**Review Article**

**Honeybee Forage Diversity and Flowering Seasons in Ethiopia: Implications for Sustainable Beekeeping**

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**ABSTRACT**

Ethiopia is home to diverse and abundant bee forages resources supporting sustainable bee keeping, honey production, and pollination services. This review evaluates the diversity, distribution, and flowering season season of nectar and pollen producing across the country. More than 800 honeybee forage species have been identified, and classified in to trees, shrubs, herbs and horticultural crops. Regional variations influences flowering periods with some areas offering years round forages while others experiences seasonal shortage. Beekeepers knowledge, attitudes and practices (KAP) vary significantly across regions, with key challenges including deforestation, land use changes, pesticide plication, and limited awareness of sustainable forage management. The review also highlights endangered bee forage plants and their declines availability due to habitat destruction. To address these issues strategies such as afforestation, conservation of indigenous bee plants, diversification of forage sources and improved land use planning are recommended. Strengthening beekeepers capacity through training and awareness program can enhance honey production and colony health. This review provides valuable insights for policymaker, researchers and beekeepers to develop sustainable apiculture practices in Ethiopia, ensuring the long term viability of honeybee population and their ecosystem services.

**Keywords**: apiculture, Ethiopia, endangered, honeybee forage, KAP,

**INTRODUCTION**

Ethiopia boasts exceptionally high biodiversity. including a rich variety of native plants [1] [2]. This biodiversity, coupled with Ethiopia's diverse topography and agro climatic conditions, supports a vast number of honeybee colonies and a wide range of honeybee flora [3]**.** The country's varied agro climatic conditions foster the growth of an estimated 6,000 to 7,000 flowering plant species, the majority of which serve as bee forage, with over 800 species specifically identified and documented [4]. Ethiopia's has thirteen distinct natural vegetation types [5]. Further contribute to this rich ecosystem. Beekeeping plays a significant role in environmental protection and natural resource conservation, complementing agroforestry practices to enhance ecosystem functioning, biodiversity, honey production, and crop pollination [6]. Numerous studies highlight the long-standing interdependence of forest management and beekeeping worldwide [7].

Bees play a critical role in Ethiopian agriculture by providing essential pollination services that enhance crop yields, improve quality, and ensure biodiversity. Ethiopia, as a major honey-producing country in Africa, benefits significantly from the presence of diverse bee species, including Apis mellifera (honeybees), stingless bees, and solitary bees [8]. This review examines significant advancements in bee forage research over the past decade, focusing on the identification, distribution and diversity of bee resources; the development of flowering calendars; the assessment and characterization of herbaceous, shrub, and tree plants; and the crucial role of honeybees in agroforestry systems and natural resource conservation.

## Objectives of the Review

To review honey bee forage plants and their status in Ethiopia

**Diversity of Honeybee Forage Plants in Ethiopia**

Ethiopia's diverse regions, including the Amhara, Tigray, Southern Nations, Nationalities, and Peoples' (SNNP), Gambela, Benishangul Gumuz each host unique bee flora that supports robust beekeeping practices [9]. And also has diverse climate and topography supported by rich variety of flowering plants making it highly suitable for beekeeping (Figure 1) [10]. in the Oromia regional states of Jimma zone a study identified 141 honey bee plant species across 62 families[4]. According to the above author at Jimma zone herbs were the most dominant growth forms of and 44% of these species is followed by trees 34% and shrubs 22%. Similar research in the Gesha sayilem forest documented 93 bee forage species from 43 families[3] . The growth forms comprised herbs 36.6% shrubs 25.8% and climbers 14%. This diversity underscores the regions variety potential for sustainable and commercial bee keeping[8].

Specific plant species have been identified as significant nectar and pollen sources for Ethiopia honeybee. these includes eucalyptus species , *schinus molle , cordia Africana , ehretia cymosa, pterolobium stellatum, lippie adoensis, aloe abrana* [5]. The diverse flowering periods of these plants enable multiple honeys harvesting seasons. For instance in the southwest Shoa zone three honey harvesting periods were identified November , January and June . mono flora honeys produced including *erica arborea*, honey in January, eucalyptus *camaldulensis* honey in June and guizotia honey in November [11]. The rich flora diversity not only supports the bee keeping industry but also plays a crucial role in the pollination of various crops, contributing to the overall biodiversity productivity of Ethiopia[6].

