flowering calendar of bee forages which is corresponding to seasonal colony management practices such as supering and honey harvesting. Therefore, identification of major bee forages and preparing floral calendar is important for determining appropriate honey flow period for multiple honey production. Thus study was designed to identify major bee forages and prepare flowering calendar and to assess the types of the mono floral honey produced in the area.

Materials and Methods

Description of the study area

The Jimma zone lies between $7^{\circ} 13' - 8^{\circ} 56' N$ and $35^{\circ} 52' - 37^{\circ} 37' E$. The Zone is characterized by a humid tropical climate of heavy rainfall that ranges from 1200- 2000mm. It has a relatively higher temperature of about $25^{\circ} C - 30^{\circ} C$ from January to April and having a minimum temperature of $7^{\circ} C - 12^{\circ} C$ during the months of October– December. The zone also has relatively high forest accounting for about 56% of the country's forest cover and different types of crops which include, coffee, maize, papaya, banana and many other root crops. The study districts includes Gomma, Tolay and Ommonada since they have a great potential for beekeeping.

Methods

Field observation

Plants visited by honeybees were identified through field observation. During observation the type of food source offered by plants, flowering periods and the behavior honeybees while collecting nectar and pollen were observed.

Inventory of bee forages

To assess the bee forages abundance and diversity, four transect lines were laid out from apiary sites to North, South, West and East within 2Km radius following GPS assuming that honeybees efficiently utilize the resources within 2km radius. Apiary sites were selected systematically within 2 km distance from one to the other in order to avoid redundancy. Along these transects plots of 20mx20 m were laid out within 400 m interval between the sample plots. In order to retain accuracy, five (5) sub plots measuring 2mx2m ($4m^2$) were laid out within the larger plot to capture herbaceous and grasses. All the plant species encountered in each sample plots were recorded and percentage cover of each species was estimated visually. For those plant species which could not identified in the field, sample of the specimens were collected using the standard Herbarium techniques and identified at National Herbarium of Addis Ababa University.

Abundance of the species

The abundance of bee flora species defined here as the total number of all individuals' species in all quadrates. Similarly the relative frequency of each bee flora species was calculated by determining the proportion of quadrate in which the species are encountered.

Percent abundance of bee flora = $\frac{\text{Number of bee flora species in particular}}{\text{Total number of bee flora species}} * 100$

Total number of bee flora species

Relative frequency = $\frac{\text{Number of sample plot in which a bee flora species occurred}}{\text{Total sample plots surveyed}} * 100$

Total sample plots surveyed

Species diversity and Richness

To compare bee flora species composition among different districts, richness, Shannon diversity index, and Shannon evenness index was used, according to the following equation.

$$\text{Shannon Index } (H') = \sum_{i=1}^s P_i \ln P_i$$

H' is Shannon-Wiener diversity index, s is the number of species (pollen type), P_i is the proportion of individuals or the abundance of the i^{th} species (pollen type), \ln is the natural logarithm, and Σ is the sum from species 1 to species S . The evenness of the species was calculated based on the following Formula.

$$J = \frac{H'}{H'_{max}} = \frac{\sum_{i=1}^s P_i \ln P_i}{\ln s}$$

Pollen load collection

Nine honeybees' colonies were established at nine sites of the districts representing different agro-ecologies (lowland, mid land and highlands). For pollen collection honeybee's colonies were fitted with pollen trap having 16% pollen trapping efficiency. The pollen grains were collected and sorted into colors and identified to the generic and species level.

Honey pollen analysis

For honey pollen analysis, honey samples were collected from the different sites of the study area. The honey samples were analyzed for identifying species composition and frequency of pollen grains following the methods adopted by [9]. All types of the pollen grains were counted and scored as it occurred in the microscope field & percentage occurrence of pollen grains was used to determine their frequencies.

Results

Floristic composition

A total of 103 plant species belonging to 97 genera, and 78 families were identified in Jimma zone(Appendix1). The Fabaceae, Asteraceae, Solanaceae, Acanthaceae, Lamiaceae, Rutaceae, Moraceae, Myrtaceae, Acanthaceae, and Euphorbiaceae represented the highest number of species accounting for 22%, 17%, 10%, 8%, 8%, 6%, 6%, 4%, 7%, and 8% respectively. All remaining families consisted of species comprising less than 2% of having with low frequency occurrence in the area.

