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Research Paper

Assessment of honeybee plant resources and establishing floral calendar in East Wollega Zone, Western Oromia, Ethiopia

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ABSTRACT

Beekeeping is a long-standing practice in the rural communities of Ethiopia but beekeepers lack flora calendar. The study was conducted to identify and develop a floral calendar in four representative districts of the East Wollega zone of Oromia (Diga, Gida Ayana, Gobu Sayo, and Wayu Tuka). For the interview, a total of 159 beekeepers were selected by the district experts and from each district, honey samples were collected and honey pollen analysis was done to determine the botanical composition of honey. Based on the interview with beekeepers, honey pollen analysis, pollen load collection, and visual observations 53 plant species were identified belong to 26 families. Based on the record of the flowering period of the majority of honey bee flora, which bloom from September to November and December to February in all districts according to the flowering calendar, beekeepers can establish apiary sites, install beehives, divide colonies, add supers, use swarm control measures, and harvest honey. It was also indicated that some of the honey bee flora species identified by the respondent were similar to honey bee plants identified through honey pollen analysis.

Key words: Pollen, honey bee, floral calendar, absconding, honey flow

INTRODUCTION

Ethiopia is endowed with diverse agro-climatic features which favor the growth of diverse natural and cultivated floral species supporting a huge number of bee colonies. The success of beekeeping depends on many factors, among which is availability of **abundant** bee flora within the surrounding area of the apiary (Crane, 1990). Honeybee forages provide honeybees with nectar and pollen to fulfill their dietary requirements, and adequate knowledge of nectar and pollen-producing plants is the prerequisite to undertaking beekeeping production (Sanjaya and Gopal, 2001).

Most of the methods for obtaining information about plants utilized by honeybees in an area are based on direct field observation. The analysis of pollen loads and palynological analysis of honey samples can provide reliable information on floral sources along with a relative preference of the bees among the diverse assemblage of plant species (Garge, 2006). Thus identification of nectar and pollen source plants and the establishment of a flowering calendar of honey plants concerning the seasonal honeybee colony cycle is critical in improving yields of honey production.

A calendar of bee forage is a timetable that indicates the approximate date and duration of the blooming periods of the important nectar and pollen source plants to the beekeepers in their respective areas (Merdan, 1984). Establishing a floral calendar of the area requires complete observation of the seasonal dynamics in the vegetation patterns and how the honeybee colonies interact with their floral environment (Mekonen et al., 2019). The accuracy of a floral calendar, and hence its practical value, depend solely on the careful recording of the beginning and end of the flowering season of the plants and how they affect the bees.

Ethiopia is endowed with various climatic conditions, topography and a wide range of altitudes favoring the

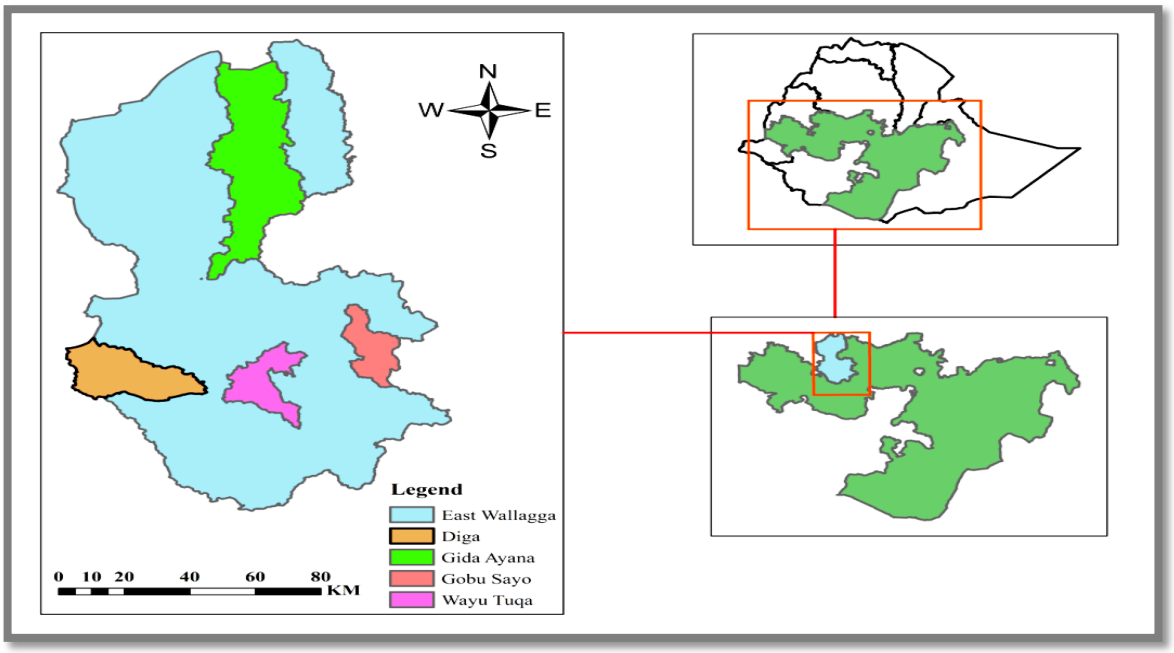

Figure 1: Map of the study area.

presence of 6000-7000 flowering plants and most of them are bee plants which include forest trees, bushes, herbs, weeds, and undergrowth (Admassu et al., 2014; Teklu, 2016)). Oromia is one of the regional states in the Federal Republic of Ethiopia rich in natural resources and favorable climatic conditions for beekeeping. For the exploitation of untapped beekeeping resources of the region identification and documentation, of major bee forages and preparing their flowering calendar are important to increase honey production.

The identification of bee plants and establishment of the flora calendar helps to indicate the approximate date and duration of the flowering of important bee plant species in the area (Desalegn, 2004) and it has paramount importance for practical beekeeping. Knowledge of bee flora helps in the effective management of bee colonies during different season of the year including active and dearth periods. The honey flow period and dearth period vary from one location to another depending on altitudes. Thus the extensive knowledge of bee flora, flowering duration, density, and quality of nectar and pollen is a prerequisite for enhancing the efficiency of the beekeeping industry. Such information enables beekeepers to utilize them at the maximum level so that they can harvest a good yield of honey.