In Tigay regional states particularly eastern parts there is high quality honey production, largely attributed to its diverse flora species, favorable climate, and topography and rainfall patterns. study’s by Mekele university and the Tigary agricultural research institutes have identified approximately 113 bee flora species in Tigray [12]. The regions undulating terrain and semi dry climate characterized by erratic rain fall , promote the dominance of forbs and shrubs which are beneficial for honey production[12].in SNNP regional states particularly in Kefa , Sheka and Bench maji zone research has documented around 200 flora species across 77 families that serve as bee forage [13] . among these 26 species from 16 families are considered major bee forage[14]

.The primary honey flow period are from march to April and November to December with *scheflera abyssinca* and *guizotia scabra* being significant nectar sources during these time [13], [14] . In Amara regional states efforts has been made to adapt and characterized major pollen and nectar source plants to enhance bee forage availability. Species such as *hypostes trifolia* and leucas abyssinica have been identified as highly suitable nectar and pollen source plants. According to [5], 290 plant species from 105 families have been identified as honeybee forage in the Amhara region (*Figure 1 )*. *Becium grandiflorum* and *Opuntia ficus-indica* are very common in western Amhara. For honeybee fodder, the *Asteraceae, Leguminosae, Fabaceae,* and *Lamiaceae* families are typically among the most significant in Ethiopia. Important species include Croton *macrostachyus, Vernonia, Brassica carinata, Andropogon abyssinicus, Guizotia, Bidens, Trifolium, Eucalyptus, Cordia africana,* and *Acacia* [7]. Overall bee flora species richness is highest in the Oromia, Amhara, SNNPR, Gambella, and Tigray regions [8].

Figure 1 bee flora species and their families

Tree as Bee Forages Plants

According to Ethiopian scholars,[4][2], [3], [5], [5], [9], [9], [16]–[21] there are several tree species commonly distributed throughout the country that serv as important bee forages . These plants are found across various regional zones with significant concentrations in areas such as Jimma, arsi, Hawasa, North Wollo, Waghimra, Gojam, Gondar, Tigray, Showa Wollega, Keffa, sheka, Bench maji, and Gambela. These areas are known for their diverse vegetation that provides vital forage resources, such as pollen and nectar, for bee populations throughout the year. The distribution of these plants highlights the significant ecological role they play in supporting both local and regional bee populations, contributing to honey production in Ethiopia. In Ethiopia there are various tree plants flowering in different seasons which is very important to bee keeping sustainability. According to the table below different trees can bloom in different months which are valuable to bees for nectar and pollen services[Table 1 ].

Trees, as evidenced by the diverse list of species and their flowering seasons, are a critical and multifaceted resource for bee forage [22]. The provided list showcases a wide range of trees, from Acacias and Cordias to Eucalypti and Syzygiums, each offering nectar and pollen during specific periods, ensuring a more consistent and extended supply of food for bees compared to shorter-blooming herbaceous plants [23]. This temporal diversity is particularly important for colony survival and growth, allowing bees to build up strength during crucial periods like spring and prepare for winter[2]. Furthermore, the variety of tree species contributes to a more balanced diet for bees, with different trees offering unique nutritional profiles in their nectar and pollen, promoting bee health and resilience [2]. Beyond food, trees also provide essential habitat, offering nesting sites and protection from the elements. The inclusion of such diverse tree species in both agricultural and natural landscapes is therefore paramount for supporting healthy bee populations, ensuring effective pollination services, and promoting the long-term sustainability of beekeeping practices [9]. Table 1 provides a list of common tree species essential for honeybee forage, highlighting their flowering periods. It helps beekeepers understand seasonal nectar and pollen availability, ensuring optimal colony management throughout the year.

