# Assessment and Establishment of Honey Bee Flora Calendar to Increase Honey Production in Selected Areas of SNNPR State, Ethiopia

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**Research Article**

## Abstract

***Purpose:*** *This study was conducted to identify and document major honeybee flora, its flowering period, and nectar and pollen potentials in three zones representing, three agro-ecologies in SNNP.*

***Methodology:*** *Three districts in each zone were used for the study and a total of 120 beekeepers were purposively selected and interviewed to collect primary data.*

***Results:*** *The results of flora inventory indicated that abundant plant identified and ranked by farmers as very good (56.36%), good (27.27%) and poor (16.37%) while bee floras in terms of honey quality were categorized as very good (48.18%) good (25.45%) and poor (26.36%.) In terms of its acceptance by honeybees, the flora was categorized as very good (45.4%), good (21.81%) and poor (32.73%). The result of pollen analysis indicated that the majority of the Shebedino and Dale woreda (district) were dominated by Vernonia, Eucalyptus, Guizotia, and Coffee Arabica species. On the other hand pollen samples collected from the honey of Wonago and Kochere woreda were dominated by Lipidium, coffee Arabica, Eucalyptus and Guizotia species. The study identified an abundance of different classes of plants in different agro-ecologies as Asteraceae in highland, Acanthaceae in midland and Mimosaceae families in the lowland. Honey plants flower throughout the year except in June, July, and January in midland, highland, and lowland respectively. However, the highest proportion of honey plants flowers from August to October, with a peak in August and September and March to May with the peak in March. Based on flowering periods, the major and minor honey flow periods for selected areas of SNNP were respectively noted to be from August to October and from March to May.*

***Implications:*** *Based on the result of this study, it is concluded that beekeeping productivity is strictly dependent on the availability of floral resources of a particular area. It is therefore recommended that farmers get prepared in line with the flowering calendar, to conserve the identified bee plant species to boost honey production. An in-depth analysis of bee plants throughout the year, determination of total carrying capacity, propagation, wise use and conservation of floral vegetation deserve special attention for better integration of the sector with the honey flow and potential of flowering plants in the study area.*

*The search for dry season-resistant major honey bee flora and provision of practical training for farmers deserve special attention.*

**Keywords**: Botanical composition, honey bee flora, flowering time, pollen, Ethiopia

## 1. Introduction

A calendar for beekeeping is a time-table that indicates the approximate date and duration of the blossoming periods of the important honey and pollen plants to the beekeepers in their respective areas. The experienced beekeepers usually acquire much of this information over the years, but published charts are important for all beekeepers to use (FAO, 1990). Assembling a beekeeping calendar for any specific area requires complete observation of the seasonal dynamics in the vegetation patterns and/or agro-ecological zones, the foraging behavior of the bees, and the manner in which the honeybee colonies interact with their floral environment. The accuracy of a beekeeping 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.

There is a lack of information about a national beekeeping calendar that relates the flowering of honeybee forage plants to honey flow and harvesting seasons. Seasonal weather affects nectar and pollen resources, which in turn affect the colony population. Reduced food means that the queen lays fewer eggs and the population of the hive falls. Increased food means an increased number of eggs and larger population. Since, more bees mean more food that can be collected by the colonies with small populations that emphasize brood rearing (FAO, 1990). Alternatively, the colonies reaching a certain size will emphasize honey production. It is therefore important to understand how the bee colony changes throughout the year because manipulating the colony at the right time (at the peak strength)is fundamental to good beekeeping (Bees for Development, 2000). Conditions for bees can vary widely throughout the country and the management of the bees depends on where they are found (Commonwealth Secretariat. 2002). Nevertheless, when managing bees for honey production, the aim is to have the maximum colony population during the nectar flow. Providing the nectar flow is good and the weather conditions are right for a good honey crop (Horn, 2004). All apiary management practices are related to the bee colony cycle and understanding which stage the colony is in. There are three periods during a cycle and these may occur more than once in a year: 1) Dearth- not much nectar is being collected due to bad weather and poor forage. 2) Build up- there are many bee forage plants and the weather is favorable for the colony to expand 3) Honey flow- many plants provide nectar and flower at the same time (FAO, 1990). In the apiculture sub-sector, the main goal is to enhance the production and marketing of honey and other hive products. In order to fulfill this, the areas have to maintain a large enough honeybee population to sustain the supply of honey and other hive products for the domestic, regional and international markets. Qualitative information about bee forage plants, their flowering period and type of blossom can be used for planning appropriate intervention to boost the production of honey and other hive products.