There is a limitation of information floral calendar of bee forages that relates to the flowering of the duration of honeybee forage plants, honey flow, and harvesting seasons in the East Wollega zone of Oromia. Considering all these facts, this study aimed to identify existing bee flora and establish a floral calendar and recommend the management intervention in each agro-ecology of the East Wollega zone.

MATERIALS AND METHODS

Description of the study area

The study was conducted in East Wollega Zone, Oromia Regional State, Ethiopia. The zone is located at 36 0 30'00" to 36 0 45'00'' longitude and 9 0 05'00'' to 9 0 15'00'' latitude with elevations ranging from 1000 to 3207 m. The annual rainfall of the zone ranged from 1500 to 2200 mm with a mean annual temperature of 15-200 C (CSA 2005, 2007). The study districts covered in this study were; Diga, Gida Ayana, Gobu Sayyo and Wayu Tuka (Figure 1).

Methods of collection

In this study, both primary and secondary sources of data were used. The primary data was collected from sample household beekeepers through a semi-structured questionnaire, focus group discussion and transect walks around the sample household.

Sampling technique and sample size determination

A multistage stage sampling procedure was employed to select beekeepers. In the first stage, four districts (Diga, Wayu Tuka, Gida Ayana, and Gobo Seyo) were selected using purposive sampling based on their potential for beekeeping. In the second stage, three peasant villages were selected from each district purposively based on their relative beekeeping potential. In the third stage, 36 beekeepers from all districts were selected and thee zander

Table 1: Household information.

Character of respondents	Category	Frequency N=159	Percent (%)
Sex	Female	6	3.8
	Male	153	96.2
Age	31-42	60	37.7
	43-45	26	16.4
	56-68	10	6.3
	>69	7	4.4
Occupation	Farmer	156	98.1
	Merchant	2	1.3
	Student	1	0.6
Educational Status	Illitrus	58	36.5
	Elementary	63	39.6
	Secondary	32	20.1
	Level	6	3.8

bee hives were distributed for pollen collection. In the fourth stage, 159 beekeepers from all districts were interviewed for the bee flora information of the study area.

Field observation

Plants visited by honeybees were observed in various sites in the study area. During field observations, the types of food sources offered by plants and the behavior of the honeybees while collecting nectar and pollen were studied. The flowering periods of bee forage, date of blooming, and shedding were also recorded.

In addition to field observation; pollen grains were collected from flower buds to identify botanical sources of the pollen loads, for this purpose a sample of ripe pollen grains was collected from live flower buds. The fat content was washed out using ether to enhance the clearness of pollen grains. The slides were covered with a coverslip and examined under a light microscope having X400 magnifications.

Pollen load collection

Thirty-six movable frame box hives were placed in each representative site of the area and honeybee colonies were transferred to the hives. Pollen trappers having 16% pollen trapping efficiency were fitted at the entrance of beehives and pollen loads were collected then dried and sorted by color and pollen grains identified to genus or species level using the pollen atlas of Ethiopia (Nuru and Admasu, 2001).

Honey pollen analysis

The honey samples were collected from beekeeping peasant associations during the honey harvesting period (April-May). From each locality 3kg of honey, samples were collected. To determine the botanical origin of honey, pollen slides of honey samples were prepared using the method of (Louveaux et al., 1978). The pollen grains extracted from honey samples were identified and compared with the reference slides collected during field observation. The percentages of pollen types in each honey sample were calculated based on the total number of different types of pollen grains counted for each honey sample.

RESULTS AND DISCUSSION

Household information

Of 159 sample households, about 96.2% were male with occupation (98.1% farmer) which indicates the beekeeping activity in the study area was practiced dominantly by the male. Beekeeping is more of a male's occupation due to traditional beehives is hung on tall tree branches that females could not access and manage. About 37.7% of respondents were in 31-42 age categories with elementary education (39.6%) background. Beekeeping activity in the study area was practiced by both educated and no educated beekeepers, but beekeepers with a better educational background are more productive since they are quicker adopters of beekeeping technologies than that non-educated ones (Table 1).

The trend of honeybee colony numbers and honey yield

Based on the interview result, about 43.8, 41.2 and 15% of the respondent stated that honeybee colonies declined,

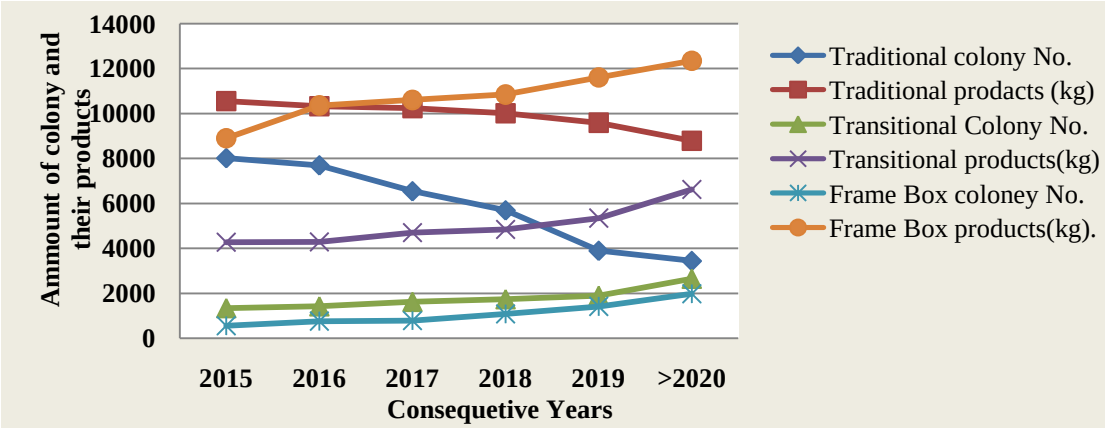

Figure 2: Hive occupation rate of honey bee colony in different hives.