Table 1 common tree plants for bee forage and their flowering months

| *Scientific Name* | | Local Name | | Flowering Season | |
| --- | --- | --- | --- | --- | --- |
| *Acacia abyssinica* | | - | | June | |
| *Acacia asak* | | Tsalwa | | April | |
| *Acacia mearnsii* | | - | | June | |
| *Acacia seyal* | | Key Girar | | May | |
| *Acacia seyal Del* | | Chea | | Sep-Nov | |
| *Acacia tortilis* | | Abiqa | | May | |
| *Adansonia digitata* | | Firtata | | June | |
| *Adansonia digitata* | | Firtata | | Year-round | |
| *Albizia amara* | | Sibqana | | May | |
| *Albizia gummifera* | | - | | February | |
| *Balanites aegyptica* | | Goza | | April | |
| *Boscia angustifolia* | | Shisha | | April | |
| *Carica papaya* | | - | | March | |
| *Citrus aurantifolia* | | - | | March | |
| *Citrus sinensis* | | - | | March | |
| *Cordia africana* | | Wanza | | May | |
| *Cordia africana* | | - | | June-July | |
| *Cordia africana* | | Waddeessa | | March-April | |
| *Cordia africana Lam.* | | Awhi | | Nov-Jun | |
| *Croton macrostachyus* | | - | | April-May | |
| *Croton macrostachyus* | | Baargamoo | | September | |
| *Dodonaea angustifolia* | | - | | October | |
| *Eriobotrya japonica* | | - | | November | |
| *Erythrina abyssinica* | | - | | October | |
| *Erythrina brucei* | | - | | October | |
| *Eucalyptus camaldulensis* | | Bahir Zaf | | May | |
| *Eucalyptus camaldulensis* | | Key Bahirzaf | | Year-round | |
| *Eucalyptus sp. Labill* | | Kelamitos | | Year-round | |
| *Eucalyptus species* | | - | | May-June | |
| *Eucalyptus spp.* | | Bakkanniisa | | Oct-Nov; Feb-Mar; Apr-May | |
| *Faidherbia albida (Del.) A. Chev.* | | Momona | | Nov-Dec | |
| *Ficus vasta* | | - | | August | |
| *Grevillea robusta* | | - | | August | |
| *Jacaranda mimosifolia* | | - | | August | |
| *Juniperus procera* | | - | | February | |
| *Juniperus procera* | | - | | February | |
| *Mangifera indica* | | - | | January-February | |
| *Mangifera indica* | | - | | January-February | |
| *Melia azedarach* | | - | | October | |
| *Melia azedarach* | | - | | October | |
| *Moringa stenopetala* | | - | | September | |
| *Musa spp.* | | - | | December | |
| *Olea europaea* | | - | | July-August | |
| *Olea europaea* | | Woyira | | Year-round | |
| *Persea americana* | | - | | March-April | |
| *Persea americana* | | - | | March-April | |
| *Prunus africana* | | - | | September | |
| *Prunus africana* | | - | | September | |
| *Psidium guajava* | | Zeyitun | | March | |
| *Rapanea melanophloeos* | | - | | June | |
| *Rapanea melanophloeos* | | - | | June | |
| *Schinus molle* | | Qundo Berberie | | March | |
| *Schinus molle* | | - | | March | |
| *Schinus molle* | | Qundabarbarree | | September | |
| *Schinus molle* | | - | | March | |
| *Syzygium guineense* | | Dokima | | April | |
| *Syzygium guineense* | | - | | January | |
| *Syzygium guineense* | | Baddeessaa | | February-March | |
| *Syzygium guineense* | | - | | January | |
| *Terminalia glaucescens* | | Ekima | | April | |
| *Terminalia glaucescens* | | Dabaqqaa | | January–March | |
| *Vernonia amygdalina* | | - | | August-September | |
| *Vernonia amygdalina* | | - | | August-September | |
| *Vernonia auriculata* | | - | | March | |
| *Vernonia auriculata* | | - | | March | |
| *Ziziphus spina-christi* | | Giba | | September | |

**Source** [3], [5], [8], [9], [14], [17], [18], [20], [21]

**Shrubs for Bee Forages**

Ethiopia definitely has a variety of shrubs that are important for beekeeping and honey bee foraging. The diverse agro-ecological zones in Ethiopia, ranging from arid lowlands to humid highlands, support a wide array of shrub species that provide valuable nectar and pollen resources for honey bees [24]. Shrubs, often overlooked in discussions about bee forage, play a significant role in supporting honey bee populations, particularly in specific environments and during certain times of the year. Their importance stems from several key factors. Many shrub species offer bloom periods that bridge gaps between the flowering of trees and herbaceous plants, providing a crucial and consistent source of nectar and pollen when other resources are scarce. This is especially important during early spring or late fall when bees are preparing for winter or building up their colonies [2].

Shrubs are often more accessible to bees than taller trees, especially for smaller or weaker colonies . They can also grow in dense patches, providing a concentrated source of forage within a relatively small area [25]. The nectar and pollen produced by shrubs can be highly nutritious, offering a diverse range of amino acids, vitamins, and minerals that are essential for bee health and colony development. Shrubs provide important habitat and shelter for bees, offering nesting sites, protection from wind and rain, and refuge from predators [26]. Shrubs are often well-adapted to a variety of environments, including marginal lands, dry areas, and disturbed sites, making them a valuable resource in areas where other forage options are limited [11]. By incorporating a diverse range of shrub species into landscapes, beekeepers and land managers can significantly enhance the availability of bee forage, support healthy bee populations, and promote the long-term sustainability of beekeeping and pollination services [11]. Table 2 Details shrubs that supply nectar and pollen, particularly during seasonal gaps when tree flowers are unavailable. Shrubs are crucial for ensuring continuous forage availability.