However, in SNNPR (Southern Nations, Nationalities, and Peoples' Region is one of the nine ethnically based regional states (*kililoch*) of Ethiopia) the major honeybee floras of the areas were not identified and the floral calendar of these areas was not established. Beekeeping practices in the study areas are the traditional type, Farmers do not use different flowering seasons for better honey harvest. Even though they know the flowering seasons of different floras in their localities, they do not predict their honey harvest and colony size. This hurts appropriate honeybee colonies and apiary site management. This study was therefore designed with the objective of (1) identifying the major honeybee floras of the study areas (2) identify sources of pollen and nectar plants and (3) establish the floral calendar based on their flowering time and to suggest management intervention in each agro-ecology of the areas.

## 2. Materials and Methods

For this study representative sample zones and potential three districts (*Woreda*) per zone and from each district one potential Ward (*Kebele*) were selected. Twenty beekeepers were selected from each Ward using a purposive sampling method based on their experience on beekeeping> they were interviewed with a pre-structured questionnaire to obtain data about the honey plants in the study area. In this study, focus group discussion, personal observations and questionnaire interviews were used to collect the desired data. Beekeepers, the experts of the districts and development agents of all Wards, NGOs, and private investors were included in the study.

The focus group was comprised of model farmer beekeepers from each selected *kebele*, bee experts and forestry experts from each *Woreda* and Zone, and researchers from Hawassa Agricultural Research Center. The discussions were focused on plants that are important as sources of forage for honeybees, their flowering time, and seasons of swarming, the right months of harvesting honey, dearth period and signs to harvest.

Field observation was conducted to identify the type of vegetation, type of crop cultivated, plant distribution, bee plant population and to know the types of feed source (nectar or pollen) and to understand their flowering pattern. On top of that, an observation was conducted to see forager bees on different plants and to determine whether the plants visited for nectar or pollen. Pollen-foragers have been attached with pollen pellets to their hind legs which would help to determine whether the bees visited flowers for nectar. The abdomen of individual bees (at least 20 worker bees) was squeezed to obtain a drop of regurgitated nectar by using insect trap nest captured (using insect trap net at least 20 worker bees) In addition to field observation; pollen grains were collected from flower buds to use as a reference for identification of pollen grains in honey samples from the study area. The samples were collected from the area of 1 $km^2$ of the apiary of the foraging honeybees in an area because honeybees effectively utilize the plant resource within a 1 km radius (Steffan-Dewenter & Tscharntke, 1999). Three honey samples (0.5kg each) from each Kebele were collected during honey harvesting periods to identify the pollen spectrum from the honey.

Standard palynological protocols (KOH digestion, acetolysis, glycerin jelly mounting) were followed for slide making. The slides were analyzed in a standardized way. First, the core area

of each slide was thoroughly searched for pollen types and types were characterized by size, shape, number, and shape of the apertures and ornamentation. Digital images were made from polar and equatorial views of all pollen types and images were entered into a pollen database that served as a working reference. Taxonomic identifications of types to the level of the plant family, genus or species (or taxonomic 'type') were made from original slides (S. van der Kaars, partly et al. 2001.) by comparison with reference pollen collected from flowers in the bees' habitat.

To get additional information about the scientific name, family name, common name, and secondary data were collected from different sources such as books and research publications and those unknown samples were sent to the National Herbarium of Addis Ababa University. The generated information was analyzed using SPSS descriptive and SAS GLM statistical software.

## 3. Results and Discussion

### 3.1. Honeybee flora inventory

Important flowering plants in the study area are described in table 1. Most of these plant species mentioned by respondents during the survey were similar to those identified through plant inventory comprehensively described in Table 3The honey bee plants of the study area were composed of 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 the 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 vegetation 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 in the study area in particular, there is a high level of natural resources degradation which demands strong conservation and rehabilitation activities.

According to the result of honey bee flora inventory, the plants were categorized as the abundant plant was classified by farmers as very good (56.36%), good (27.27%) and poor (16.37%). The use of the flora to produce quality honey was graded as very good (48.18%), good (25.45%) and poor (26.36%). In terms of the flora acceptance by the bees, it was categorized as very good (45.4%) good (21.81%) and poor (32.73%) respectively.

Accordingly, most of the plant species mentioned by respondents during the survey and identified through plant inventory were categorized as very good in their abundance (56.36%), in their use to quality honey production (48.18%) and their acceptance by the bees (45.4%) (Table 3).