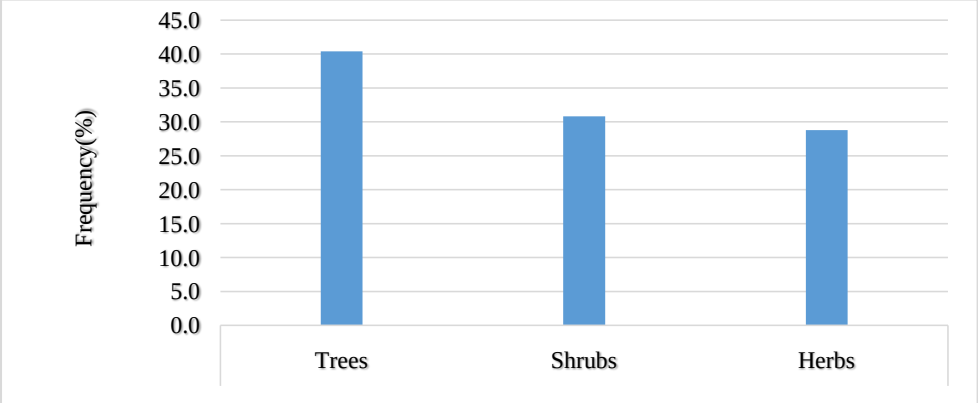

Figure 3: Honeybee plant inventory.

increased, and were stable in the area, respectively. Most respondents mentioned that the honey bee colony numbers and bee products varied from year to year in the area. This is due to the low level of management practice, technological adoption, and shrinkage of vegetation coverage due to expansions of agricultural land and destruction of forest trees for fuelwood and timber. Furthermore, the respondents also stated that repeated fluctuation of weather change occurrence between three/four years was causing fluctuation of flowering phenology resulting in decreasing honey yield in the area. Frame box and transitional beekeeping with the product was increasing due to awareness of the honeybee management system and most beekeepers were shifting from traditional beekeeping to transitional and frame box beekeeping. In terms of beekeeping systems, frame box and transitional beekeeping with the product is increasing due to awareness of the honeybee management system and most beekeepers were shifting from traditional beekeeping to transitional and frame box beekeeping.

Concerning the occupation rate of honey bee colonies in different beehives, the respondent stated that the honey bee colonies stay in traditional bee hives as per the cropping cycle of honey for six months (Figure 2). In transitional beehives, honey bee colonies stay for one or more years while in modern bee hives honey bee colonies stay for more than two years and the beekeeper can harvest honey and other bee products without the cost of honey bee colonies for many years.

Honeybee plant inventory

According to the inventory, 53 plant species belonging to 26 families were identified in the honey bee flora. Among the plant families were Fabaceae, Asteraceae, Acanthaceae, Rosaceae and Poaceae. Trees, herbs, and shrubs account for approximately 40.4, 30.2, and 28.8% of the plant's growth habits, respectively.

The dominancy of trees in the study area is due to the protection and preservation of forest trees, and hanging beehives for traditional beekeeping which might have contributed to the availability of a higher number of trees in the area (Figure 3).

Table 2: Honey pollen analysis.

Districts		Honey samples	Kebele/Village	Major Pollen/flora type	Minor type
Diga	1	Geme1	Gamachis	vernonia sp, Trifolium spp, Guizotia spp, Eucalyptus spp	Coffee Arrabica, Maize, Lipidium, Vernonia
	2	Geme2	Gamachis	Trifolium spp, Guizotia spp, Vernonia spp, Eucalyptus globules.Brassica spp	Accacia spp., Grass spp.
	3	Geme3	Gamachis	Trifolium spp, Guizotia spp, Vernonia spp, Eucalyptus globules	Coffee arabica, Albizia schimperiana
	4	Firom1	Firomsa	Brassica spp, GuizotiaVernonia spp	Brassica spp, Croton macrostachyus
	5	Firom2	Firomsa	Eucalyptus spp, Guizotia, Vernonia spp.	Carissa edulis
	6	Firom3	Firomsa	Eucalyptus spp.Guizotia Vernonia spp	Guizotia, Syzygivm guineese
	7	Damak1	Damaksa	Guizotia spps, Guizotia spp	Eucalyptus, Guizotia, Syzygivm guineese
	8	Damak2	Damaksa	Vernonia spp, Guizotia spp, Trifollium spp	Sorghum bicolor, Syzygivm guineese
	9	Damak3	Damaksa	Vernonia spp eucalyptus,Trifollium spp	Accacia, daturaarborea, Syzygivm guineese
Gida Ayana	1	Kon1	Konneji	vernonia sp, Trifolium spp, Guizotia spp,	Accacia spp.
	2	Kon2	Konneji	Trifolium spp, Guizotia spp, Vernonia spp, Eucalyptus sp.	Grass spp, Brassica spp
	3	Kon3	Konneji	Trifolium spp, Guizotia spp, Vernonia spp, Eucalyptus globules	unknown
	4	hrbkan1	Harbu Kane	Brassica spp, GuizotiaVernonia spp	Vernonia
	5	hrbkan2	Harbu Kane	Croton macrostachyus, Eucalyptus spp, Guizotia, Vernonia spp.	Coffee Arabica
	6	hrbkan3	Harbu Kane	Eucalyptus spp.Guizotia Vernonia spp	Vernnia spp. Justicia shimperiana)
	7	gati1	Gatira	Guizotia, DaturaArborea, Guizotia	Trifolium
	8	gati2	Gatira	Vernonia spp Accacia spp.,	Triffolium
	9	gati3	Gatira	Vernonia spp eucalyptus Coffee Arrabica	Romex
Gobu Sayo	1	Sokej1	Sombo Kejo	vernonia sp, Trifolium spp, Guizotia spp, Coffee Arrabica	Vernonia
	2	Sokej2	Sombo Kejo	Trifolium spp, Guizotia spp, Vernonia spp, Combretum paniculatum.Brassica spp	Eucalyptus spp.
	3	Sokej3	Sombo Kejo	Trifolium spp, Guizotia spp, Vernonia spp, Eucalyptus globules	Trifollium spp.
	4	ongob1	Ongobo	Brassica spp, GuizotiaVernonia spp	Coffee arabica
	5	ongob2	Ongobo	Eucalyptus spp, Guizotia, Vernonia spp.	Pissamsativum
	6	ongob3	Ongobo	Eucalyptus spp. Guizotia Vernonia spp	Guizotia, Millettia ferruginea
	7	Gambt1	Gambela Tare	Guizotia, DaturaArborea, Guizotia	Vernonia spp.
	8	Gambt2	Gambela Tare	Vernonia spp Accacia spp.,	Guizotia, Apodytes dimidata
	9	gambt3	Gambela Tare	Vernonia spp eucalyptus Coffee Arrabica	Pterolobium stellatum
Wayu tuka	1	warbab1	Wara babu minya	vernonia sp, Trifolium spp, Guizotia spp, Coffee Arrabica	Schefflera abyssinica
	2	warbab2	Wara babu minya	Trifolium spp, Guizotia spp, Vernonia spp,	Sorghum bicolor, Syzygivm guineese, Schefflera abyssinica
	3	warbab3	Wara babu minya	Trifolium spp, Guizotia spp, Vernonia spp, Eucalyptus globules	Accacia,daturaarborea
	4	mikur1	Migna Kura	Brassica spp, GuizotiaVernonia spp	Guizotia,Syzygivm guineese
	5	mikur2	Migna Kura	Eucalyptus spp, Guizotia, Vernonia spp.	Guizotia,