Table 2 common honeybee’s shrubs forage species

| *Scientific Name* | Local Name | Flowering Season |
| --- | --- | --- |
| *Acacia brevispica* | Echileqana | May |
| *Acacia etbaica Schweinf* | Seraw | Apr-Nov |
| *Acacia mellifera* | Gumarna | May |
| *Agave spp.* | Chiret | September |
| *Aloe berhana Reynolds* | Ere | Aug-Nov |
| *Asparagus spp.* | Malqoza | March |
| *Becium grandiflorum* | Mentese | July |
| *Becium grandiflorum* | Tebeb | Year-round |
| *Bidens prestinaria* | - | September-October |
| *Brassica intergrifolia* | - | June-July |
| *Callistemon citrinus* | - | July-August |
| *Citrus aurantifolia* | Lomin | Year-round |
| *Citrus reticulate Blanco* | Menderini | Year-round |
| *Citrus sinensis (L.) Osb.* | Aranshi | Oct |
| *Coffea Arabica* | Buna | Feb-Mar |
| *Dovyalis abyssinica* | - | March |
| *Echinops spp.* | Kushele | September |
| *Euclea schimperi* | Dedeho | March |
| *Euphorbia spp.* | Kulqual | March |
| *Grewia bicolor* | Saha | June |
| *Grewia villosa* | Matta | July |
| *Hypoestes forskaolii* | - | December |
| *Leucaena leucocephala* | - | Nov-Jan |
| *Leucaena leucocephala* | - | Nov-Jan |
| *Leucas abyssinica* | Siwa-kerni | Sep-Nov |
| *Maytenus obscura* | - | November |
| *Maytenus obscura* | - | November |
| *Maytenus undata* | - | March |
| *Maytenus undata* | - | March |
| *Moringa stenopetala* | - | September |
| *Opuntia ficus-indica (L.) Miller* | Qolqual bahri | Apr-Jun |
| *Opuntia spp.* | Bahir Kulqual | June |
| *Pterolobium stellatum* | Kentafa | March |
| *Rosa abyssinica* | - | November |
| *Rosa abyssinica* | - | November |
| *Rumex nervosus* | Enbacho | March |
| *Schefflera abyssinica* | - | November |
| *Schefflera abyssinica* | - | November |
| *Sesbania sesban* | - | Nov-Jan |
| *Sesbania sesban* | - | Nov-Jan |

**Source: (*source*** [3], [5], [8], [9], [14], [17], [18], [20], [21]**)**

**Herbaceous Bee Forage Plants in Ethiopia**

According to Ethiopian scholars,[4][2], [3], [5], [5],Ethiopia has diverse climatic zones and ecosystem make it home to a wide variety of herbaceous plants many of which serve as vital forage sources for honey bee (Table 2). Herbaceous plants are vital for maintaining the biodiversity of Ethiopia s ecosystem and their role in supporting honey bee populations [10]. In different regional states of Ethiopia such as Oromia, Amhara Tigray SNNP, Benishangul gumuz and Gambela are the richest herbaceous bee forage plants and supporting bee populations by providing vital nectar and pollen [8] . In Ethiopia herbaceous plants are widely distributed across the country different agro ecological zone [11]. The role of these plants in bee forage is critical because they are usually abundant during the peak flowering season [26].

The precise percentage may be vary according to the different regional variations[13]. Studies suggest that the herbaceous bee forage plants are the portion of bee forages withAvailability of forage [20]. Seasonal availability: Herbaceous plants are important for supporting bee colonies during times when trees or other woody plants are not in bloom [6][8][15]. The contribution percentages of herbaceous bee forage plants are vary in different regions of Ethiopia. some study expects 35 – 40 % of the country honey bee forage was supported by herbaceous plants [2]. Generally herbaceous plants are key components of bee forage in many parts of the country and the distributions are varying according to the countries agro ecological zone [13]. Factors influencing this percentage include: **Altitude and climate**: Herbaceous plants are found in various ecosystems across Ethiopia, with highland and midland regions having different herbaceous plant species compared to lowland areas [14]. **Ecological variation**: Different ecological zones (e.g., grasslands, savannahs, and wetlands) support different species of herbaceous plants, each providing varied contributions to bee forage. The following plants are the most commonly identified bee forage plants found in all parts of Ethiopia[9], [13], [17].

