Journal of Agriculture and Environment for International Development - JAEID 2025, 119 (2): 97-118
DOI: 10.36253/jaeid-15509

Beekeeping and perception of local beekeepers on the diversity of bee flora and flowering phenology in the community of Welkait, Western Tigray, Ethiopia

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Abstract: Knowledge on honeybee flora is very crucial to identify diversity of honeybee plant species and their contribution in improving beekeeping. The study was conducted to identify the honeybee flora diversity, floral calendar, their nectar and pollen contribution in Welkait district, Tigray region. Moreover, the study addressed the honeybee practices by the local beekeepers. A semi-structured questionnaire interview, focus group discussions and field observation were used to gather the data. Hundred fifty two purposefully selected local beekeepers were approached for this interview. Results revealed that 106 honeybee plant species belonging to 46 families, 27.4% of them from lowlands, 34.9% from midland and 37.7% from both agroecological zones were collected and identified. Among the honeybee plant species, 44.3% were herbs, 39.6% were trees, 16.1% were shrubs. This study demonstrated that people have a rich knowledge of honeybee flora of the Welkait that could strengthen beekeeping practices of the region via natural conservation for sustainable use and development.

Keywords: Honeybee flora, flora diversity, floral calendar, beekeepers, Tigray

Introduction

Ethiopia is a country with high floral diversity and bees, as well as other pollinators, benefit from hundreds of melliferous plants which are distributed over a variety of altitudes (Gratzer et al., 2021). Thus diverse and unique floral diversity makes the country to be highly suitable for sustaining large number of honeybee colonies and long established of beekeeping (Fikru, 2015). Honey bee pollinators are crucial for the maintenance of biodiversity and agricultural crop production (Ollerton et al., 2011). Honey bee (*Apis mellifera* L.) provides highly valued pollination services and ranks as the most frequent single species of pollinator for crops worldwide (Garibaldi et al., 2013). Honeybees are primary pollinators for the majority of the world's flowering plants, pollinating about 66% of the world's 1500 crop species, accounting for 15-30% of food production (Ollerton et al., 2011). Honeybee plays a central role in agriculture as pollinators and their contribution to the global

economy for food production is estimated between $ 235 and $ 285 billion annually (Alebachew, 2018).

Bee flora resources are essential for the development of beekeeping. Honey bee colony performance and health are closely linked, which changes with seasonal phenology. The sustainability of a beekeeping system depends on continuous access to quality forage resources for bees to maintain healthy and productive colonies (Pilati and Fontana 2018). Understanding the primary bee plant species and their flowering calendar in various agroecological zones is crucial for estimating the honey flow period, which is essential for effective beekeeping operations (Bereke and Addi, 2019). A flowering calendar provides beekeepers with a timetable that estimates the dates and durations of the blossoming periods of key honey and pollen-producing plants (Bereke and Addi, 2019). Local ecological knowledge plays a crucial role in sustaining the honeybee health and colony performance especially during the dreath period by determining the flowering times and plant distribution (Maderson, 2023). This local ecological knowledge helps to manage the colony health. In Ethiopia, beekeepers heavily rely on traditional ecological knowledge of flowering seasons and plant uses, which is crucial for managing bee colony (Workneh, 2011). Understanding flowering period and plant distribution allows beekeepers to make informed decisions to ensure healthy survival of the colony.

Beekeping is one of the agricultural sectors substantially contribute to rural household food security and income generation. Currently the total managed honeybee population of the country are 6,958,004 with an average honey production of 150-258 metric tones per year (CSA, 2020). Apiculture practices have been traditionally practiced for a long time and it is an integral part of lifestyle of the farming communities in Tigray (Gebreyohanes, 2010). The total number of managed honeybee colonies in Tigray has been estimated 343,243 honeybee colonies (CSA, 2020) contributing about 4.93% of the nation. Tigray is known for its unique white color honey, produced at highland and mid highland of the region attracting domestic and international market (Bezabih et al., 2020a). The majority of the honeybee colonies in the region have been kept traditionally. The average honey harvested per hive per year was the second highest in the nation (Bezabih et al., 2020b). Beekeeping is practiced mostly at the backyard very close to human.