## Table1: List of honey bee flora plants identify by the respondents

| No | Local name | Scientific name | Family name | Life form | Plant abundance | It use to quality honey | Preference by bees | Feed source | Flowering time(month) | No of day stayed in flowering |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Eucalyptus | Eucalyptus sp. | Myrtaceae | Tree | 2 | 1 | 1 | POL/NEC | March-April | |
| 2 | Wanza | Cordiaafricana | Boraginaceae | Tree | 1 | 2 | 2 | POL/NEC | Jan-Feb | |
| 3 | Grara | Acacia sp. | Mimosaceae | Tree | 2 | 3 | 3 | POL/NEC | March-Sept | |
| 4 | Bahirzaf | Eucalyptus camaldlensis | Myrtaceae | tree | 1 | 2 | 1 | POL/NEC | May | 30 |
| 5 | Kosso | Hygeniaabyssinica | Rosaceae | Tree | 1 | 2 | 2 | POL/NEC | Sept-O Spe-Oct | |
| 6 | Besana | Croton macrostachys | Euphorbiaceae | Tree | 1 | 1 | 1 | POL/NEC | April-June | |
| 7 | Kulkual | Euphorbia sp | Euphorbiaceae | Tree | 2 | 1 | 3 | POL/NEC | Sept-Nov | |
| 8 | Geteme | Scheffleraabyssinica | Araliaceae | Tree | 1 | 1 | 1 | POL/NEC | Sept-Dec | |
| 9 | Woyra | Oleaafricana | Oleaceae | Tree | 3 | 2 | 2 | POL/NEC | Sept-Nov | |
| 10 | Tree man tree | Schinusmolle | | Tree | 2 | 1 | 1 | POL/NEC | Spt-Dec | |
| 11 | Qorch | Erythriniaabyssinica | Fabaceae | Tree | 2 | 3 | 3 | POL/NEC | Nov-Dec | |
| 12 | Dokima | Syzygivmguineese | Myrtaceae | Tree | 3 | 1 | 3 | POL/NEC | April | 29 |
| 13 | Bottlebrush | Callistemon citrunus | Myrtaceae | Tree | 1 | 1 | 1 | POL/NEC | Dec-Feb | |
| 14 | Gesho | Rhamnussp | Rhamnaceae | Tree | 1 | 3 | 2 | POL/NEC | March-May | |
| 15 | Keraro | Anigariaaltisma | Sapotaceae | Tree | 1 | 1 | 1 | POL/NEC | Nov-Feb | |
| 16 | Zeyiton | Psidiumsp | Myrtaceaea | Tree | 3 | 3 | 3 | POL/NEC | March | 30 |
| 17 | Grevilea | Grevilearobusta | Proteacaeae | Tree | 1 | 2 | 2 | POL/NEC | Oct-Dec | |
| 18 | Lottoba orm | Acacia tortolis | Fabaceae | tree | 2 | 3 | 3 | POL/NEC | Jan Feb | 10 |
| 19 | Grawa | Vernoniasp | In caill | tree | 1 | 2 | 2 | POL/NEC | Dec-Feb | 32 |
| 20 | Senbelet | Hyparrheniarufa | Poaceae | Shrubs and herbs | 1 | 3 | 3 | Pollen | August | 5 |
| 21 | Adeyabeba | Bidensspp | Asteraceae | weed | 1 | 2 | 1 | POL/NEC | Sep-Oct | 15 |
| 22 | GomenZer | Brassica spp. | Brassicaceae | Shrubs herb | 2 | 3 | 2 | POL/NEC | Sept | 15 |
| 23 | Yehayajoro | Verbascummsinatum | Scrophulariaceae | Shrubs herbs | 1 | 1 | 3 | POL/NEC | August-may | |
| 24 | Enbacho | Rumexnervosus | Polygonaceae | Shrubs herbs | 3 | 2 | 3 | POL/NEC | March | 30 |
| 25 | Clover | Trifoliumsp | Fabaceae | Shrubs herbs | 1 | 1 | 1 | POL/NEC | July-Oct | |
| 26 | Yemeskelabeba | Bidenspachylom a | Asteraceae | Shrubs herbs | 1 | 1 | 1 | POL/NEC | Spt-Oct | |
| 27 | Kosheshila | Echinopesellenbeckil | Asteraceae | Shrubs herbs | 2 | 1 | 3 | POL/NEC | Nov-May | |
| 28 | Mechi/shashe | Guizotiascabrasp | Asteraceae | weed | 1 | 1 | 1 | POL/NEC | August/Feb | 6months |