Table 3 common herbaceous bee flora plants found in all parts of Ethiopia

| *Scientific Name* | Local Name | Flowering Season |
| --- | --- | --- |
| *Acalypha indica* | - | September |
| *Achyranthus spp.* | Aluma | September |
| *Andropogon abyssinicus* | Baallammii | September |
| *Bidens pachyloma* | Gelgele-meskel | Aug-Oct |
| *Bidens pilosa* | Maxxannee | Jul-Oct |
| *Bidens prestinaria* | Keelloo | Sep-Nov |
| *Bidens spp.* | Adey Abeba | August |
| *Brassica abyssinica* | Raafuu | October |
| *Brassica nigra var. abyssinica* | Hamli adri | Aug-Oct |
| *Brassica spp.* | Gomen Zer | September |
| *Cucurbita pepo* | - | September |
| *Echinops hispidus* | Dender | Aug-Oct |
| *Eleusine floccifolia* | - | Sep-Nov |
| *Glycine wightii* | - | Sep-Dec |
| *Guizotia abyssinica* | Nug | September |
| *Guizotia scabra* | - | Sep-Nov |
| *Guizotia spp.* | Tuufoo/Nuugii | Sep-Nov |
| *Helianthus annuus* | Yeferenj Suf | September |
| *Helianthus annuus* | Suufi | Jan-Feb |
| *Helichrysum formosissimum* | - | Sep-Oct |
| *Hibiscus berberidifolius* | - | Sep-Oct |
| *Hibiscus ludwigii* | - | Sep-Nov |
| *Hibiscus micranthus* | - | February |
| *Hypoestes forskaolii* | Girbia | Year-round |
| *Hypoestes triflora* | - | Sep-Oct |
| *Hypoestes trifolia* | Tej Matebia | September |
| *Hypoestes trifolia* | Darguu | Jan-Feb |
| *Ipomea indica* | - | Sep-Oct |
| *Ipomea purpurea* | - | Sep-Oct |
| *Isoglossa somalensis* | - | Sep-Nov |
| *Justicia schimperiana* | - | Sep-Nov |
| *Laggera crispata* | - | Aug-Oct |
| *Lantana camara* | - | July-August |
| *Lepidium sativum* | Feexoo | Aug-Sep; May |
| *Malva verticillata* | - | Sep-Oct |
| *Medicago sativa* | - | Oct-Nov |
| *Millettia ferruginea* | - | Sep-Oct |
| *Nuxia congesta* | - | Sep-Oct |
| *Ocimum basilicum* | Aba Timara | August |
| *Periploca linearifolia* | - | Sep-Dec |
| *Phytolacca dodecandra* | - | Sep-Dec |
| *Piper capense* | - | Sep-Nov |
| *Plantago lanceolata* | - | Sep-Dec |
| *Rhamnus prinoides* | - | Sep-Dec |
| *Rothmannia urcelliformis* | - | Sep-Dec |
| *Sesamum indicum* | Selit | August |
| *Sorghum bicolor* | Mashila | September |
| *Sorghum bicolor* | Bishingaa | Aug-Oct |
| *Sphaeranthus suaveolens* | - | Sep-Dec |
| *Trifolium polystachyum* | - | Sep-Dec |
| *Trifolium spp.* | Maget | August |
| *Trifolium spp.* | Siddisa | Oct-Dec |
| *Verbena officinalis* | Tihuan Tila | July |
| *Vernonia auriculifera* | - | Sep-Nov |
| *Vernonia ituriensis* | - | Sep-Nov |
| *Vicia faba* | Bakiela | September |
| *Vicia faba* | - | September |
| *Vicia faba* | - | February |
| *Zea mays* | Bekolo | August |
| *Zea mays* | - | July-August |
| *Zea mays* | Boqqolloo | Sep-Oct |

Source [3], [5], [8], [9], [14], [17], [18], [20], [21]

**Horticultural crops for bee forage**

Horticultural crops play a significant role in providing forage for honey bee in Ethiopia offering nectar and pollen resources that support bee health and enhance honey production[27]. Horticultural crops are cultivated crops that provide nectar and pollen for honey bees. These include fruit trees, vegetables, herbs and flowering plants grown for human consumption or other agricultural purpose[28]. These plants offer seasonal or year round forage supporting bee colonies during flowering periods they play crucial role in pollination, biodiversity conservation and improving honey yield. Horticultural crops such as **watermelon (**Citrullus lanatus**), mango (**Mangifera indica**), papaya (**Carica papaya**), sesame (**Sesamum indicum**), lemon (**Citrus limon**), and orange (**Citrus sinensis**)** are important sources of **nectar and pollen** for honeybees in Ethiopia[29]. These crops contribute to both **bee nutrition and pollination services**, leading to improved agricultural productivity and honey production. Crop varieties planted in watersheds are observed as major honeybee forage and important to maximize honey yield and spread the farmer's economic risk[30].

A mixture of different weedy species maintained between crop boarders and uncultivated land of watershed contributed as major honeybee forage, rainwater harvesting, watershed biodiversity conservation, and climate adaption as well[23]. Allium cepa (Red onion): It is one of the important condiment and vegetable crops grown in Ethiopia. In Ethiopia, the production and productivity of the red onion is far below the world average despite to its year-round production scenarios[29]. Honeybee was responsible for about 84.1% of the watermelon yield increment and the majority of the physicochemical attributes were Honeybee-pollinated plants significantly outperformed open-pollinated and self-pollinated plants by the most physicochemical parameters, whereas open-pollinated plants significantly exceeded self-pollinated plants in half of the physicochemical parameters[31]. In Ethiopia, 53 major agricultural crops, 33 of them (62.2%) are dependent on biological pollinators and from the total biological pollinator; honeybees contribute 80% of pollination service[31], [32]. The contribution of managed honeybee pollination to crop production and quality has been estimated to be more than the value of honey and wax production [32]. The following crops are the most importance horticultural crops and mostly dependent on honey bee pollinations.