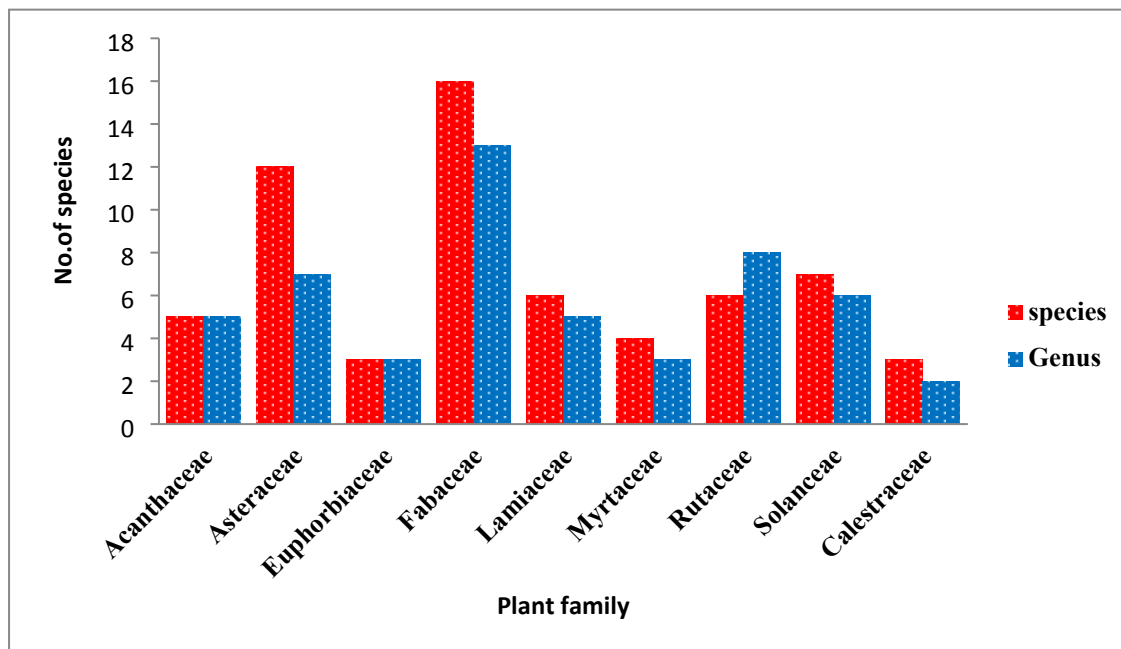


Fig 1. Percent of bee forage species composition and number of genera in west shoa zone

Growth habit

The growth forms of bee forage utilized by honeybees comprises herb (35%) , shrubs (32%), trees (29%) and climbers (4%) Fig.2. The herbaceous flora is dominant bee forages comprising weeds (*Guizotia scabra*, *Hypoestes forskaolii*, *Hypoestes triflora* and *Trifolium* spp) and some cultivated crops(*Brassica*,spp, *Vicia faba*, pulses cereals and oil crops also greatly contribute to honey production in the area.

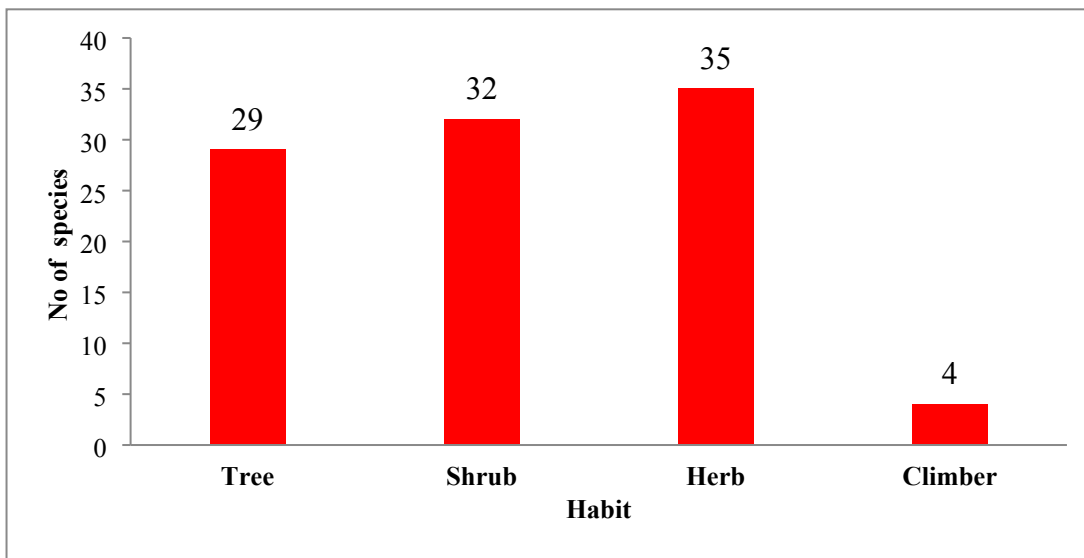


Figure.2. The growth habit of bee forages in the study area

Abundance and diversity of bee flora

From field inventory of bee forages a few plant species are found to be the most frequent and abundant species in the area Table1. These include *Eucalyptus* spp, *Croton macrostachysus*, *Justicia schimperana*, *Cordia africana*, *Vernonia* spp, *Guizotia scabra*, *Ageratum conyzoides*, *Achyranthes aspera* and *Hypoestes* spp and *Coffea arabica*.

Table 1. The abundance of major bee forages of the study districts

Plant species	Gomma		Omonda		Boter-Tolay	
	Abundance	R.F	Abundance	Relative freq	Abundance	Relative freq
<i>Acacia spp</i>	3.3	40	3.3	33.33	15	6.7
<i>Acanthus sennii</i>	1.04	2	100	1.67		0.0
<i>Albizia schimperiana</i>	1.66	48	1.7	38.33	1.4	3.3
<i>Bersama abyssinica</i>	3.1	12	3	10.00	-	0.0
<i>Caesalpinia decapetala</i>	7.4	53	7.4	55.00	6.2	6.7
<i>Calpurnia aurea</i>	4.3	40	4.3	40.00		0.0
<i>Carica papaya</i>	1.2	5	1.4	6.67	5.2	10.0
<i>Catha edulis</i>	11.7	22	11.7	21.67	-	0.0
<i>Citrus sinensis</i>	2.4	22	1.7	8.33		0.0
<i>Clausena anisata</i>	2.4	20	2.4	6.67	13	6.7
<i>Clematis hirsuta</i>	1.27	38	1.7	40.00	-	0.0
<i>Coffea arabica</i>	8.6	38	9	38.33	-	0.0
<i>Cordia africana</i>	2.4	43	2.4	43.33	17	35.0
<i>Croton macrostachyus</i>	8.65	85	8.5	70.00	6.3	6.7
<i>Ekebergia capensis</i>	0.5	7	0.5	6.67		0.0
<i>Erythrina brucei</i>	2	15	2	15.00		0.0
<i>Ehretia cymosa</i>	1	17	1.09	11.67	8.7	5.0
<i>Eucalyptus camaldulensis</i>	9	62	16	58.33	20.3	20.0
<i>Eucalyptus globulus</i>	1.69	7	1.4	6.67	0.2	1.7
<i>Euphorbia tirucalli</i>	24.8	73	24	68.33	25	13.3
<i>Grevillea robusta</i>	3.2	35	3.2	33.33		0.0
<i>Masea lanceolata</i>	3.5	12	2.8	40.00		0.0
<i>Ocimum urticifolium</i>	2.2	12	1.52	41.67		0.0
<i>Pavonia urens</i>	9.1	12	1.6	3.33	43.9	5.0
<i>Vernonia amygdalina</i>	5.7	17	1.2	6.67	10.3	8.3
<i>Vernonia auriculifera</i>	12	38	3	78.33	9.2	10.0