| No | Local name | Scientific name | Family name | Life form | Plant abundance | It use to quality honey | Preference by bees | Feed source | Flowering time(month) | No of day stayed in flowering |
|---|---|---|---|---|---|---|---|---|---|---|
| *29* | Muz | Musa paradisca | *Musaceae* | HorticCrops | *1* | *1* | *1* | *POL/NEC* | Sept-Oct | |
| *30* | *Bekolo* | Zea mays | *Poaceae* | *Field crops* | 1 | *3* | *3* | *Pollen* | Sept-Oct | *5* |
| *31* | Bakela | Viciafaba | *Papilionaceae* | *Field crops* | *2* | *2* | *2* | *POL/NEC* | *Sept* | *15* |
| *32* | Chat | Catha edulis | *Cceaeelastra* | HorticCrops | *1* | *3* | *3* | *POL/NEC* | July-Sept | |
| *33* | Buna | Coffee arbica | *Rubiaceae* | *Field crops* | 1 | *1* | *1* | *POL/NEC* | April-May | |
| *34* | Hadda | Guizotiascabra sub sp | *Asteraceae* | Shrubs herbs | *1* | *1* | *1* | *POL/NEC* | Throughout the year | |
| *35* | Noug | Guizotiaabyssinica | *Asteraceae* | Oil crops | *1* | *2* | *1* | *POL/NEC* | Oct-Nov | |
| *36* | Sunflower | Helianthnsannus | *Asteraceae* | Oil crops | *1* | *1* | *2* | *POL/NEC* | *variable* | |
| *37* | Rapesced | Brassica sp | *Brassicaceae* | Oil crops | *2* | *1* | *1* | *POL/NEC* | Sept- Nov | |
| *38* | Soybean | Glycine max | *Leguminosea* | Oil crops | *2* | *1* | *1* | *POL/NEC* | Sept-Oct | |
| *39* | Safflower | Carthamus tine-torius | *Carthamaceaes* | Oil crops | *2* | *2* | *2* | *POL/NEC* | Nov-Jan | |
| *40* | Mashila | Sorghum bicolor | *Poaceae* | Hortic Crops | *2* | *1* | *1* | *Pollen* | *Sep* | *21* |
| *41* | ɜe lllTosgn | Saturejaparadoxa | *Lamiaceae* | Oil crops | *2* | *1* | *1* | *POL/NEC* | *March to June* | |
| *42* | Gulo | Ricinuscommunis | *Euphorrrbiacaea* | Oil crops | *1* | *2* | *2* | *POL/NEC* | Sept | *21* |
| *43* | Wine | Vitisvinifere | | HorticCrops | *2* | *1* | *1* | *POL/NEC* | Sept-Oct | |
| *44* | Tenaadem | Rutachalopensis | *Rutaceae* | Spice | 2 | *3* | *3* | *POL/NEC* | Sept | |
| *45* | Besobila | Salvia nilotica | *Lamiaceae* | Spice/hurbs | 2 | *2* | *1* | *POL/NEC* | Throughout the year | |
| *46* | Lomi | Citrus sp | *Rutaceae* | HorticCrops | *1* | *1* | *3* | *POL/NEC* | Sept-Oct | |
| *47* | Kessie | Lippiaadoensis | | Spice | 1 | *2* | *2* | *POL/NEC* | Sept-Oct | |
| *48* | Serdo grass | *Cynodondactylon* | *Poaceae* | *Weed* | *1* | *3* | *3* | *POL/NEC* | August | *7* |
| *49* | Tikurazmud | Nigenasativa | *Ranunculaceae* | Spice./hurb | 3 | *2* | *1* | *POL/NEC* | August to Oct | |
| *50* | *Feto* | Lipdumsativum | *Brassicaceae* | Spice | *2* | *1* | *1* | *POL/NEC* | Sept-Oct | |
| *51* | Gwaya | Lathyrussativus | *Fabaceae* | *Field crops* | 2 | *1* | *1* | *POL/NEC* | Nov-Dec | |
| *52* | Avocado | Perseaamericana | *Lauraceae* | Hortic Crops | *1* | *1* | *1* | *POL/NEC* | Oct to Dec | |
| *53* | Mango | Mangifraindica | *Anacardiaceae* | HorticCrops | *1* | *3* | *3* | *POL/NEC* | Dec to Feb | *45* |
| *54* | papaya | Papaya carica | Caricaceae | Hortic Crops | *1* | *3* | *3* | *POL/NEC* | Sept-Nov | *41* |
| *55* | Enjory | Rubusteduneri | | HorticCrops | *1* | *1* | *1* | *POL/NEC* | Sept-Oct | |

As shown in (table 2) , the majority of the Shebedino and Dale woreda of Sidama Zone honey samples were dominated by Vernonia, Eucalyptus, and Guizotia and Coffee Arabica species. As shown in the table, the majority of the wonago and Kochereworeda honey samples were dominated by Lipidium, coffee Arabica, Eucalyptus and Guizotia species.