Table 4 **Fruit Trees** (Major nectar and pollen sources)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| *Scientific name* | Common name | Pollination dependency | Found region | Bee forage importance | Reference |
| *Mangifera indica* | Mango | 80-90% | Oromia, Amhara, SNNP | Rich nectar for honey production | [33] |
| *Citrus sinensis* | Orange | 20-30% | Oromia, Amhara, SNNP | High pollen & nectar content | [23], [34] |
| *Persea americana* | Avocado | Not specified | Amhara, Oromia , SNNP , Gambela | Pollen source | [27], [29] |
| *Citrullus lanatus* | Water melon | 70% | SNNP, Amhara , Oromia | Both source | [35] |
| *Psidium guajava* | Guava | Not specified | Gambela, Benishangul | Provides nectar in dry seasons | [27] |
| *Carica papaya* | Papaya | 75-85% | Amhara, Oromia , SNNP , Gambela | Strong floral scent attracts bees | [30] |
| *Sesamum indicum* | Sesame | 20-30 | Amhara, Oromia, Tigray | Nectar source | [23] |
| *Citrus limon* | Lemon | 20% | All region | Pollen source | [33] |

Source [36]–[39][40].

Table 5 Vegetable & Herbaceous Plants

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Scientific name* | Common name | Region | Bee forage importance | reference |
| *Coriandrum sativum* | Coriander | Amhara, Oromia, SNNP | Produces high-quality nectar for honey | [28] |
| *Ocimum basilicum* | Basil | Tigray, Amhara, Oromia | Attracts bees for strong colonies | [27]–[29] |
| *Brassica nigra* | Mustard | Oromia, SNNP, Amhara | High nectar & pollen content | [33] |
| *Allium cepa* | Onion | Nationwide | Major pollination crop for bees | [30] |
| *Medicago sativa* | Alfalfa | Amhara, Oromia, Tigray | Provides continuous nectar flow | [23] |

Source [36], [40], [41].

Table 6 Flowering Ornamental Plants

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Scientific name* | Common name | Region | Importance | reference |
| *Helianthus annuus* | Sun flower | Amhara , Oromia , SNNP | Excellent nectar source | [27], [30], [34] |
| *Tagets erecta* | Marigold | Oromia, Amhara, Gambela | High pollen production | [35] |
| *Rosa spp.* | Rose | SNNP, Amhara | Provides supplemental nectar | [33] |

Source [36], [40], [42].

**Endangered bee forage plants in Ethiopia**

Ethiopia hosts diverse bee forage plants that support honeybees, but many of these are endangered due to deforestation, land-use changes, climate change, and overgrazing [9]. Some endangered or declining bee forage plants in Ethiopia include: Bidens spp. Cordia africana (Wanza) Vernonia amygdalina (Girawa), Acacia spp. Croton macrostachyus (Bisana, Shibha) Hagenia abyssinica (Kosso) Syzygium guineense (Dokma, Waterberry tree) Bersama abyssinica (Bekanisa, Birbira) Albizia spp. Ashen dye, *(torch lily*) Adey Ababa's (*Bidens macroptera*) Asta (*Erica arborea*) Yeberha Qulqwal (*ficus-indica opuntia*) Keskessie (*Laggera crispata*) Tsalwa (*Acacia asac*) [10].

**Ashendye, *(torch lily*)**

With dense terminal spikes that yield yellow, red, or orange blooms, Kniphofia sp. (Torch Lily) is an endangered, indigenous species that can grow up to 1.5 meters in height (Figure 2). Its range is restricted to floristic and highland areas of Tigray, Gondar, Gojam, Welo, Shewa, Arsi, Bale, and Harerge, and it occurs at elevations between 2500 and 4000 meters. According to [8] this species provides honeybees with a substantial source of nectar and pollen, and it is highly advised to plant Kniphofia sp. at lower elevations to increase honey production and fortify colonies [6]. Deforestation, habitat fragmentation from agricultural expansion, and excessive grazing are the main threats to its current range [14].



Figure 2 *torch lily*

**Adey Ababa's (*Bidens macroptera*)**

Reaching up to 60 cm in height, Bidens macroptera, also called Adey Ababa, is an endangered perennial herb with several stems arising from a woody rootstock and producing roots at lower nodes. It features yellow blooms in upright panicles (Figure 3). This species is found in stony or rocky areas between 2000 and 3700 meters above sea level in the Ethiopian highlands (Ethiopia and Eritrea). Mountain slopes, grasslands, forest borders, and open areas within ericaceous scrub are some of its habitats. According to [2]it can also occasionally be found by the sides of roadways. Honeybees consume B. macroptera from September to December, collecting light orange pollen to maintain colony health and rear offspring during dry spells [3]. It is also sometimes found by the sides of roads [43]. From September to December, honeybees feed on B. macroptera, gathering light orange pollen to support colony health and raise brood during dry spells [44].