<i>Ageratum houstonianum</i>	9.2	33	55			0.00			0.0
<i>Guizotia scabra</i>	0	0	0	1.82	55	91.67	0		0.0
<i>Hygrophilia auriculata</i>	21	3	5	0.2	7	11.67			0.0
<i>Mangifera indica</i>	0	0	0	3.5	22	36.67	5.7	6	10.0
<i>Musa paradisca</i>	0	0	0	6.2	17	28.33	13.9	3	5.0
<i>Persea americana</i>	0	0	0	2.5	30	50.00	3.5	3	5.0
<i>Psidium guajava</i>	0	0	0	3.3	13	21.67	0		0.0
<i>Rosa abyssinica</i>	0	0	0	3.9	6	10.00	0		0.0
<i>Schefflera abyssinica</i>	0	0	0	0.4	2	3.33	0		0.0
<i>Sida spp</i>	7.2	27	45	0	0	0.00	10.5	5	8.3
<i>Solanium spp</i>	0	0	0	4.4	20	33.33	0	29.5	49.2
<i>Syzygium guineense</i>	0	0	0	5	19	31.67	30.5	4	6.7
<i>Terminalia schimperiana</i>	0	0	0	1.8	4	6.67	22.4	6	10.0

Species richness and diversity

The analysis of Shannon diversity of bee forages indicated that there is variation of Shannon diversity index between three districts. The species richness also varied among the districts and relatively higher richness occurs in Gomma, and Omonada district as compared to Botertolay district Table 2.

Table 2: Species diversity of bee forages in west shoa zone

District	H	Richness	Evenness
Omonada	2.1	69	0.841
Boter-tolay	1.5	63	0.85
Gomma	1.95	89	0.71

Pollen load analysis of major bee forages

Among the identified pollen source plants, *Ageratum conizoides*, *Guizotia scabra*, *Cordia africana*, *Datura arborea*, *Plantago lanceolatum*, *Rumex nervosus*, and *Justicia schimperina*, were the most frequent pollen source plants and foraged for more than 50 days. The moderately foraged plant species were *Croton macrostachyus*, *Carica papaya*, *Gravillea robusta*, *Clematis simensis*, *Rhus vulgaris*, *Rosa abyssinica*, *Vicia faba* for foraged for 25-45 days and the rest of the species were least foraged by honeybees Table 3.

Table 3: Foraging length of the major bee forages in Jimma zone.

Plant species	Families	starting	ending	days
<i>Acacia spp</i>	Fabaceae	Oct	Dec	54
<i>Ageratum conizoides</i>	Asteraceae	Feb	Aug	108
<i>Albizia spp</i>	Fabaceae	Oct	Nov	54
<i>Carex spp</i>	Cyperaceae	May	Jun	54
<i>carica papaya</i>	Caricaceae	Oct	Nov	30
<i>Clematis simensis</i>	Ranuclaceae	Dec	Jan	30
<i>Coffea arabica</i>	Rubiaceae	Feb	March	27
<i>Cordia africana</i>	Boraginaceae	Aug	Oct	60
<i>Croton macrostachys</i>	Euphorbiceae	April	May	40
<i>Datura arborea</i>	Solanceae	Feb	May	54
<i>Echionpoes spp</i>	Asteraceae	Feb	March	54
<i>Eucalyptus camaldunsis</i>	Myrtaceae	May	Jun	35
<i>Grevillea robusta</i>	Proteaceae	March	April	43
<i>Guizotia scabra</i>	Asteraceae	Oct	Dec	144
<i>Justicia schimperina</i>	Acanthaceae	Nov	Feb	56
<i>Mangifera indica</i>	Ancardiaceae	July	Aug	58
<i>Persea americana</i>	Luraceae	May	Jun	60
<i>Phaseulous vulgaris</i>	Fabaceae	Aug	sept	30
<i>Plantago lanceolatum</i>	Plantaginaceae	May	Oct	60
<i>Rhus vulgaris</i>	Anacardiaceae	sept	Oct	45
<i>Rosa abyssinica</i>	Roseaceae	July	Aug	42
<i>Rumex nervosus</i>	Polygonaceae	July	Aug	60

Plant species	Families	starting	ending	days
<i>TTrifolium spp</i>	Fbaceae	Feb	Aug	48
<i>Vernonia amygdalina</i>	Asteraceae	Nov	Jan	35
<i>Vicia faba</i>	Fabaceae	Aug	Oct	42
<i>Zea mays</i>	Poaceae	Mar	May	25

Seasonal availability pollen in the districts

Regarding the monthly pollen weight collection for Tolay, Gomma and Omonada districts, the highest pollen weight was recorded during the months of October, November and December. Relatively better amount of pollen was also collected during January and February in Gomma district. On top of this higher pollen weight was recorded during April to May in Gomma and Omonada as indicated in Figure 2. The scarcity of pollen or very low pollen collection was recorded during February and July in Boter-Tolay and Omonada districts.