**Table 2: Results of honey pollen analysis of Sidama zone**

| No | Honey samples | Place of collection | Major Pollen/flora type | Minor type |
|---|---|---|---|---|
| 1 | Ss01 | Shebedino | Guizotia, Coffee Arrabica | Eucalyptus spp. |
| 2 | Ss02 | Shebedino | Eucalyptus globules | Trifollium spp. |
| 3 | Ss03 | Shebedino | Eucalyptuscamcldulensis | Coffee arabica |
| 4 | Ss04 | Shebedino | Guizotia | Pissamsativum |
| 5 | Ss05 | Shebedino | Brassica spp. | Guizotia |
| 6 | Ss06 | Shebedino | Eucalyptus spp. | Vernonia spp. |
| 7 | Ss07 | Shebedino | Eucalyptus spp. | Guizotia |
| 8 | Ss08 | Shebedino | Guizotia, Eucalyptus | Vernonia spp. |
| 9 | Ss09 | Shebedino | Guizotia, DaturaArborea | Eucalyptus,Guizotia |
| 10 | Ss10 | Shebedino | Vernonia spp., Eucalyptus | Unidentified |
| 11 | SD11 | Dale | Accacia spp., | Sorghum bicolor |
| 12 | SD12 | Dale | eucalyptus Coffee Arrabica | Accacia,daturaarborea |
| 13 | SD13 | Dale | Accacia spp., Coffee Arrabica | Guizotia |
| 14 | SD14 | Dale | Brassica spp. | Guizotia |
| 15 | SD15 | Dale | Eucalyptus | Unidentified |
| 16 | SD16 | Dale | Biden sprestinaria | Crassoephalumvitellinum |
| 17 | SD17 | Dale | Eucalyptus, Coffee Arrabica | Coriadrumsativum |
| 18 | SD18 | Dale | Cyprus., Coffee Arrabica | Hypoestestrifolia |
| 19 | SD19 | Dale | Eucalyptus, Coffee Arrabica | Lipidiumsativum |
| 20 | SD20 | Dale | Eucalyptus | Coffee Arrabica |

The results of honey pollen analysis of Gedeo zone are shown in table 3. The dominant flora/pollen plants in Gedoe Zone were Eucalyptus, Vernonia, Coffee Arabica and Accacia.

**Table 3: Gedeo zone honey pollen analysis result**

| No | Honey samples | Place of collection | Major flora/pollen plants | Minor flora identified |
|---|---|---|---|---|
| 1 | Gw1 | Wonago | Eucalyptus | unknown |
| 2 | Gw2 | Wonago | Lipidium,Vernonia | Accacia spp. |
| 3 | Gw3 | Wonago | Accacia spp. | Grass spp. |
| 4 | Gw4 | Wonago | Eucalyptus | unknown |
| 5 | Gw5 | Wonago | Vernonia, Lipidium | Trifollium |
| 6 | Gw6 | Wonago | Triffolium, Lipidium | Vernonia |
| 7 | Gw7 | Wonago | Lipidium | Coffee Arabica |
| 8 | Gw8 | Wonago | Coffee Arabica | Vernnia spp. |
| 9 | Gw9 | Wonago | Coffee Arabica | Trifolium |
| 10 | Gw10 | Wonago | Coffee Arabica | Triffolium |
| 11 | GK11 | Kochere | Lipidium | Romex |
| 12 | GK12 | Kochere | Lipidium | Guizotia |
| 13 | GK13 | Kochere | Acacia | Vernonia |
| 14 | GK14 | Kochere | Vernonia | Eucalyptus |
| 15 | GK15 | Kochere | Coffee Arabica | Eucalyptus |
| 16 | GK16 | Kochere | Lipidium | unknown |
| 17 | GK17 | Kochere | Vernonia,lipidium | Unknown |
| 18 | GK18 | Kochere | Eucalyptus | Coffee arabica |
| 19 | GK19 | Kochere | Lipidium | Vernonia,acacia,grass |
| 20 | GK20 | Kochere | Pisumsativum, | Brassica |