Table 2 Conts:

6	mikur3	Migna Kura	Eucalyptus spp.Guizotia Vernonia spp	Unidentified, Vicia faba
7	Dalko1	Dalo Komto	Guizotia, DaturaArborea, Guizotia	Crassoephalumvitellinum
8	Dalko2	Dalo Komto	Vernonia spp Accacia spp.,	Coriadrumsativum
9	Dalko3	Dalo Komto	Vernonia spp eucalyptus Coffee Arrabica	Hypoestestrifolia, Ekbergia capensis

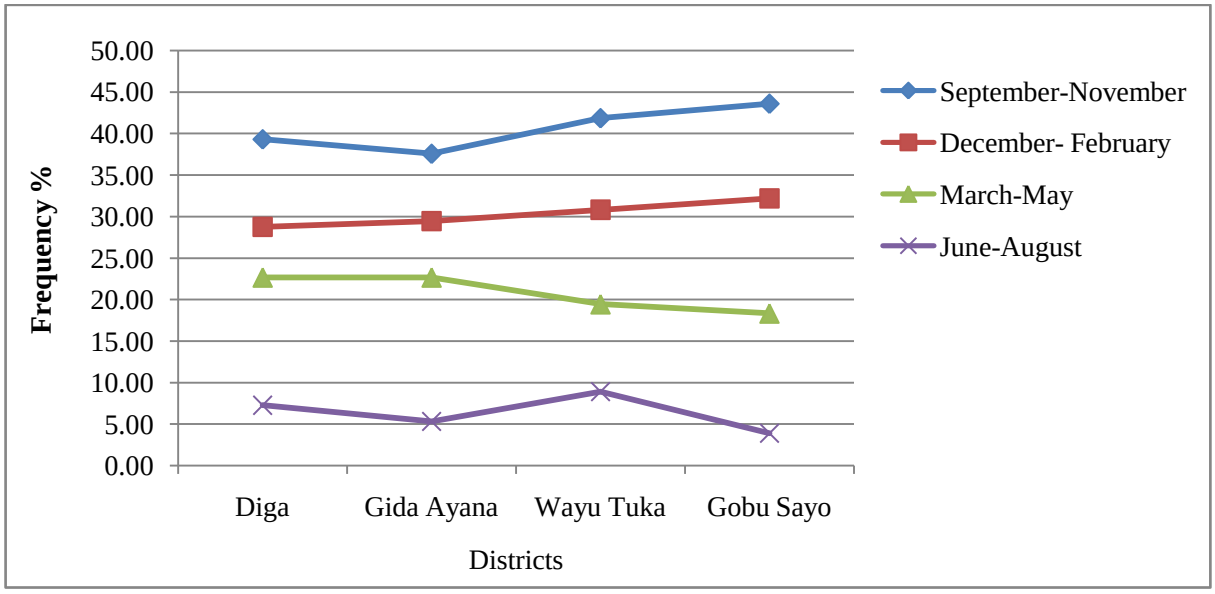

Figure 4: Bee floral Calendar.

Honey pollen analysis

Fresh honey samples at different seasons were collected for laboratory analysis. A total of 1 kg/farmer honey samples were collected per site of the study area from 36 beekeepers across the actual surveyed farmers. The pollen analysis was made following the methods adopted by (Louvuex, 1978), for the determination of botanical composition and frequency of pollen grains in the honey at Holleta Bee research center Laboratory. During the present investigation, 102 honey samples were collected from 4 study districts (Table 2).

Floral calendar of bee forages

Bee flora of East Wollega was studied during the period 2019 – 2021. Preparation of a Floral calendar enables the beekeeper to know the dates and duration of the blooming period of the important nectar and pollen plants which can provide information on the honey flow period of the area (Table 3). According to the analysis of the flowering period of bee forages 40% of the species flowered from September-November, 32% flowered from Dec-Feb, 15% flowered from March-April, and 13% from June-August. The presence of a higher percentage of flowering species during Sept–Nov, and Dec-Feb due to summer rain which starts in the middle of June and extends up to December Figure 2. Based on the flowering calendar of honey bee flora species of the area, two main honey flow periods and one minor honey flow period were identified. These are October –November, December to February, and March to May (Figure 4). The first two flowering seasons are considered major honey flow seasons and the third one is a minor honey flow period in the area. Following this calendar of bee flora, beekeepers should manage their colonies for better honey production which agrees with report of Kumari et al. (2003) who stated that the Preparation of honeybee flowers is based on the duration of flowering of honeybee plants which is very important for the management of honeybee colonies.