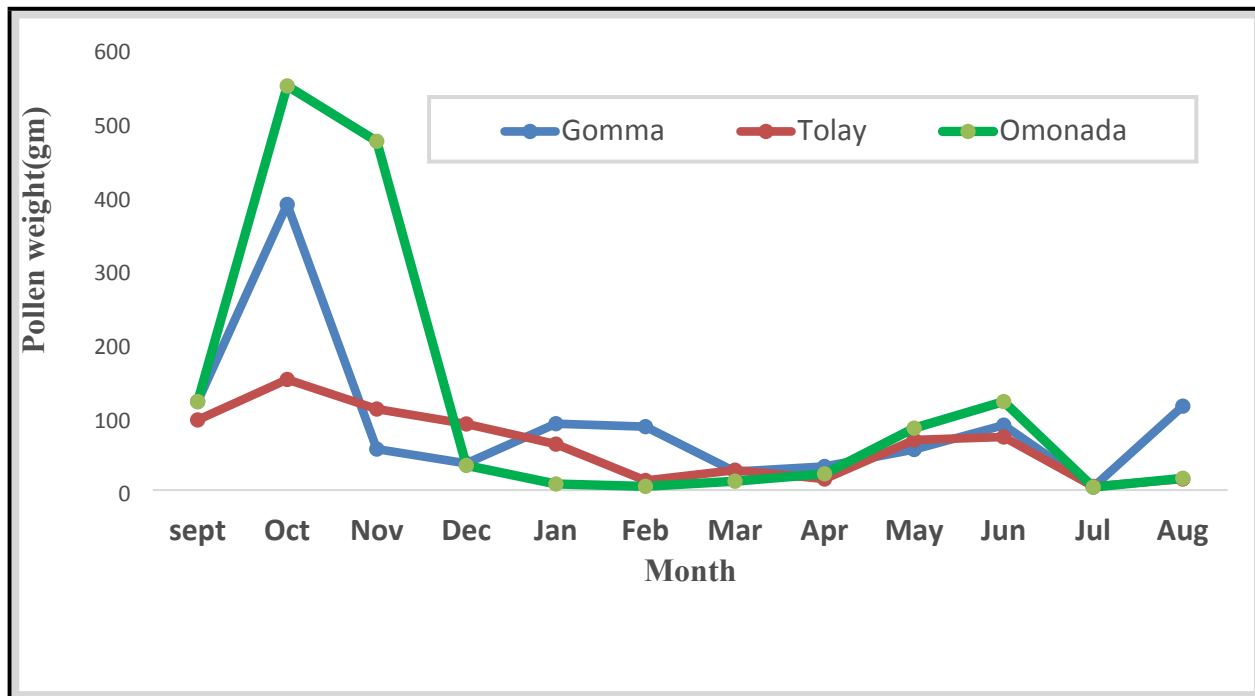


Figure 2. Monthly pollen collections in Jimma zone

Flowering calendar bee forages in area

The majority of bee plant species flowers in the area starting from mid-September to December reaching peak in November. About 30.6 % bee plant species flowers during spring (September to November) which includes *Ageratum conizoides*, *Andropogon abyssinica*, *Bidens* spp, *Cordia africana* and *Guizotia scabra*. Approximately 44.4 % of the plant species flowered during the dry season (December to February) including *Vernonia amygdalina*, *Coffea arabica*, *Bersama abyssinica* and *Clematis* spp. About 13.5% of the plant species flower during the small rainy season (March-May) which include *Eucalyptus camaldensis*, *Syzygium guineense*, *Mangifera indica* and *Croton macrostachyus* while 11.1% flowered during the big rainy season June-August (*Vicia faba*, *Zea mays* and *Maesa lanceolata*). The analysis of flowering period of the bee forages, and seasonal pollen weight collection, three honey flow season were identified in Gomma district starting from mid-November to December from *Guizotia scabra* honey. The minor honey flow period was identified at end of January and March mainly from *Vernonia amygdalina* and *Coffea arabica*. On the other hand, *Croton macrostachyus* and *Eucalyptus* spp honey were harvested during months of May and June around Gomma, Omonada, and Tolay. The overall flowering period of major bee forages in Jimma zone was indicated in Figure 4.

plant species	S	O	N	D	J	F	M	A	M	J	J	A
<i>Acacia spp</i>								■	■			
<i>Ageratum conizoides</i>		■	■	■								
<i>Albizia schimperiana</i>	■	■		■	■							
<i>Andropogon abyssinica</i>	■	■	■	■	■	■						
<i>Bersama abyssinica</i>		■	■	■	■							
<i>Bidens pilosa</i>		■	■									
<i>Clematis simensis</i>			■	■	■	■						
<i>Coffea arabica</i>				■	■	■	■					
<i>Cordia africana</i>	■	■										
<i>Croton macrostachyus</i>									■	■		
<i>Cyperus spp</i>	■	■										
<i>Eucalyptus camaludensis</i>							■	■	■			
<i>Gravelia robusta</i>	■	■										
<i>Guizotia scabra</i>		■	■	■								
<i>Justicia spp</i>	■	■	■	■								
<i>Mesea lanceolata</i>											■	■
<i>Persea americana</i>								■	■			
<i>Rumex nervosus</i>				■	■	■	■					
<i>Syzygium guineense</i>				■	■		■					
<i>Terminalia schimperi</i>				■	■	■	■					
<i>Vernonia auriculifera</i>				■	■	■	■					
<i>Vernonia amygdalina</i>				■	■	■	■					