### 3.2. Honey bee plant species and their flowering time in each agro-ecologies of the areas

Honey plant families and their flowering time in the highlands are given table 4. The distribution and type of honeybee plants, as well as their flowering duration, vary from one place to another place due to variation in topography, climate and farming practices. The top 10 more frequent plants in most sample plots of the highland representative areas were *Guizotiaabyssinica*, *Bidensspp*, *Viciafaba*, *Cynodondactylon*, *Acacia seya*l, *Hypoestestrifolia*, *Schefflerabyssinica*, *Echinopesellenbeckil*,*Ocimumbacilicum* and *Coffee arbica* while were (Table 4)

**Table 4. Honey plant families and their flowering time in the highlands**

| No | Local name | Scientific name | Family name | Spt | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Ranking based on abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1* | *Noug* | *Guizotiaabyssinica* | *Asteraceae* | | *x* | *x* | | | | | | | | | | *1* |
| *2* | *Adeyabeba* | *Bidensspp* | *Asteraceae* | *x* | *x* | | | | | | | | | | | *2* |
| *3* | Bakela | Viciafaba | *Papilionaceae* | *x* | *x* | | | | | | | | | | x | *3* |
| *4* | *Serdo grass* | *Cynodondactylon* | *Poaceae* | | | | | *x* | *x* | | | | | | *x* | *4* |
| *5* | *Wasiya* | *Acacia seyal* | *fabaceae* | | | | | *x* | *x* | | | | | | | *5* |
| *6* | *Drgu (orm)* | *Hypoestestrifolia* | *Acanthaceae* | | | | | | *x* | | | | | *x* | | *6* |
| *7* | *Getme* | *Schefflerabyssinica* | *Araliaceae* | *x* | *x* | | | | | | | | | | | *7* |
| *8* | Kosheshila | Echinopesellenbeckil | *Asteraceae* | | | x | | | | | | *x* | | | | *8* |
| *9* | *Besobla* | *Ocimumbasilicum* | *Lamiaceae* | *x* | *x* | *x* | *x* | *x* | *x* | X | *x* | *x* | X | *x* | *x* | *9* |
| *10* | Buna | Coffee arbica | *Rubiaceae* | | | | | | | X | *x* | *x* | | | | *10* |
| *11* | Keraro | Anigariaaltisma | *Sapotaceae* | | | x | x | *x* | | | | | | | | *11* |
| *12* | Tenaadem | Rutachalopensis | *Rutaceae* | X | | | | | | | | | | | | *12* |
| *13* | Besana | Croton macrostachys | Euphorbiaceae | | | | | | | X | *x* | *x* | X | | | *13* |
| *14* | *Feto highland* | Lipdumsativum | *Brassicaceae* | X | *x* | | | | | | | | | | | *14* |
| *15* | Tikurazmude | Nigenasativa | *Ranunculaceae* | X | x | | | | | | | | | | x | *15* |
| *16* | Rapesced | Brassica sp | *Brassicaceae* | X | x | | | | | | | | | | | *16* |
| *17* | Clover | Trifoliumsp | *Fabaceae* | X | x | | | | | | | | | *x* | x | *17* |

*Source: survey*

The dominant honey bee floras in the midland are given in table 5. In this agro-ecology, the dominant species included *Hypoes testrifolia, Ocimumbacilicum, Guizotiascabrasp, Coffee arbica, Croton macrostachys, Bidensspp, Vernoniaspp, coridiacafrican, Viciafaba, and Guizotiaabyssinica.*