Seasonal honeybee colony dynamic of the area

According to the result, the maximum brood-rearing occurred during September, and the minor was in January and February. The honey flow months were January to February. The dearth period occurs in March and April while June and July were wet and the second dearth period

Table 3: Checklist of bee flora species from east Welega zone.

Plant species	Local name	Family	Habit	Plant source	flowering period
Acacia spp	lafto	Fabaceae	Tree	P&N	Mar-May
Albizia schimperina	Mukarbaa	Fabaceae	Tree	P&N	Mar-May
Albizia grandibracteata	Mukarba	Fabaceae	Tree	P&N	Mar-August
Albizia gummifera	Sootalloo	Fabaceae	Tree	P&N	Sep-Dec
Apodytes dimidata	Wandaboo	Icaniaceae	Tree	P&N	Sept-Nov
Biden spp	Habaaboo masqalaa	Asteraceae	herb	P&N	Sep-Feb
Borassus aethiopium	Meexxii	Aricaceae	shrub	N	Mar-May
Brassica carinata	Goommanzara	Brassicaceae	herb	P&N	Aug-Nov
Capsicum annum	Hotpepper	Solanaceae	herb	P&N	Sep-Nov
Carisa edulis	Agamsa	Apocynaceae	shrub	P&N	Dec-May
Citrus sinensis	Burtukana	Rutaceae	shrub	P&N	Sep-Nov
Climatis hisrsuta	Hidda fitii	Ranuculaceae	shrub	P&N	Dec-May
Coffea arabica	Buna	Rubiaceae	shrub	P&N	Mar-May
Combretum molle	Dhandhansa	Combretaceae	Tree	P&N	Dec-May
Combretum Paniculatum	Hidda bagi	Combretaceae	Tree	P&N	Dec-May
Cordia africana	Wadeessa	Boraginaceae	Tree	P&N	Sept-Feb
Croton macrostachyus	Bakkanniisa	Euphorbiaceae	Tree	P&N	Mar-Augest
Cucuerbita pepo	Dabaaqula	Cucubritceae	herb	P&N	Dec-Febr
Ekbergia capensis	Somboo	Meliaceae	Tree	P&N	Sep-Nov
Eucalyptus spp	bargamo	Myrtaceae	Tree	P&N	Dec-May
Grewia spp	Dhoqini	Tiliaceae	shrub	P&N	Jun-Aug
Guizota abysinica	Nuugii	Asteraceae	herb	P&N	Sep-Nov
Guizota scabra	Tufo	Asteraceae	herb	P&N	Sept-Nov
Helianthus annus	sufi	Asteraceae	herb	P&N	Sept-Nov
Hypoestes triflora	Dergu	Acanthacae	Tree	P&N	Mar-May
Justice schmperiana	dhummugaa	Acanthacae	shrub	P&N	Sep-Nov
Mangifira indica	Mango	Ancaridiaceae	Tree	P&N	June-Nov
Millettia ferruginea	Birbirraa	Fabaceae	Tree	P&N	Mar-May
Musa paradisca	muuzii	Musaceae	herb	P&N	Through year
Nigella sativa	Abasuuda adii	Ranuculaceae	herb	N	Sep-Nov
Ocimum sanctum	Mosobila	Lamiaceae	herb	P&N	Sep-Nov
Phytolacca dodecandra	Andode	Phytolacceae	shrub	P&N	Mar-May
Pisum sativum	Atara	Fabaceae	herb	P&N	Sep-Nov
Plantago lanceolata	Qorxobbii	Plantaginaceae	herb	P	Sep-May
Prunus africana	Hoomii	Roseaceae	Tree	P&N	Sept-Nov
Pterolobium stellatum	Harangamaa	Fabaceae	shrub	P&N	Dec-May
Rhus glutinosa	Xaaxessaa	Anacaridaceae	Tree	P&N	Dec-Aug
Rosa abyssinica	Qaqawwii	Roseacaceae	shrub	P	Dec-Aug
Rubus apetalus	Gora	Roseacaceae	Tree	P&N	Dec-Febr
Schefflera abyssinica	Gatamaa	Araliaceae	Tree	N	Mar-May
Sesbania sesban	Sasbaaniyaa	Fabaceae	shrub	N	Jun-Aug
Agave sisalana	sisal	Agavaceae	herb	P&N	Dec-Febr
Solanum tubersum	Dinnicha	Solanceae	herb	P&N	Sep-Feb
Sorghum bicolor	Bisinga	Poaceae	herb	P&N	Sep-Feb
Stereospermum kunthianum	Botoro	Bignoniaceae	Tree	P&N	Dec-May
Syzygium guineese,	Baaddeessaa	Myrtaceae	Tree	P&N	Dec-May
Trifolium burchellianum	Siddisa	Fabaceae	herb	P	Sept-Nov
Vernonia amygdalina	eebicha	Asteraceae	shrub	P&N	Dec-May
Vernonian auriculifera	Reejjii	Asteraceae	shrub	P&N	Dec-Febr
Vicia faba	Baaqalaa	Fabaceae	herb	P&N	Aug-Nov
Zea mays	Boqqolloo	Poaceae	herb	P	Jun-Nov