Figure 3: Flowering chart of major bee forages in Tolay, Gomma and Omonada districts

Honey pollen analysis

From the pollen analysis of honey samples 39 species representing 19 families were identified. The predominant pollen types (> 45%) identified was, *Guizotia scabra*, *Eucalyptus spp*, *vernonia spp*, *Croton macrostachys*; unidentified lamiaceae and *Coffea arabica* (Table 4). It is interesting to note that *Guizotia scabra* appeared as pre-predominant honey source plants during October honey flow season while *Croton macrostachys* and *Eucalyptus spp*, are dominant honey source plants during May–June and there is also honey from *Vernonia amygdalina*, *Coffea arabica* and *Albizia spp* were also reported during January and February. Finally, establishment of flowering calendar in the area shows that three honey flow seasons were identified of which September to October and April to May and during January and February.

Table 4. Predominate and secondary pollen source plants in west shoa zone

District	Predominant pollen source (> 45%)	Secondary pollen (> 45%)	Secondary pollen (16-45%)	Important minor pollen (3-15%)	Minor pollen source (< 3%)
Boter-Tolay	<i>Guizotia spp</i> (65%)		<i>Croton macrostachyus</i> (37%)	<i>Coffea arabica</i> (10%)	<i>Ageratum spp</i> (3%) <i>Acacia spp</i> (2%) <i>Terminalia spp</i> (1%)
Gomma	<i>Coffea arabica</i> (49%) <i>Vernonia amygdalina</i>		<i>Vernonia amygdalina</i> (35%) <i>Guizotia scabra</i> (15%)	<i>Schefflera abyssinica</i> (4%) <i>Hypoestes spp</i> (4%)	<i>Saturja spp</i> (2%) <i>Allophylus abyssinica</i> (1.2%) <i>Gravillea roubusta</i> (1.2%) <i>Olea africana</i> (2.17%)
Omonda	<i>Guizotia scabra</i> (65%) <i>Croton macrostachyus</i>		<i>Croton macrostachyus</i> (10%) <i>Eucalyptus spp</i> (3%)	<i>Syzygium guineese</i> <i>Terminlia schimperii</i>	<i>Hypoestes spp</i> (1%) <i>Zea mays</i> (2%) <i>Solanum spp</i> (1.3)

Monofloral honey

The classification of pollen percentage count using PCA clustering indicated that three monofloral honey types were identified, from Jimma zone. Accordingly, the *Guizotia* spp monofloral honey type covers large portion of cultivated areas of zone. On the other hand, *Coffea arabica* honey some degree of mixing with *Vernonia amygdalina* and *Croton macrostachyus* honey were found in Gomma district while *Croton macrostachyus* found in Omonada and Chora-Boter -Becho forest Figure6. The pollen count percent dominance for monofloral honey ranges from 45 % to 100%.