Figure 3 *bidden macroptera*

**Chegogit (***Bidens pilosa****)***

Can reach a height of 1.5 meters and has simple or branched stems that can grow upright or perennially (**Figure 4**). It is a common species in tropical, subtropical, and some temperate climates worldwide, and it is found at elevations ranging from 700 to 2400 meters throughout Ethiopia [9]. With its profusion of flowers in September and October, B. pilosa is a key honey source plant in the country, giving honeybees plenty of pollen and nectar. However, the growth of cultivated land poses a serious threat to its dispersion, resulting in greater weeding and the use of fire to eradicate this plant as an unwanted weed [10].

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Figure 4 *bidden pilosa*

**Kosheshila (***Carduus nyassanus***)**

Carduus nyassanus (Kosheshila) is a perennial herb that grows up to two meters tall and has green stems with white stripes (Figure 5). Clusters of spiky flower heads with red to pale violet blossoms are seen at the apex of the stalks [45]. This plant is a good source of pollen and nectar. It thrives in highland bamboo thickets, along streams and gorges in Junipers forests, and in open Hagenia-Hypericum woods at elevations between 2300 and 3400 meters. Among other floristic regions of Ethiopia, its range includes Tigray, Wollo, Gondar, Shewa, Arsi, Welega, Gamo Gofa, Sidamo, and Bale [25]. However, the way things are snow dispersed is seriously endangered by habitat fragmentation caused by deforestation, agricultural expansion, and fire used to clear ground for cultivation and grazing, all of which are exacerbated by the plant's prickly nature [46].



Figure 5 *carduus nyassanus*

**Yeberha Qulqwal (***ficus-indica opuntia***)**

Yeberha Qulqwal, another name for Opuntia ficus-indica, is a five-meter-tall, endangered succulent tree or shrub. Its stem and branches are made up of large, flattened, and elliptic to obovate joints that can reach a length of 40 cm and are covered in tufts of brittle, prickly hairs [47]. This species can be found up to 2400 meters above sea level in semi-arid, desert, and rainy regions of Ethiopia (Figure 6). Its blossoms generate copious amounts of pollen and nectar, which honeybees gladly hunt for. The honey output is particularly crucial during periods of partial drought because it guarantees bee survival. A major producer of honey in northern Ethiopia, O. ficus-indica produces high-quality honey that is characterized by its granulation, slow, delicate, creamy white color, and fragrant aroma (Adi et al., 2014). Nevertheless, habitat loss, cochineal However, its current range is seriously threatened by habitat fragmentation, cochineal illness, and deforestation [48].



Figure 6  *opuntia ficus-indica*

**Asta (***Erica arborea***)**

Has many branches and a profusion of flowers, *Erica arborea*, also known as Asta, is a severely endangered evergreen shrub [10]. Like those of the Ericaceous, its leaves are closely packed around the stems and are stiff, thin, and pointed (Figure 7). With a noticeable purple stigma that contrasts with the white petals, each bloom has the appearance of a little, hanging bell [1]. The white to pinkish flowers are abundant and carried terminally on short stalks. At elevations between 2200 and 3900 meters, this species can be found in the majority of Ethiopia's floristic zones. It is often found on exposed lava flows that are kept up by periodic burning, as well as in woodland grasslands that are frequently burned and grazed. In the Ethiopian highlands, E. arborea is a major source of honey, supplying honeybees with plenty of pink pollen and nectar. The resultant honey has a golden-red hue, a strong, deep scent, and a high glucose and fructose content (51.03% and 43.76%, respectively) [9]. However, widespread deforestation, burning, and overgrazing are reducing the amount of honey produced by E. arborea, especially in regions like the Bale region and the Wondachi, Abune Yosef, Abuneselama, and Rasdashin Mountains [16]. Deforestation, habitat fragmentation from agricultural development, the use of firewood and charcoal, and continuous grazing pressure pose serious threats to the current distribution of.

**Keskessie (***Laggera crispata***)**

Typically growing to a height of 2–4 meters, aggera crispata (Keskessie) is an aromatic perennial herb or shrub with narrowly winged stems that can be smooth or serrated [49]. [50] This plant, which belongs to the Asteraceae family, is very important to Ethiopian culture and medicine. Traditionally, it has been used as a herbal tea or infusion to treat fevers, headaches, colds, and stomach issues (Figure 8). Because of its attractive scent, the leaves and petals are also occasionally burned as an insect repellent, especially against mosquitoes, and are utilized in Ethiopian coffee ceremonies [47]. The antibacterial, anti-inflammatory, and antioxidant qualities of L. crispata are attributed to its abundance of essential oils, flavonoids, and sesquiterpenes. Continued investigation indicates that its bioactive components may find use in contemporary medicine [48]. According to botany, it is a tiny, fragrant shrub with oblanceolate, deeply lobed leaves that alternate and have serrated edges. Its stems are frequently sticky because of glandular hairs, and its tiny, yellowish to pink flowers are grouped in hairy heads [3].  
Typically found at the edges of montane scrub, in open woodland and grasslands, along riverbanks and streams, and even as a weed in cultivated areas and wastelands, this species is widely distributed throughout the Ethiopian highlands and mid-altitudes, with elevations ranging from 1400 to 2700 meters [43]. It can be found in the floristic regions of Tigray, Gondar, Shewa, Arsi, Welega, Ilubabor, Kefa, Gamo Gofa, Sidamo, Bale, and Harerge. Honeybees forage a lot. In order to raise brood, crispata flowers are used throughout the dry season[14]. The entire plant is used as a disinfectant and the roots are used to cure snakebites in addition to being used as bee food. Deforestation and habitat fragmentation brought on by agricultural development pose a serious danger to populations of L. crispata, despite its vast distribution and variety of uses [51].