**Table 5. Honey plant families and their flowering time in the midland**

| No. | Local name | Secintific name | Family name | Sep | Oct | Nov | Dec | Jan | Feb | Apr | Mar | May | Jun | Jul | Aug | Ranking based on abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1* | *Drgu (orm)* | *Hypoestestrifolia* | *Acanthaceae* | | | | | | X | | | | | X | | *1* |
| *2* | *Besobla* | *Ocimumbasilicum* | *Lamiaceae* | X | *x* | *x* | *x* | *x* | X | *x* | *x* | *x* | *x* | X | X | *2* |
| *3* | *Mechi/shashe* | Guizotiascabrasp | *Asteraceae* | | | | | | X | | | | | | X | *3* |
| *4* | Buna | Coffee arbica | *Rubiaceae* | | | | | | | *x* | *x* | *x* | | | | *4* |
| *5* | Besana | Croton macrostachys | Euphorbiaceae | | | | | | | *x* | *x* | *x* | *x* | | | *5* |
| *6* | *Adeyabeba* | *Bidensspp* | *Asteraceae* | X | *x* | *x* | *x* | | X | *x* | *x* | *x* | *x* | X | *x* | *6* |
| *7* | Grawa | Vernoniasp | *In caill* | | | | x | x | X | X | *x* | *x* | | | | *7* |
| *8* | Wanza | Cordiaafricana | *Boraginaceae* | | | | | x | X | | | | | | | *8* |
| *9* | Bakela | Viciafaba | *Papilionaceae* | X | *x* | | | | | | | | | | | *9* |
| *10* | *Noug* | *Guizotiaabyssinica* | *Asteraceae* | | *x* | *x* | | | | | | | | | | *10* |
| *11* | Grara | Acacia sp. | *Mimosaceae* | X | | | | x | X | X | *x* | | | | | *11* |
| *12* | Bottlebrush | Callistemon citrunus | *Myrtaceae* | X | x | x | x | x | X | X | *x* | *x* | *x* | X | X | *12* |
| *13* | Chat | Catha edulis | *Cceaeelastra* | X | x | x | x | x | X | X | *x* | *x* | *x* | X | X | *13* |
| *14* | *Bahirzaf* | *Eucalyptus camaldlensis* | *Myrtaceae* | | | | | | | | | *x* | | | | *14* |
| *15* | Zeyiton | Psidiumsp | *Myrtaceaea* | | | | | | | | *x* | | | | | *15* |
| *16* | Muz | Musa paradisca | *Musaceae* | X | x | | | | | | | | | | | *16* |
| *17* | *Bekolo* | Zea mays | *Poaceae* | X | x | | | | | | | | | | | *17* |

**Source: survey**

The dominant honey bee floras in the low land are given in table 6. Acacia spp, Sorghum bicolor, Biden spp, Guizotiascabrasp, Callistemon citrunus, Acacia seyal, Cynodondactylon,Vernoniaspp, grass spp. Croton macrostachys and Guizotiascabra sub spp were the more frequent ones in the lowland (Table 6).

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 the sample quadrate due to its growth habit in degraded areas and harsh climate conditions. In this study, it is found that Asteraceae, Acanthaceae, and Mimosaceae families were the plant families in higher abundance in the highland, midland and lowland areas respectively (Tables 4 - 6). On the other hand tree and shrub densities were lower in the study area due to deforestation and the expansion of crop farming in the area.

**Table 6. Honey plant families and their flowering time in the lowlands**

| *No.* | *Local name* | *Secintific name* | *Family name* | *Sep* | *Oct* | *Nov* | *Dec* | *Jan* | *Feb* | *Apr* | *Mar* | *May* | *Jun* | *Jul* | *Aug* | *Ranking based on abundance* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1* | Grara | Acacia sp. | *Mimosaceae* | *x* | | | | | | | *x* | | | | | *1* |
| *2* | Mashila | Sorghum bicolor | *Poaceae* | *x* | | | | | | | | | | | | *2* |
| *3* | *Adeyabeba* | *Bidensspp* | *Asteraceae* | *x* | *x* | | | | | | | | | | | *3* |
| *4* | *Mechi/shashe* | Guizotiascabrasp | *Asteraceae* | | | | | | X | | | | | | x | *4* |
| *5* | Bottlebrush | Callistemon citrunus | *Myrtaceae* | | | | X | *x* | X | | | | | | | 5 |
| *6* | *wasiyaorm* | *Acacia seyal* | *fabaceae* | | | | | | X | | | | | | *x* | *6* |
| *7* | Serdo grass | *Cynodondactylon* | *Poaceae* | | | | | | | | | | | | x | *7* |
| *8* | Grawa | Vernoniasp | *In caill* | | | | X | *x* | X | | | | | | | 8 |
| *9* | Besana | Croton macrostachys | Euphorbiaceae | | | | | | | | *x* | *x* | x | | | 9 |
| *10* | Hadda | Guizotiascabra sub sp | *Asteraceae* | *x* | *x* | *x* | X | *x* | X | X | *x* | *x* | x | X | x | *10* |
| *11* | Dokima | | | | | | | | | X | | | | | | *11* |

**Source: survey**

### 3.3. The phenological picture of total flowering

The phenological picture of the dominant honey bee flora varies depending on agro-ecology (figure 1). The phenological picture defines the changes in the seasonal landscape of the flora in a particular area of interest. As indicated in figure 1 honey plants flower throughout the study period/year except in June, July and January in midland, highland, and lowland respectively.