Beekeeping is a viable option for small-scale farmers and landless peasants (Waykar and Baviskar, 2015). Beekeeping does not compete for resources with other agricultural operations and can be managed along with them (Carvalheiro et al., 2011). Beekeeping does not disrupt the ecological balance, as do crop production and animal husbandry methods (Power, 2010). Beekeeping contributes significantly to agricultural economy in the development of crops and fruits via pollination service (Degu and Megerssa, 2020; Etxegarai-Legarreta and Sanchez-Famoso, 2022). Initial investment and ongoing costs are low, with little risk and can be run with limited resources (Elzaki and Tian, 2020). The whole family can participate because most work can be done at home by men, women, or older children (Belete and Ayele, 2020). FAOSTAT (2020) recorded a steady increase of managed beehives in Ethiopia over the years 1993–2018. To improve yield and quality of honeybee products the government and non governmental organizations have been supplying modern beehives and accessories (Yirga and Teferi, 2010).

Agro climatic conditions of Ethiopia create environmental conditions supportive to the growth of 6000 to 7000 species of flowering plants which have supported the existence of large number of bee colonies in the country (Tadesse and David, 2007). In Ethiopia, 500 species has been identified and characterized as source of pollen and/or nectar (Fichtl and Adi, 1994). Abundant availability of bee forage is one of the main factors that determine the success of beekeeping (Crane, 1990).

The distribution and type of honeybee plants as well as their flowering duration vary from one place to another. Every locality has its own honey flow and floral dearth periods of short or long duration. Depending the abiotic and biotic conditions of the locality availability of the nectar and

pollen resources vary. Recently a study carried out by Bezabih et al. (2020b) in Tigray showed that type and availability of the major honeybee plants vary across the different zones of the region. The same study confirmed a great diversity of honeybee plants in the region; however, *Becium grandiflorum* (Lam.)*, Hypoestes forskaolii* (Vahl) and *Cordia africana* (Lam.) are known as the most common honey species in six zones of the Tigray region. Knowledge on flower type, flowering period, blooming time, and quality of bee flora are fundamental for enhancement of beekeeping (Bezabih et al., 2020b).

The honeybee colony efficiency and its development as well as production of honey, beeswax and other hive products depend on quality and quantity of pollen and nectar obtained from bee forage plants (Brodschneider and Crailsheim, 2010). Any successful sustainable beekeeping practice requires knowledge on honeybee flora. Hence, good understanding of indigenous knowledge on honeybee flora by local beekeepers is important. Indigenous knowledge includes understanding the distribution patterns of honeybee plants in a particular area, the nature and type of vegetation, growth habits, flowering periods, together with environmental factors such as precipitation and temperature (Khabbach et al., 2013). This knowledge helps to assess the availability of nectar and pollen, ensuring the sustenance of bee colonies and honey production. Knowledge on the honeybee flora helps in the sustainable management of bee colonies and good honey harvest. Local knowledge on the beeflora may contribute to anticipate the diversity of honeybee plant species during dearth and rainy periods of the year in the villages of Welkait district. Establishing beeforage calendar in the locality is relevant to improve and maintain the honeybee colonies in these potential villages of Welkait district. The most common beeflora of the Tigray region including the western zone is studied (Bezabih et al., 2020b); however, research on beeflora in the vilages of Welkait district is little. This case study assumes that knowledge on the honeybee plants can help identify the diversity of species available for the beekeeping throughout the dry and rainy seasons in the Welkait district. The information obtained on local knowledge on the honeybee plants can help to complete the annual flowering cycle required to maintain the honeybee colonies. Moreover, it can also help to recognize the major honeybee plants in the district that need prioritization in the conservation initiative to ensure their protection. Such an approach could be useful for deep understanding of opportunities and constraints faced by the beekeepers in the district, contributing to broader discussions on the challenges and prospects of beekeeping in Tigray and Ethiopia in general. Hence, this study aimed at identifying which plant species are most commonly used, how the flowering phenology of major honeybee plants varies across seasons, and the relative contribution of nectar and pollen from different plant species to hive health and production.

We hypothesize that local community has in-depth knowledge of major honeybee plants that are essential during the different seasons. These honeybee plants exhibit distinct phonological patterns that can be mapped to optimize beekeeping schedules. Moreover, integrating local knowledge into beekeeping calendar is likely to significantly improve colony health and honey production in Welkait district.

Materials and Methods

Study area

The study was conducted in the Welkait district ($13^0$31'20"-$14^0$11'40" N and $37^0$7'40" - $37^0$27'50"E), western zone of Tigray. Welkait is found at a distance of 480 km from the capital city of Tigray, Mekelle. The annual precipitation of the district ranges from 900 to 1800 mm. The mean

annual temperature varies from 15^0C to 30^0C, respectively (Welkait Wereda Office of Planning and Finance, 2018). The district has a total population of 138,926; with an area of 3,374.52 km^2. The farmers cultivate cereals, oil seeds, pulses and vegetables in the area.