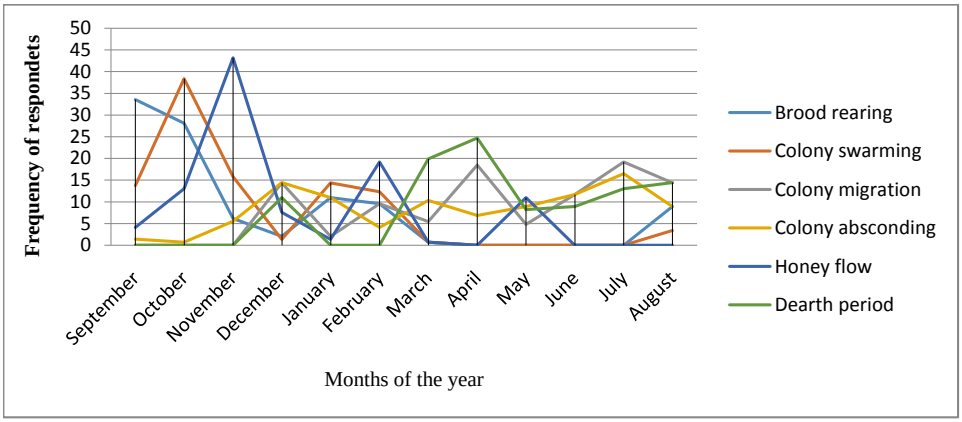

Figure 5: Major dynamic of the Year.

for the area. The maximum colony absconding occurred during March, June, and July (Figure 5). Thus by using the identified bee plants and calendar of bee flora, beekeepers can plan when they could transfer colony, suppering hive, colony multiplication, and honey harvesting in their respective areas.

CONCLUSION AND RECOMMENDATION

Identification of nectar and pollen producer plants is very important for honey production. During the study period, 53 bee plant species were identified. In all districts, the peak flowering period was from September to November which is found to be the major flowering season while the medium flowering period occurred from December to February**.** Based on the flowering season two major and one minor honey flow period was identified in all districts, and the beekeeper can select an apiary site, transfer bee colonies, multiply colony, add supers, and take action on swarm control measures and harvest honey. A beekeeper must provide artificial feeding during the dearth period. It is therefore awareness creation should be made to farmers about the flowering calendar of the area, to manage their honeybee colony to increase honey production.

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APPENDICES

Appendix 1: Bee flora species of the east Wollega.

Districts	Scientific Name	Common Name	Plant Habit	Food source	Flowering Season
				P&N	
	Syzygivm guineese	Baaddeessaa	Tree	P&N	Dec-May
Diga	*Brassica carinata*	Goommanzara	herb	P&N	Aug-Nov
	Accasia spp	Laaftoo	Tree	P&N	Mar-May
	Albizia schimperiana	Mukarbaa	Tree	P&N	Mar-May
	Biden spp	Habaaboo masqalaa	herb	P&N	Sep-Feb
	Borassus aethiopum	Meexxii	shrub	N	Mar-May
	Capsicum spp.	Mixmixa	herb	P&N	Aug-Nov
	Carissa edulis	Agamsa	shrub	P&N	Dec-May
	Citrus spp	Burtukana	shrub	P&N	Sep-Nov
	Coffea arabica	Buna	shrub	P&N	Mar-May
	Cordia africana	Wadeessa	Tree	P&N	Sept-Feb
	Croton macrostachyus	Bakkanniisa	Tree	P&N	Mar-Augest
	Cucurbita pepo	Dabaaqula	herb	P&N	Dec-Febr
	Ekbergia capensis	Somboo	Tree	P&N	Sep-Nov
	Euculyptus spp	Baargamoo	Tree	P&N	Dec-May
	Guizota abysinica	Nuugii	herb	P&N	Sep-Nov
	Guizotia scabra	Tufo	herb	P&N	Sep-Feb
	Helianthus annus	sufi	herb	P&N	Sept-Nov
	Combretum paniculatum	Hidda bagi	shrub	P&N	Dec-Aug
	Clematis hirsuta	Hidda fitii	shrub	N	Sep-Feb
	Justicia shimperiana)	Dhumuugaa	shrub	P&N	Sep-Nov
	Musa paradisca	muuzii	herb	P&N	Through year
	Nigella sativa	Abasuuda adii	herb	N	Sep-Nov
	Ocimum basilicum	misobilaa	herb	P&N	Sep-Nov
	Phytolacca dodecandra a	Andode	shrub	P&N	Mar-May
	Pisum sativum	Atara	herb	P&N	Sep-Nov
	Plantago lanceolata	Qorxobbii	herb	P	Sep-May
	Prunus africana	Hoomii	Tree	P&N	Sept-Nov
	Pterolobium stellatum	Harangamaa	shrub	P&N	Dec-May
	Schefflera abyssinica	Gatamaa	Tree	N	Mar-May
	Sesbania sesban	Sasbaaniyaa	shrub	N	Jun-Aug
	Solanum tubersum	Dinnicha	herb	P&N	Sep-Feb
	Sorghum bicolor	Bisinga	herb	P&N	Sep-Feb
	Trifolium burchellianum	Siddisa	herb	P	Sept-Nov
	Vernonia amygdalina	Eebicha	shrub	P&N	Dec-May
	Vernonian auriculifera	Reejjii	shrub	P&N	Dec-Febr
	Vicia faba	Baaqalaa	herb	P&N	Aug-Nov
	Zea mays	Boqqolloo	herb	P	Jun-Nov
	Apodytes dimidata	Wandaboo	Tree	P&N	Sept-Nov
	Millettia ferruginea	Birbirraa	Tree	P&N	Mar-May
	Combretum molle	Dadamsa	Tree	P&N	Dec-May
	Galinsoga quadriradiata	Abbadabo	shrub	P&N	Mar-Augest
	Grewia spp	Dhoqini	shrub	P&N	Jun-Aug
Gida Ayana	*Acacia spp*	lafto	Tree	P&N	Mar-May
	Albizia schimperian	Mukarba	Tree	P&N	Mar-May
	Bidens spp	Kelloo	herb	P&N	Sept-Nov