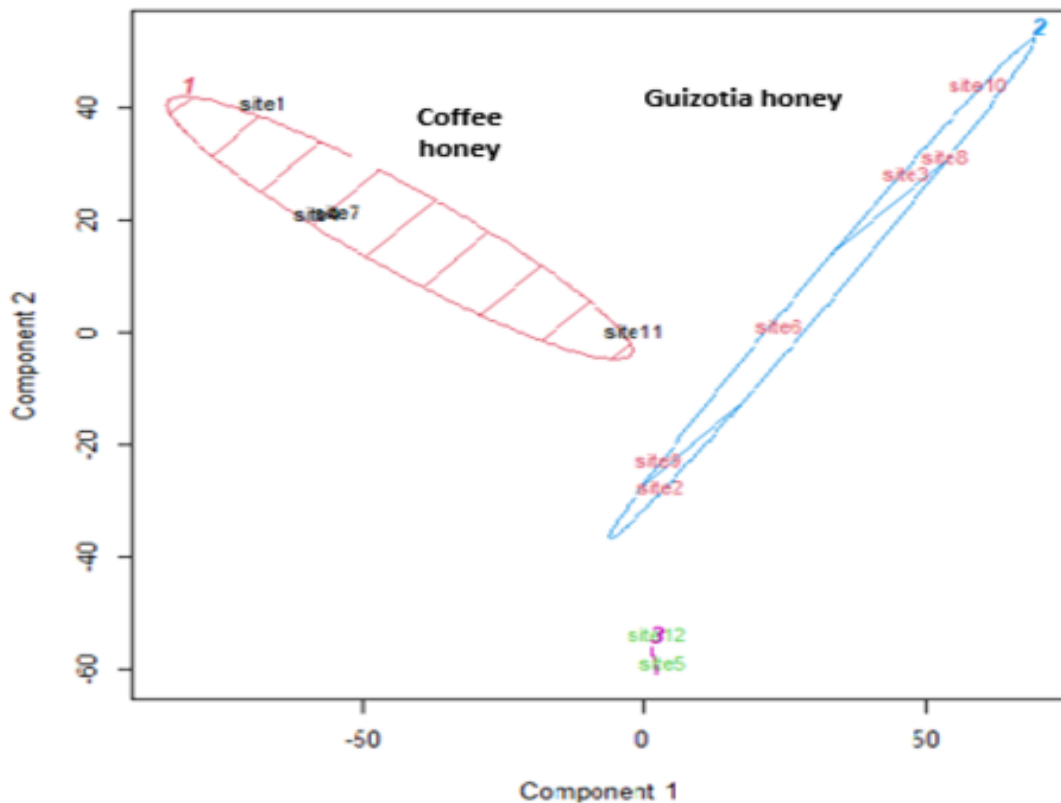


Figure 4. Monofloral honey types in Jimma zone

Discussions

From pollen load collection and honey pollen analysis, 103 plant species were identified belonging to 78 families. Among the plant families Fabaceae, Asteraceae, Acanthaceae and Lamiaceae are dominant families, comprising higher number of bee forage species composition in the area. These families are also reported to be the most species-rich families in the Flora of Ethiopia and Eritrea [10], [1]. Moreover the Fabaceae is one of the pollinator dependent plant family and contributing for honey production and serving as food source for other pollinators. Analysis of life forms of the plant revealed that the herbaceous flora contributes for 35% of the total species composition of the area. This could be due to removal of shrubs and trees from farmland for cultivation and forest encroachment favoring the growth of herbaceous flora. This is in agreement with [11] agricultural practices favor for the growth various weeds and other herbaceous flora.

Based on plant inventory and honey pollen analysis indicated that the bee forage diversity of bee plants was not vary among the districts but species richness was highest for Gomma and Omonda. This is due to the area located in one of the Biodiversity hot spots which is known as Eastern Africa Biodiversity hot spots which is known for high plant diversity. Similar finding by [12] in the Borena Zone of Oromia, Ethiopia. The PCA analysis of honey samples of the study districts revealed that, *Guizotia spp*, contributed more than 72% of the pollen count.

Identification of major bee forages from pollen trap

The identification of bee-collected pollen loads from pollen traps indicated that not only honeybees collected pollen from plant species but also it shows the relative importance of each plant species as source of pollen for honeybees. A total of 41 plant species were identified from pollen trap, however the large quantity of pollen came from only a few plant species such as *Bidens spp*, *Eucalyptus spp*, *Guizotia scabra*, *Plantago lanceolata*, *Masea lanceolata*, *Trifolium spp*, *Vernonia spp*, *Terminalia schimperiana* and *Zea mays*. The contribution of each species as major source of pollen is due to abundance and potentiality of plant for pollen. This result is also supported by findings of [8] and [13], who reported that honeybees forage on more productive and profitable plants that provide necessary nutrition nearby their hives.

Seasonal pollen collection

The highest fresh weight of pollen was collected during the months of October, November and December in the area due to extended rainy season resulting for longer duration of plants in flower. In addition, there are some drought tolerant species such as *Vernonia amygdalina*, *Bersama abyssinica*, *Terminalia schimperiana* and *Coffea arabica*. This is agreeing with [14], [15], [16] who reported that *Vernonia Spp*, *Coffea arabica*, and *Croton macrostachyus*, are the major bee flora flowering both in dry period and small rainy season in the Gomma district. According to the same author *Vernonia amygdalina* is a very valuable honey source plant in the area. In this district low pollen collection was occurred during the months of March due to availability of low moisture in the soil resulting drying of flowers. Relatively higher pollen collection was recorded during the months of April, May and June for Gomma, Tolay and Omonada districts due to availability of *Croton macrosatchyus* and similar finding also reported by [14], [15].

Flowering calendar of the bee forages in west and south west shoa

From field observation and pollen load collection the highest percentage of flowering bee forages occurred during September to November reaching peak flowering in October in all study districts. The availability of higher proportion of flowering species during October to November is due to occurrence of summer rains in June, July and August and at the end of this rainy period, majority of the plants come into flower. Similar flowering pattern was observed for Tolay, Gomma and Omonada in which majority of bee forages flowering from October to December due to extension of summer rainfall creating availability of enough moisture until end of December. Exceptionally some plant species including *Vernonia amygdalina*, and *Coffea arabica* abundantly flowering from January to February and minor honey flow is expected in Gomma district. This study also agreement with [13], [8] indicated that *Vernonia Spp.*, *Coffea arabica*, *Schefflera abyssinica* and *Croton macrostachyus* were common honey bee floras in Jimma zone flowering from January to May. As reported [18] small honey harvesting periods was identified in Gomma district which depend on the type of flowering plants and rainfall patterns.

Pollen analysis of honey

Pollen spectra of honey analysis revealed that a variety of pollen source plants were identified ranging from predominate, secondary pollen and minor important. The degree of the dominance of the bee forages depend on abundance, nectar and pollen potential of the plants. Based on honey pollen analysis the highest bee forage diversity of bee plants was found in the honey sample collected from Tolay and Ejere as compared to the rest of the districts since the study area is located in central highland which is known for high plant diversity. Similar finding by [12] in the Borena Zone of Oromia, Ethiopia. The PCA analysis of honey samples of the study districts revealed that, *Guizotia spp*, contributed more than 72% of the pollen count. The dominance of *Guizotia* pollen from honey can be attributed to widespread distribution in agricultural lands, fallow land and since it is associated weed of major crops that grow within and at the margin of field crops. This is agreeing with [13],[19],[20] who reported that *Guizotia scabra* was a predominant monofloral honey source plant in east and west shoa and Borena zones of Oromia. The availability of coffee honey and croton honey in Jimma zone were reported by [13] and [17].