Of the 24,286 hectares of private land surveyed, over 86.69% was in cultivation, 1.27% pasture, 10.37% fallow, 0.03% in woodland, and1.65% was devoted to other uses. For the land under cultivation in this woreda, 63.29% was planted in cereals, 18.24% in oilseeds, 4.19% in pulses, and 0.17% in vegetables is missing (CSA, 2007).

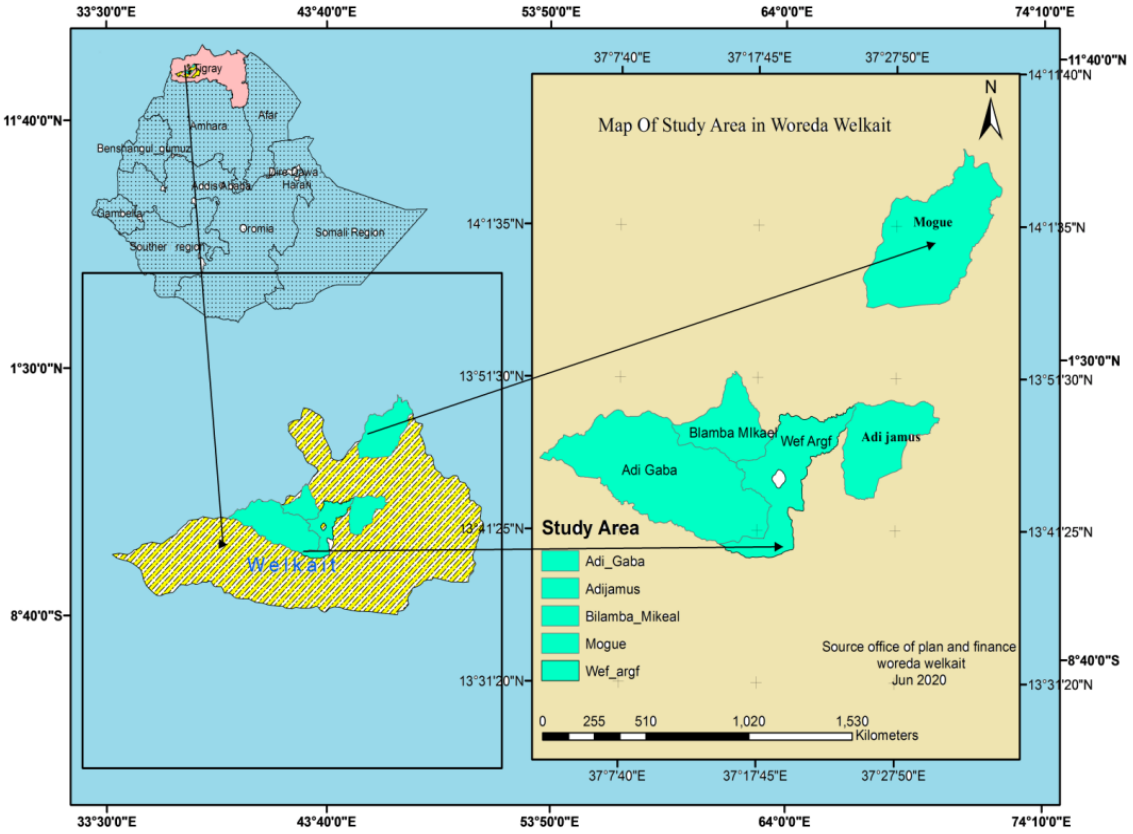

Figure 1. Map of the study area.

Study villages and beekeepers

The study was carried out from December 2019 to March 2020. Purposive sampling was employed to select five villages with potential beekeeping. Two of them, Adi Mogue and Adi-Jamus, were selected from the lowland agroecological zone; the other three villages, Blanba Michael, Adi-gaba and Wefargf, from the midland agroecological zone. A total of 152 local beekeepers, 60% from each agroecological zone, with 62 from lowland and 90 from highland, participated in the interview with open and closed questions.

The questionnaire was administered to the randomly selected 152 household heads. Under the quantitative data, age, family size, number of hives owned, honeybee plant species, and flowering season were taken. Sex and educational level of respondents, types of hives owned, beekeeping placement, were taken as qualitative data.

Three focus group discussions were conducted and consisted of 8- 12 key informants including farmers' association leaders, developmental associations, bee technicians, and individuals, who are

believed to be knowledgeable about beekeeping. Detailed information about the honeybee management practices, honeybee flora diversity, and season of flowering was collected. Furthermore, field observation on flowering plants was conducted to support questionnaires.