	Brassica carinata	Goomanzara	herb	P&N	June-Nov
	Capsicum spp.	Hotpepper	herb	P&N	Sep-Nov
	Carissa edulis	Agamsa	shrub	P&N	Dec-Febr
	Climatis hirsuta	Hidda fitii	shrub	P&N	Dec-May
	Coffea arabica	Coffee	shrub	P&N	Mar-Aug
	Combretum Paniculatum	Hidda bagi	Tree	P&N	Dec-May
	Cordia africana	Waddeessa	Tree	P&N	June-Nov
	Croton macrostachyus	Bakkanisa	Tree	P&N	June-Dec
	Eucalyptus spp	bargamo	Tree	P&N	Dec-May
	Guizotia scabra	Tufo	herb	P&N	Sept-Nov
	Hypostes spp.	dereku	Tree	P&N	Mar-May
	Linum usitatissimum	Talba	herb	P&N	June-Nov
	Millettia ferruginea	Sotalloo	Tree	P&N	Mar-May
	Ocimum sanctum	Mosobila	herb	P&N	Sep-Nov
	Justicia shimperiana	dhummugaa	shrub	P&N	Sep-Nov
	Pisum sativum	Pea	herb	P&N	Sep-Nov
	Pterolobium stellatum	Harangama	shrub	P&N	Sept-May
	Rhus glutinosa	Xaaxessaa	Tree	P&N	Dec-Augest
	Rubus apetalus	Gora	Tree	P&N	Dec-Febr
	Sterospermum Kunthianum	Botoro	Tree	P&N	Dec-May
	Syzygium guineese	Baddesssa	Tree	P&N	Dec-May
	Trifolium burchellianum	Siddisa	herb	P&N	Sept-Nov
	Vernonia amygdalina	eebicha	Tree	P&N	Dec-Febr
	Vicia faba	Bean	herb	P&N	Sep-Nov
	Zea mays	Maize	herb	P&N	June-Nov
	Rosa abyssinica	Qaqawwii	shrub	mesophytes	21.1
Gobu Sayo	*Croton macrostachyus*	Bakkanisa	Tree	P&N	Mar-Augest
	Cordia africana	Waddeessa	Tree	P&N	Sept-Nov
	Vernonia amygdalina	eebicha	shrub	P&N	Dec-May
	Eucalyptus *spp*	bargamo	Tree	P&N	Sept-may
	Albizia grandibracteata	Mukarba	Tree	P&N	Mar-Augest
	Albizia gummifera	Sootalloo	Tree	P&N	Sep-Dec
	Acacia spp	lafto	Tree	P&N	Mar-Augest
	Vernonian auriculifera	Rejii	shrub	P&N	Mar-May
	Trifolium burchellianum	Siddisa	herb	P	Sept-Nov
	Rosa abyssinica	Qaqawwii	shrub	P&N	Dec-May
	Bidens spp.	Kelloo	herb	P&N	Sept-Nov
	Guizotia scabra	Tufo	herb	P&N	Sept-Nov
	Mangifera indica	Mango	Tree	P&N	June-Nov
	Syzygium guineense	Baddesssa	Tree	P&N	Mar-May
	Millettia ferruginea	birbirraa	Tree	P&N	Dec-May
	Helianthus annus	sufi	herb	P&N	Sept-Nov
	Ocimum sanctum	Mosobila	herb	P&N	Dec-Febr
	Nigella sativum	Nechasmud	herb	P&N	Dec-Febr
	Agava sisalina	sisal	herb	P&N	Dec-Febr
	Justicia scimperiana	Dhumugaa	shrub	P&N	Through year
Wayu Tuka	*Acacia spp*	Laaftoo	Tree	P&N	Mar-May
	Albizia schimperiana	Mukarbaa	Tree	P&N	Mar-May
	Bidens prestinaria	Habaaboo masqalaa	herb	P&N	Sep-Feb
	Bidens spp.	Bidens spp.	herb	P&N	Sept-May
	Brassica carinata	Goommanzara	herb	N	Aug-Nov
	Borassus aethiopum	Meexxii	shrub	P&N	Mar-May
	Capsicum spp	Mixmixa	herb	P&N	Aug-Nov
	Carissa edulis	Agamsa	shrub	P&N	Dec-May

	Citrus spp	Burtukana	shrub	P&N	Sep-Nov
	Coffea arabica	Buna	shrub	P&N	Mar-May
	Cordia africana	Wadeessa	Tree	P&N	Sept-Feb
	Croton macrostachyus	Bakkanniisa	Tree	P&N	Mar-Augest
	Cucurbita *pepo*	Dabaaqula	herb	P	Dec-Febr
	Ekbergia capensis	Somboo	Tree	P&N	Sep-Nov
	Eucalyptus spp	Baargamoo	Tree	P&N	Dec-May
	Guizota abysinica	Nuugii	herb	P&N	Sep-Nov
	Guizota scabra	Tufo	herb	P&N	Sep-Feb
	Helianthus annus	sufi	herb	P&N	Sept-Nov
	Combretum paniculatum	Hidda bagi	shrub	P&N	Dec-Aug
	Climatis spp	Hidda fitii	shrub	P&N	Sep-Feb
	Justitia schimperana	Dhumuugaa	shrub	P&N	Sep-Nov
	Musa paradisca	muuzii	herb	P&N	Through year
	Ocimum basilicum	misobilaa	herb	P&N	Sep-Nov
	Phytolacca dodecandra	Andode	shrub	P&N	Mar-May
	Pisum sativum	Atara	herb	P&N	Sep-Nov
	Plantago lanceolata	Qorxobbii	herb	P	Sep-May
	Prunus africana	Hoomii	Tree	P&N	Sept-Nov
	Pterolobium stellatum	Harangamaa	shrub	P&N	Dec-May
	Schefflera abyssinica	Gatamaa	Tree	P&N	Mar-May
	Sesbania seban	Sasbaaniyaa	shrub	P&N	Jun-Aug
	Solanum tubersum	Dinnicha	herb	P&N	Sep-Feb
	Sorghum bicolor	Bisinga	herb	P	Sep-Feb
	Syzygium guineense	Baaddeessaa	Tree	P&N	Dec-May
	Trifolium burchellianum	Siddisa	herb	P&N	Sept-Nov
	Vernonia amygdlina	Eebicha	shrub	P&N	Dec-May
	Vernonia auriculifera	Reejjii	shrub	P&N	Dec-Febr
	Vicia faba	Baaqalaa	herb	P&N	Aug-Nov
	Zea mays	Boqqolloo	herb	P	Jun-Nov
	Apodytes dimidata	Wandaboo	Tree	P&N	Sept-Nov
	Combretum molle	Dhandhansa	Tree	P&N	Dec-May
	Galinosoga parviflora	Abbagabo	shrub	P&N	Mar-Augest
	Grewia spp	Dhoqini	shrub	P&N	Jun-Aug

Appendix 2: Pollen source plants from pollen tarp.