Figure 7 *laggera crispata*

**Tsalwa (***Acacia asac***)**

Acacia asak, also known as Tsalwa, is a tree or shrub that can grow up to 10 meters tall. Young stems are yellow and peeling, while elder stems are dark gray and fissured. The thorns can be small, straight, or recurved, and they can be found alone or in clusters of three [9]. The central thorn is frequently hooked (Figure9Figure **9**). With three to six widely separated pairs of pinnae on a stalk up to five centimeters long, the leaves are compound; the leaflets are gray-green and have rounded tips [52]. Three significant honey source species A.etbaica, A.asak, and A.tortilis are specifically researched for nectar and honey yield estimates in the Tigray region and the Waghimra zone of Amhara [7]. According to [8] the Zequala (lowland) area of the Waghimra zone in Amhara and a few other places in Tigray are the main habitats of A. asak. Differences in agro-ecology and climate, as well as niches within the species, have a significant impact on distribution patterns. Presently, deforestation, habitat fragmentation from agricultural expansion, and the use of firewood and charcoal, which are made worse by continuous land clearing, pose a serious danger to A. asak populations [6].



Figure 8 *acacia asac*

**Beekeepers' Knowledge, Attitudes, and Practices (KAP) on Bee Forage in Ethiopia**

Ethiopian farmers' perceptions of bee forage are influenced by various factors, including environmental changes, agricultural practices, and awareness of pollinators' roles. bee keepers, knowledge, Attitudes and practices (KAP)regarding bee forage vary across different regions, influenced by local environmental conditions traditions practices awareness level [53]. In the afar region, beekeepers recognize the abundance of special bee forages plants such as *acacia melifera, ziziphus* *spinachris*t and *balanites**aegyptica*. Over 65% of respondents reported high availability of bee forage leading to multiple honey harvests per season. In the Hadiya Zone, beekeepers have observed a decline in bee forage due to deforestation and agricultural expansion. This reduction in floral resources, particularly during dry seasons, poses challenges for maintaining healthy bee colonies[54]. A study in Gozamin District, Amhara Region, assessed farmers' knowledge of pollination and insect pollinators. The findings indicated that while some farmers recognize the importance of insect pollinators for crop production, there is a need for increased awareness and education on the benefits of pollination services [55].

Beekeepers in the Arsi zone have identified 98 plant species as major bee forage resources including Guizotia scabra, Eucalyptus globulus, and Vernonia species. Despite this diversity, honeybee colony face forage shortage from December to august. This suggest a need for improved knowledge and practices in seasonal colony management to mitigate forage scarcity [56]. In Tigray regional state beekeepers predominantly use traditional hives and often lack awareness of internal hive inspection practices. This is attributed to factors such as fear of bee sting and lack of protective equipment. Additionally there is a limited understanding of the importance of seasonal colony management leading to suboptimal honey yields [57]. Beekeepers in Arsi Negelle and Shashemene districts rely heavily on natural vegetation for bee forage. [56].

**Conclusion**

Ethiopia's rich floral diversity provides essential nectar and pollen sources for honeybee populations, supporting beekeeping and pollination services critical to agriculture and biodiversity conservation. This review highlights the regional variations in bee forage availability, with over 800 identified forage species distributed across trees, shrubs, herbs, and horticultural crops. Despite this diversity, challenges such as deforestation, land-use changes, pesticide application, and seasonal shortages threaten the sustainability of beekeeping. The varying knowledge, attitudes, and practices (KAP) of beekeepers further influence the effectiveness of hive management and forage conservation. Addressing these challenges is essential to ensuring sustainable honey production, pollination services, and the long-term viability of Ethiopia’s apiculture sector.

**Recommendation**

* Bee Forage Conservation: Protect and restore native bee forage plants through afforestation and controlled land use to mitigate habitat loss.
* Beekeeper Training and Awareness: Strengthen extension services to educate beekeepers on the importance of bee forage plants, seasonal management, and modern apiculture techniques.
* Research and Policy Development: Encourage research on bee forage dynamics, flowering calendars, and climate change impacts while developing policies that support sustainable beekeeping.
* Community-Based Initiatives: Engage local communities in conservation and beekeeping projects to enhance their role in protecting bee forage plants and improving honey production.
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