Honeybee flora and their flowering period

All the 106 plant species, in study area was identified using honeybee flora of Ethiopia (Fichtl and Adi, 1994) and flora of Ethiopia and Eritrea (Hedberg and Edwards, 1989; Hedberg et al.,2003, 2006). The flowering period of the honeybee plants were made based on the information by the local farmers during the interview and focus group discussion.

Results and discussion

Beekeepers socio-economic characteristics

Beekeeping practices in the community of Welkait are dominated by males (96.05%).The average age of Welkait beekeepers is 35.5 with 48.0% in the range of 31-45 years, 29.0% is above 45 years, and 23.0% between 18-30 years (Figure 2A). The study noted that the majority of the beekeepers are in the age range of 31 – 45 years. This indicates that most of the productive ages are engaged in beekeeping. In Welkait, 40.1% of the local beekeepersare illiterate, 25.0% can read and write with informal education, 31.0% with primary education and 3.9% with secondary education (Figure 2B). The results showed that majority of the beekeepers (52.0%) had family size between 6-10 where 20.4% of them had less than 5 and 27.6% had more than 11 family size (Figure 2D). Beekeepers with more than 20 years of experience is only 8.6%; 11.8% had from 16 to 20 years of experience, , 22.4% from 11 to 15 years, 39.5% from 6 to 10 yearsand 17.8% less than 5 years (Figure 2C). The majority of the beekeeepers (57.2%) have ≤ 10 years of experience. This showed that the community had been attracted towards beekeeping practice and increased their engagement in recent years. This increase of beekeeping practice could be strong promotion of beekeeping by government and non-government organizations to use beekeeping as a tool for poverty alleviation in Ethiopia (Bihonegn and Begna, 2021), as well as awareness of the economic benefits of honey and other bee products (Sebsib and Yibrah, 2018)

The majority of the beekeepers, representing 97.4%, own livestock, while the remaining 2.6% do not own any. The average farmland size owned by the beekeepers is 1.6 ha with 41.4% of the informants having 0.5 to 1 ha, 32.2% 1 to 1.5 ha, 9.2% 1.5 to 2.0 ha, and 3.9% greater than 2 ha; 13.2% declared to have no farmland (Figure 2E). The local beekeepres use beekeeping as sideline business. Agriculture and livestalk is as main source of income in Welkait local communities. Cash crops such as sesame (*Sesamum indicum* L.), sorghum (*Sorghum bicolor* L. Moench) and wheat (*Triticum aestivum* L.) are common crops grown by the local people. Similar studies in the region and other parts of the country showed beekeeping is dominantly practiced as integrated farming practice (Gebru et al., 2016; Belina et al*.,* 2016; Gebreyohans and Gebremariam, 2017).

Source of honeybee colony and means of honeybee colony increment

In Welkait, 85.5% of the local beekeepers are engaged in beekeeping by catching bee swarms via hanging empty traditional hives on trees and the remaining 14.5% inherited from their parents.

Catching swarms to establish apiaries by hanging empty hives on trees is a common indigenous practice by which most of the beekeepers begin beekeeping practices in the region (Gebreyohans

and Gebremariam, 2017; Tesfaye et al., 2017). In another part of the country, Tesfaye et al. (2017) reported 98.3% of the beekeepers started beekeeping by catching swarms in Bale, southeastern Ethiopia. Likewise, Kinati et al. (2012) reported 87.8% of beekeepers started beekeeping by catching swarms in Gomma, southwest Ethiopia. Moreover, 90.8% of the beekeepers in Welkait also use swarm catching to increase the bee colony number. Therefore, catching swarm from the surroundings is the highest source of the honeybee colonies in the study area. This indicates that beekeepers depend more on natural colony reproduction rather than adopting breeding techniques. Factors, such as higher swarming tendency of African bees (Nuru et al., 2002), lower cost compred to purchasing or establishing new colonies (Bihonegn and Begna, 2021), and absence of appropriate queen rearing practice (Hailu and Tadesse, 2016), may also influence beekeepers to depend on swarm catching.

However, this also confirm that the beekeepers in the study area still use mainly the traditional method to increase their bee colony and they are short of the modern beekeeping improvement. Reasons why the local beekeepers rely on swarm catching to obtain bee colonies probably due to limitation of skills and knowledge in artificial queen rearing (Shanku and Ijara, 2024). Several studies show Ethiopia has been challenged by absence of appropriate queen rearing practice (Hailu and Tadesse, 2016; Bihonegn and Begna, 2021). Moreover, usually beekeepers in Tigray accomplish queen rearing and colony multiplication through splitting early in rainy season irrespective of suitability for queen rearing. This results in less developed and less productive queens or queens that are not mated and they perish soon (Hailu and Tadesse, 2016) as a result colonies from the market have relatively great differences in colony strength and the absence of queens (Gratzer et al., 2021). Swarm catching practice remains most common practice in Tigray due to the fact that no adequate research on identifying suitable season for queen rearing and colony multiplication is conducted in the region (Hailu and Tadesse, 2016).