Districts	**No.**	**Honey samples**	**Kebele/Village**	***Major Pollen/flora type***	***Minor flora type***
Diga	1	Geme1	Gamachis	*vernonia sp, Trifolium spp, Guizotia spp, Coffee Arrabica,Syzygivm guineese, Vernonia spp.*	*Brassica carinata, Eucalyptus spp, Maize*
	2	Geme2	Gamachis	*Trifolium spp, Guizotia spp, Trifollium spp, Eucalyptus globules, Vernonia spp.*	*Accasia spp*
	3	Geme3	Gamachis	*Vernonia spp. ,Trifolium spp, Guizotia spp, Eucalyptus globules, Albezy shyflera*	*Coffee arabica*
	4	Firom1	Firomsa	*Brassica spp, Guizotia, . Biden spp*	*Zea maize*
	5	Firom2	Firomsa	*Eucalyptus spp, Guizotia, Vernonia spp.*	*Borassus aethiopum*
	6	Firom3	Firomsa	*Guizotia, Brassica spp, Guizotia, . Biden spp*	*Capsium spp. Eucalyptus spp*
	7	Damak1	Damaksa	*Guizotia spp, Guizotia, Guizotia*	*Eucalyptus, carisa edulis*
	8	Damak2	Damaksa	*Accacia spp., Brassica spp, Guizotia, . Biden spp*	*Sorghum bicolor , Citrus*
	9	Damak3	Damaksa	*eucalyptus Coffee Arrabica, Brassica spp, Guizotia, Biden spp*	*Accacia, Coffe Arabica, Cordia Africana*

Gida Ayana	1	Kon1	Konneji	*Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	. *Justitia schimperana*
	2	Kon2	Konneji	*Accacia spp. Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Grass spp.*
	3	Kon3	Konneji	*Eucalyptus, Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*unknown*
	4	hrbkan1	Harbu Kane	*Triffolium, Lipidium, Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Vernonia* *Euculptus spp*
	5	hrbkan2	Harbu Kane	*Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Coffee Arabica* *Guizota abysinica*
	6	hrbkan3	Harbu Kane	*Coffee Arabica Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Vernnia spp.* *Guizota scapra*
	7	gati1	Gatira	*Coffee Arabica, Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Trifolium* *Helianthus annus*
	8	gati2	Gatira	*Coffee Arabica, Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Triffolium* *Hidda bagi*
	9	gati3	Gatira	*Lipidium, Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Romex* *clamates sp*
Gobu Sayo	1	Sokej1	Sombo Kejo	*Acacia, Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Syzygivm guineese , musa paradisca*
	2	Sokej2	Sombo Kejo	*Guizotia spp, Coffee Arrabica Vernonia spp , Accacia spp, Eucalyptus globules*	*Eucalyptus spp, Ekbergia capensis, Nechasmud, mangifera Indica*
	3	Sokej3	Sombo Kejo	*Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys Eucalyptus globules*	*Ocimum santum Eucalyptus spp, mangifera Indica*
	4	ongob1	Ongobo	*Eucalyptus, camcldulensis , Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys , Eucalyptus globules*	*Coffee arabica* *Phytolacca dedecandra*
	5	ongob2	Ongobo	*Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys Guizotia*	*Eucalyptus spp,* *mangifera Indica*
	6	ongob3	Ongobo	*Brassica spp. Guizotia, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys Eucalyptus spp.*	*Plantago lanceolatum Eucalyptus spp, mangifera Indica*
	7	Gambt1	Gambela Tare	*Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys Eucalyptus spp.*	*Vernonia spp.* *Prunus africana*
	8	Gambt2	Gambela Tare	*Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys Eucalyptus spp.*	*Guizotia* *Pterolobium stellatum*
	9	gambt3	Gambela Tare	*Guizotia spp, Eucalyptus spp, Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Vernonia spp.* *Schefflera abyssinica*
				Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys Guizotia, DaturaArborea	*Eucalyptus,Guizotia* *sesbania*
Wayu tuka	1	warbab1	Wara babu minya	*Vernonia spp, Trifoliu spp, Ekbergia capensis, , Accacia spp, Croton macrostachys Eucalyptus spp.*	*Unidentified* *solanumtubersum*
	2	warbab2	Wara babu minya	*Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys Accacia spp., Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Sorghum bicolor Eucalyptus spp,* *mangifera Indica*
	3	warbab3	Wara babu minya	*eucalyptus Coffee Arrabica Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Accacia, Daturaarborea* *Burchellianum*
	4	mikur1	Migna Kura	*Accacia spp., Coffee Arrabica Brassica spp, Trifoliu spp,*	*Guizotia,vernonia amygdlina*

			Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys	
5	mikur2	Migna Kura	*Brassica spp. Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Guizotia* *Vernonian auriculifera*
6	mikur3	Migna Kura	*Bidens spp, Eucalyptus Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Unidentified* *Vicia faba*
7	Dalko1	Dalo Komto	*Bidens sp, sprestinaria Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Croton macrostachys*	*Crassoephalumvitellinum* *Zea mays*
8	Dalko2	Dalo Komto	*Bidens spp, Brassica spp, Trifoliu spp, Ekbergia capensis, Vernonia spp , Accacia spp, Eucalyptus, Coffee Arrabica*	*Brassica carinata, Coriadrumsativum, Croton macrostachys*
9	Dalko3	Dalo Komto	*Cordia Africana, Bidens sp, Albizia schimperian , Acacia spp, Croton macrostachys*	*Hypoestestrifolia* *Millettia ferruginea, Eucalyptus Coffee Arrabica*