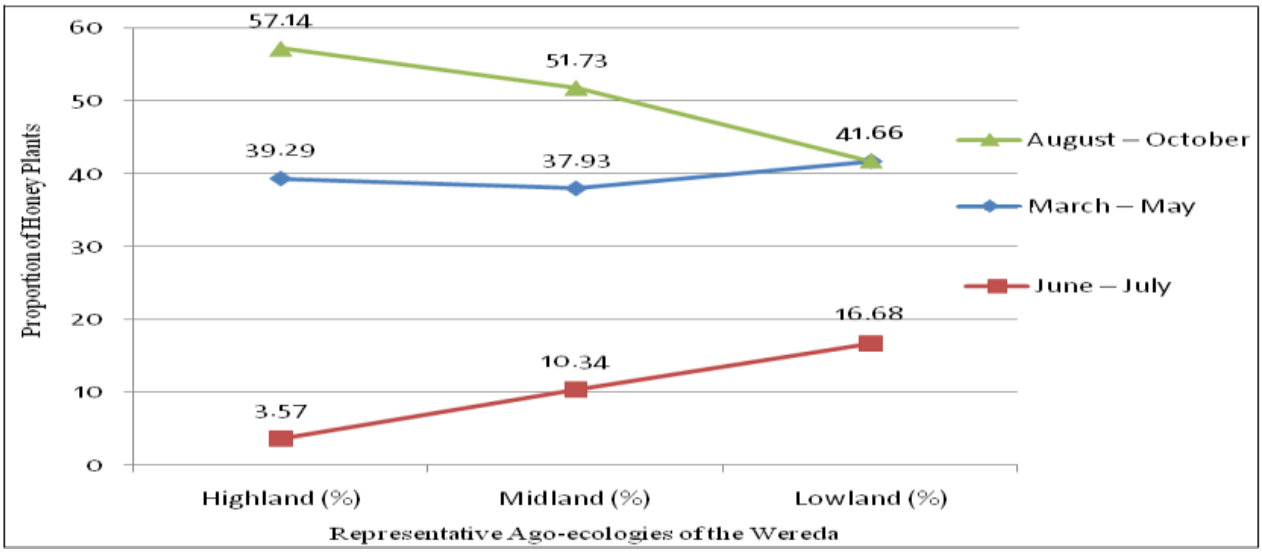


**Fig. 1: The influence of agro-ecology on flowering periods of honey plants**

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 suggesting that August to October is the major and March to May is the minor honey flow periods of the study areas corroborating the hypothesis that flowering period differs in each agro-ecology dictating honey production.

### 3.4. Colony management plan based on flowering calendar

The beekeepers should identify honey plant flowering seasons in their area in order to provide bees with additional feed during the drought period. Supplying feed during drought would assist the colony to conduct their regular activities. Feeding the colonies during the dearth period minimizes the effect of the drought and there would be very little effect on honey production during the flowering season. When the flowering season approaches, preparation should be made for optimizing yield and good qualities of the product. Various management activities could be performed in the various season of the year to make the colonies productive and attain a good harvest.

## 4. Conclusion and Recommendation

The study has confirmed that criteria set by respondents in prioritizing honey bee plants were in agreement with the amount of nectar and pollen collected by laboratory analysis. Honey plants flower throughout the study period except in June, July and January in midland, highland, and lowland respectively. The beekeepers should provide supplementary feed in order to minimize the effect of dearth period on amount of honey harvested.

The result explained that August to October is the major and March to May is the minor honey flow periods of the study area. It is therefore recommended that farmers get prepared in line with the flowering calendar, to conserve the identified bee plant species to boost honey production. An in-depth analysis of bee plants throughout the year, determination of total carrying capacity, propagation, wise use and conservation of floral vegetation deserve special attention for better integration of the sector with the honey flow and potential of flowering plants in the study area. The search for dry season-resistant major honey bee flora and provision of practical training for farmers deserve special attention.

**Authors' contribution:** Mekonen Debara, and Dinku Negash conceived the idea, Bangu Bekele and Bereket Zeleke collected and analyzed the data; all the authors participated in writing the paper.

**Conflicts of Interest:** The authors declare no conflict of interest.

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