All the local beekeeper in Welkait have traditional beehives but only 28% of the beekeepers possess modern bee hives (Figure 2F). Among the beekeepers who own traditional hives 15.1% owned 1-5 hives, 29.6% owned 6-10 hives, 22.4% owned 11-15 hives, 20.4% owned 16-20 hives and 12.5% owned more than 20 hives. Traditional beekeeping is the major and oldest type of beekeeping practiced in Ethiopia. In Tigray, 84% of the beekeeping practice is using traditional beeehives (Bezabih et al., 2020b). Traditional beekeeping is practiced by traditionally constructed hives which are mostly cylindrical in shape (1-1.5 meter in length and 30-50-centimeter width) (Figure 3A) and single chamber fixed comb (MoARD, 2007).This traditional hive management system is known for its low honey production (Yirga et al., 2012) and the average amount of honey produced from traditional beehive is estimated between 7 – 15 kg honey per year (CSA, 2017; Gebreyohans and Gebremariam, 2017; Tesfaye et al., 2017).

Out of the total beekeepers who own modern hive 88.55% have 1-5 beehives and only 11.4% of the local beekeepers have 6-10 beehives (Figure 2F). The modern beehives in the study villages Welkait district are 28% which is higher compared to the Tigray region that is 14% (Bezabih et al., 2020b). District agricultural development extension efforts focused on improving production through introducing modern beehives, and the western zone of the Tigray, where the study was conducted, cultivates cash crop like sesame, which may also enable beekeepers to afford modern hives.