Conclusion and Recommendation

Based on direct field observation, and pollen load collection 103 plant species were identified and herbaceous flora comprising the major portion of bee forages in the area. The higher proportion of the pollen weight was collected from a few plant species including *Guizotia spp*, *Vernonia spp*, *Eucalyptus camaludensis*, *Echinops macrostchyus*, *Bidens pilosa*, *Masea lanceolata*, *Planatago lanceolata*, *Echinopes macrostachus*. Majority of plant species flower two times a year during September to November and April to May in most districts. Based on floral calendar, the scarcity of pollen collection was occurred in early march and July and feeding colonies may require. Thus creation of awareness and on farm demonstration of the important of floral calendar for appropriate management of honeybee colonies is recommended to increase frequency of honey harvest. Moreover *Masea lanceolata* was identified as major bee forages during rainy period and further study on the rapid propagation methods is recommended.

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Appendix1. Checklist of plant species from Jimma zone

Plant species	Habit	Family	Flowering period	Food source
<i>Acacia abyssinica</i>	Tree	Fabaceae	Sept- Nov	N,P
<i>Acacia seyal</i>	Tree	Fabaceae	Sept- Nov	N,P
<i>Acacia tortoils</i>	Tree	Fabaceae	April- May	N,P
<i>Acanthus senni</i>	Shrub	Acanthaceae	Sept-Oct	N
<i>Achranthes aspera</i>	Herb	Amaranthaceae	Sept-Oct	P
<i>Agava sisalina</i>	Shrub	Agvaceae	Dec-Jan	N
<i>Ageratum houstonianum</i>	Herb	Asteraceae	Sept- Dec	P
<i>Albizia gummifera</i>	Tree	Fabaceae	Sept-Oct	N,P
<i>Bersama abyssinicum</i>	Tree	Meliaceae	Sept-Dec	N,P
<i>Bidens pillosa</i>	Herb	Asteraceae	Oct- Dec	P
<i>Bidens prestinaria</i>	Herb	Asteraceae	Sept- Oct	P
<i>Brassica spp</i>	Herb	Brassicaceae	Sept- Oct	N,P
<i>Brucea antidysenterica</i>	Shrub	Simaroubaceae	Sept- Oct	P
<i>Caesalpinia decapetala</i>	Climber	Fabaceae	Oct- Dec	N,P
<i>Calpurnia aurea</i>	Shrub	Fabaceae	Oct- Dec	P
<i>Capiscum annum</i>	Herb	Solanaceae	Sept- Oct	P
<i>Carica papya</i>	Shrub	Caricaceae	Sept- Dec	N,P
<i>Carrisa edulis</i>	Shrub	Apocynaceae	Sept- Dec	P,N
<i>Catha edulis</i>	Shrub	Celastraceae	Sept- Nov	P
<i>Caylusea abyssinica</i>	Herb	Resedaceae	Oct- Dec	N
<i>Celtis africana</i>	Shrub	Ulmaceae	Sept-Nov	P
<i>Cicer arietinum</i>	Herb	Fabaceae	Dec-Jan	N,P
<i>Citrus sinensis</i>	Shrub	Rutaceae	Sept-Nov	N,P
<i>Clausena anisata</i>	Shrub	Rutaceae	Sept-Nov	P,N
<i>Climatis hirsuta</i>	Climber	Ranunculaceae	Nov-Dec	P,N
<i>Coffea arabica</i>	Shrub	Rutaceae	Jan- Feb	N,P
<i>Cordia africana</i>	Tree	Boraginaceae	Sept- Oct	N,P
<i>Croton macrostachyus</i>	Tree	Euphorbiaceae	May- June	N,P
<i>Cynotis barbarta</i>	Herb	Commelinaceae	Sept-Oct	P
<i>Cytisus proliferus</i>	Shrub	Fabaceae	July- Aug	N,P
<i>Datura arborea</i>	Shrub	Solanaceae	Sept- Jan	N,P
<i>Datura stramonium</i>	Shrub	solanaceae	Sept- Nov	N,P
<i>Desmodium unicilayum</i>	Herb	Fabaceae	Sept- Oct	N,P
<i>Dombeya torrida</i>	Tree	Stericulaceae	Sept- Oct	N,P
<i>Dovalis caffra</i>	Shrub	Flocourtiaceae	Mar- May	P
<i>Echinopes spp</i>	Herb	Asteraceae	Sept-Oct	P
<i>Ehretia cymosa</i>	Shrub	Boraginaceae	Sept-Oct	N,P
<i>Ekbergia capensis</i>	Tree	Meliaceae	Sept-Oct	N,P