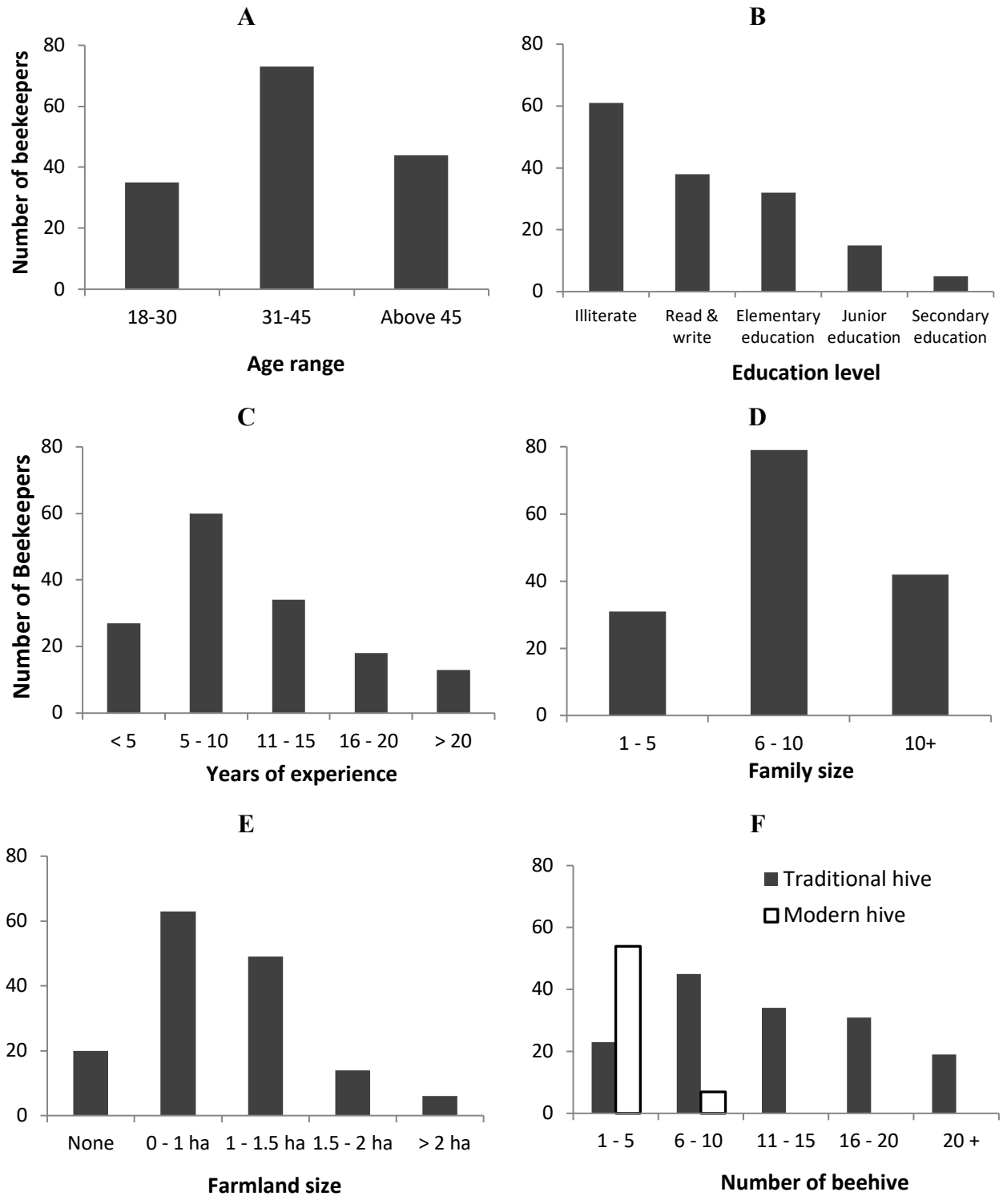

Figure 2. Sociodemographic characteristics of the community.
A. Age range of beekeepers; B. Level of education of beekeepers; C. Experience of beekeepers; D. Family size of beekeepers; E. Farmland owned by beekeepers; F. Type and number of beehive owned by beekeepers.

Majority (59.7%) of the beekeepers in Welkait kept their honeybee colonies at the backyard, whereas 17.8% of the beekeepers placed their honeybee colonies inside the house and the rest 13.0% and 9.5% of the beekeepers placed their honeybee colonies hang on trees and at closure areas (protected area) (Figure 3). In most part of the country including beekeepers in Tigray, they kept their hives around their backyard (Yirga et al., 2012; Gebru, 2016; Godifey et al., 2018). This method could be for better management that is easy to follow up and inspection, and guarding (Gallman and Thomas, 2012). This form of bekeeping significantly contributes to the family's income without the requirement of own farming land (Sebsib and Yibrah, 2018). This system of beekeeping is mainly practiced in the central, eastern and northern parts of the country where there is relatively low forest coverage (EIAR, 2017). These parts of the country, particuluarly in the northern and central highlands ecological degradation, including deforetaion, is wide spread (Limenih, 2024). To the contrary in the south-west of Ethiopia, relatively with high coverage of the forest, beekeepers practice forest beekeeping by hanging hives on tall trees (Tarekegn, 2022).

Figure 3. Location of apiaries at the backyard.
A. Bamboo made traditional bee hive; B. Modern bee hive.

Feeding management of honeybee colony

During the dreath period bee face shortage of food and the local beekeepers provide their bee colony with supplementary feed. Most common feed types used for colony supplements were wheat flour (56.6%), rosted spiced chickpea flour (25.6%) and sugar syrup (17.8%) (Figure 4). Gebreyohanes and Gebremariam (2017) also reported that sugar, roasted spiced pulses flour and barely flour were used as feed supplement in eastern Tigray. In Kilete awlaelo district majority of the local beekeepers (89.1%) provide barely flour as supplementary feed (Gebremeskel et al., 2015). However, the study by Bezabih et al. (2020b) reported most of the beekeepers in Tigray region use

sugar as supplementary feed. All these findings show that there is variation on supplementary feed provided to bee colony across the districts in the region.

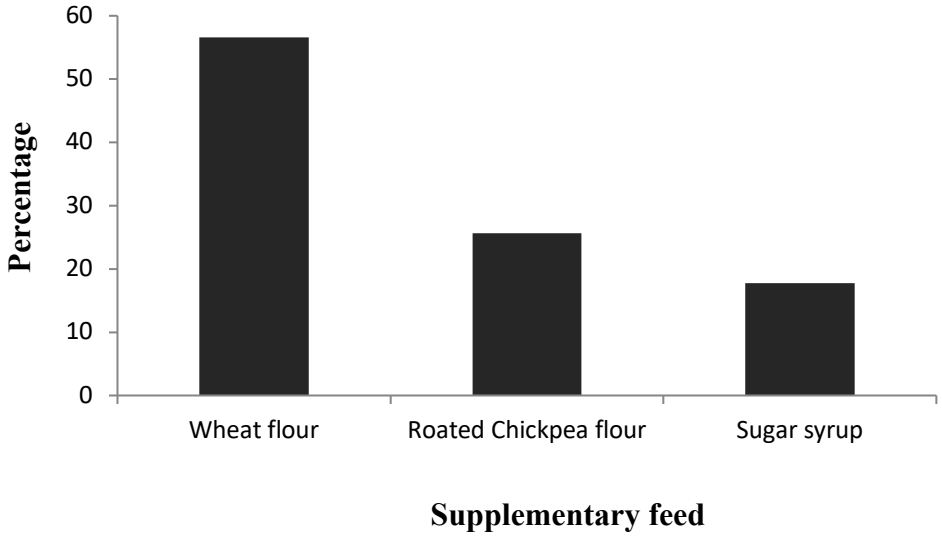

Figure 4. Supplementary feeding of bee colony in Welkait, Tigray.

Honeybee flora and their flowering period

Vegetation characteristics of the locality are considered to be an important indicator for the potential of the area for beekeeping. Beekeeping is dependent on ecological suitability of the area for beekeeping (Adgaba, 2002) and knowledge of honeybee plant species allows local beekeepers to have better management of their apiaries. Several authors have reported that the knowledge of honeybee flora for a given area is absolutely important for beekeepers for feeding their bees (Berhe et al., 2016; Chauhan et al., 2017; Coh-Martínez et al., 2019). It's critical to comprehend the mutualism that exists between available plant species and honeybees in order to improve beekeeping production (Al-Ghamdi and Al-Sagheer, 2023). The abundance of bee flora and their continuous availability is one of the major pre-requisites for successful beekeeping. A good beekeeping area is the one in which honeybee plants grow abundantly and with a relatively long blooming season (Gebru and Gebretsadik, 2015).

A total 106 different honeybee species belonging to 46 families were identified as a useful honeybee food source by the local beekeepers. From this finding 27.4% honeybee flora species were found in the lowland agro-ecological zone, 34.9% species were found in the midland agro-ecological zone and the rest 37.7% species were found in the two agroecological zones. The diversity of honeybee plant species reported in Welkait (five villages) is relatively high comparing to other studies in the region. This is probably the beekeeper's have noteworthy knowledge of the local flora. Gebru et al. (2016) reported 44 honeybee plants in south eastern Tigray. Likewise, Teklay (2011) also documented 52 honeybee plants in eastern zone of Tigray. Similarly Gebremedhn et al. (2013) reported 89 honeybee plants from Kolatemben district, central zone of Tigray.

The local people reports 30 species of plants belonging to 14 families as the most common honeybee forage sources (Table 1). Out of these, 33.33%, 13.33% and 10% were Fabaceae, Asteraceae and Combretaceae families, respectively. The number of major honeybee plant species

identified was relatively small compared with the total bee flora point out by the local beekeepers. 12 honeybee flora species from lowland, 10 bee plant species from midland and 8 bee plant species from both agro-ecological zones were identified as the common honeybee plants by the local beekeepers.

Table 1. Common honeybee flora species.

NO.	AGRO-ECOLOGY	BOTANICAL NAME	FAMILY	RESPONSE OF PREFERENCE (%)
1		*Pterocarpus lucens*	Fabacea	100
2		*Acacia polyacantha*	Fabaceae	96.77
3		*Acacia senegal*	Fabaceae	96.77
4		*Anogeissus leiocarpa*	Combretaceae	90.32
5		*Bridelia micrantha*	Phyllanthaceae	88.71
6	Lowland	*Dalbergia melanoxylon*	Fabaceae	83.87
7		*Sesamum orientale*	Pedaliaceae	98.39
8		*Terminalia brownii*	Combretaceae	93.55
9		*Terminalia laxiflora*	Combretaceae	91.94
10		*Ximenia americana*	Oleaceae	77.42
11		*Zeziphus mucronata*	Rhamnaceae	72.58
12		*Gardenia ternifolia*	Rubiaceae	66.13
13		*Pterolobium stellatum*	Fabaceae	100
14		*Croton macrostachyus*	Euphorbiaceae	97.78
15		*Acacia albida*	Fabaceae	94.44
16		*Pluchea dioscoridis*	Asteraceae	93.33
17	Midland	*Trifolium* sp.	Fabaceae	98.89
18		*Pisum sativum*	Fabaceae	91.11
19		*Carissa edulis*	Apocynaceae	84.44
20		*Syzygium guineense*	Myrtaceae	76.67
21		*Eucalyptus camaldulensis*	Myrtaceae	66.67
22		*Erica arborea*	Ericaceae	72.22
23		*Bidens* sp.	Asteraceae	99.34
24		*Guizotia abyssinica*	Asteraceae	98.02
25		*Cordia africana*	Boraginaceae	98.68
26	Lowland and	*Brassica rapa*	Brassicaceae	95.39
27	Midland	*Acacia pilispina*	Fabaceae	96.05
28		*Dichrostachys cinerea*	Fabaceae	92.11
29		*Echinops* sp.	Asteraceae	88.82
30		*Vicia faba*	Fabaceae	85.53

Majority of bee plants were wild species. The growth habit of the plant species showed that 44.3% were herbs, 39.6% trees, 16.1% shrubs (Figure 5). Gebreyohanes and Gebremariam, (2017)

noted that major bee floras in eastern Tigray classified as trees, shrubs and herbs, with herb being dominant followed by trees. Several studies carried out in other parts of the country revealed the major bee floras are trees (Olana and Demrew, 2019; Gebru et al., 2016).