Plant species	Habit	Family	Flowering period	Food source
<i>Erhrina abyssinica</i>	Tree	Fabaceae	Sept- Oct	N
<i>Eucalyptus camadulensis</i>	Tree	Myrtaceae	Mar- April	N,P
<i>Eucalyptus globulus</i>	Tree	Myrtaceae	Mar- April	N,P
<i>Euclea schimperi</i>	Tree	Ebenaceae	Sept-Oct	N,P
<i>Galinosoga parviflora</i>	Herb	Asteraceae	Sept-Oct	P
<i>Glycine weightii</i>	Herb	Fabaceae	Sept-Oct	P
<i>Terminalia brownii</i>	Tree	Combretaceae	Dec-Jan	N,P
<i>Grvillea robusta</i>	Tree	Proteaceae	Sept-Nov	N
<i>Polysicas fluva</i>	Tree	Araliaceae	Sept-Nov	N,P
<i>Guizotia scabra</i>	Herb	Asteraceae	Oct-Nov	P
<i>Haygrophilia auriculata</i>	Herb	Acanthaceae	Sept-Nov	N,P
<i>Hypoestes triflora</i>	Herb	Acanthaceae	Sept-Oct	N,P
<i>Impomea spp</i>	Herb	Impomeaceae	Sept-Oct	N,P
<i>Jacarnda mimosifolia</i>	Tree	Bignoniaceae	Sept-Oct	N,P
<i>Justicia bizunesh</i>	Shrub	Acanthaceae	Sept-Oct	N,P
<i>Justicia schimperana</i>	Shrub	Acanthaceae	Sept-Dec	N,P
<i>Casimiroa edulis</i>	Shrub	Rutaceae	Sept-Dec	N,P
<i>Leucas marienthesis</i>	Herb	Lamiaceae	Sept-Dec	N,P
<i>Leucaena leucocephala</i>	Tree	Fabaceae	Sept-Dec	N,P
<i>Lippia adoensis</i>	shrub	Verbenaceae	Sept-Oct	N,P
<i>Malus silvestris</i>	shrub	Roseaceace	Sept-Oct	N,P
<i>Mangifera indica</i>	shrub	Anacardiaceae	Sept-Oct	N,P
<i>Masea lanceolata</i>	Shrub	Myrisenaceae	Aug- sept	P
<i>Mayntus obscura</i>	Shrub	Calestraceae	Sept-Oct	P
<i>Maytenus arbutifolia</i>	shrub	Calestraceae	Sept-Oct	P
<i>Mornings stenopetala</i>	Tree	Moringaceae	Sept-Oct	N,P
<i>Morus alba</i>	shrub	Moraceae	Sept-Oct	P
<i>Musa paradisca</i>	Shrub	Musaceae	Sept-Oct	N,P
<i>Myrica salicifolia</i>	Shrub	Myricaceae	Sept-Oct	N,P
<i>Nicandra physaloides</i>	Herb	solanaceae	Sept-Oct	N,P
<i>Ocimum lamifolium</i>	Herb	Lamiaceae	Oct -Dec	N,P
<i>Ocimum urticifolium</i>	Herb	Lamiaceae	Sept-Oct	N,P
<i>Octea kenysis</i>	Shrub	Rutaceae	Sept-Oct	N,P
<i>Olea capensis</i>	Shrub	Oleaceae	May	N,P
<i>Opuntia ficus indica</i>	Shrub	Euphorbiaceae	Sept-Oct	N,P
<i>Pavonia urens</i>	Herb	Malvaceae	Sept-Oct	N,P
<i>Persea americana</i>	Tree	Luraceae	Sept-Oct	N,P
<i>Phonix reclinata</i>	Tree	Areceae	Sept-Oct	N,P
<i>Phytolacca dodocandra</i>	Shrub	Phytolaceae	Sept- Oct	N,P
<i>Piper capense</i>	Shrub	Piperaceae	Sept- Oct	P
<i>Plantago lanceolata</i>	Herb	Plantaginaceae	Sept-Jan	P

Plant species	Habit	Family	Flowering period	Food source
<i>Plectranthus punctata</i>	Herb	Lamiaceae	Sept-Oct	N
<i>Premena schimeprina</i>	Shrub	Preminaceae	Oct-Nov	N,P
<i>Psidium guajava</i>	Shrub	Myrtaceae	Sept-Oct	N,P
<i>Capparis tomentosa</i>	Climber	Cappridaceae	Sept-Oct	N,P
<i>Rhamnus prinooides</i>	Shrub	Rhamnaceae	Sept-Oct	P
<i>Ricinus communis</i>	Shrub	Euphorbiaceae	Sept-Oct	N,P
<i>Rubus steudneri</i>	Shrub	Roseaceae	Sept-Dec	N
<i>Rumex nervosus</i>	Shrub	Polygonaceae	Sept- Dec	P
<i>Schefflera abyssinica</i>	Tree	Araliaceae	March- April	N
<i>Sida rhombifolia</i>	Shrub	Malvaceae	Sept- Dec	P
<i>Sorghum bicolor</i>	Herb	Poaceae	Sept-Oct	P
<i>Stereospermum kunthianum</i>	Tree	Bignoniaceae	Sept-Oct	N,P
<i>Syzygium guineese</i>	Tree	Myrtaceae	Feb-Mar	N,P
<i>Tagetes minuta</i>	Herb	Asteraceae	Sept-Oct	N,.P
<i>Terminalia schimperiana</i>	Tree	Combretaceae	Dec-Jan	P
<i>Tobacco tubersum</i>	Herb	solanaceae	Sept-Nov	N
<i>Urerea hyplocladon</i>	Climber	Urticaceae	Sept-Nov	P
<i>Vernonia amygdalina</i>	Shrub	Asteraceae	Dec- Jan	N,P
<i>Vernonia auriculifera</i>	Shrub	Asteraceae	Dec- Jan	N,P
<i>Vernonia leopoldii</i>	Shrub	Asteraceae	Nov-Dec	N,P
<i>Vernonia thomsonii</i>	Shrub	Asteraceae	Dec- Jan	N,P
<i>Zea mays</i>	Herb	Poaceae	Sept	P
<i>Zehneria scabra</i>	Herb	Cucurbitaceae	Sept-Nov	N

N= nectar, P=pollen, NP= Nectar and Pollen