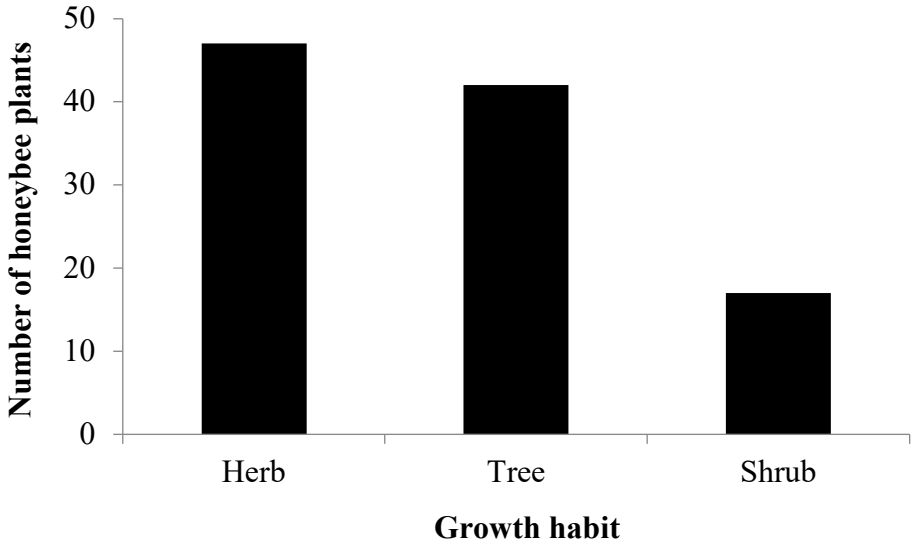

Figure 5. Habit of the plant species.

Flowering period

The flowering duration of bee plant species is very important for beekeeping practice. Knowledge on flowering period of the bee plant species plays an important role for sustainable management of bee colonies. Flowering duration of beeplant species vary from one place to another place due to biotic and abiotic factors and knowledge on floral calendar is very vital to initiate bee keeping (Bista and Shivakoti, 2001). The local beekeepers reported that the distribution and flowering period of bee plants vary depending on the agro ecological zones of the area. According to the response of beekeepers and field observation, the most common bee floras in the lawland mainly blossom from June to July and in the midland from October to February whereas, the most common bee flora species found in both lowland and midland flowering mainly from August to November (Table 2). The study also revealed that the majority of bee plant species flowering started from August to September and reached peak in October and November. 45.3% bee plant species flowered during August to November and flowering pattern varied from plant to plant species (Table 2).

Beekeepers reported that the peak honey flow period in the lowland occurs during October to November and June to July and the minor flow period occurs during August to September, whereas in the midland peak honey flow period occurs during October to November and the minor flow period occurs during June to July. The major and minor honey harvesting season depend on the bee flora blossoming season (Degaga, 2017). The knowledge on the duration of blooming period and variation in blooming period of the bee plant species have a paramaount importantance for sustainable management of bee colonies as well as for planning proper seasonal management (Gichora, 2004). Similar studies by Gebreyohanes and Gebremariam (2017) reported major honey

flow season in the eastern Tigray is September and October. This showed every region has its own honey flow and floral dearth periods.

The local beekeepers reported there is shortage of food during dry season especially March and April. Moreover, the beekeepers reported that bee forages keep decreasing from time to time due to forest degradation and expansion of farming practices. According the local beekeepers population explosion, expansion of farming land and overgrazing were identified as a main problem for decreasing honeybee flora. In other part of the country, where beekeeping is practiced, several authors reported similar reasons for the decrease of beeforage (Degaga, 2017; Kidane et al., 2018).

Table 2. Flowering calendar of common bee forage.

NO.	AGRO-ECOLOGY	BOTANICAL NAME	FAMILY	FLOWERING PERIOD (MONTHS)	BEE FORAGE VALUE
1		*Pterocarpus lucens*	Fabaceae	May-July	N,P
2		*Acacia polyacantha*	Fabaceae	June-July	N,P
3		*Acacia senegal*	Fabaceae	June-July	N,P
4		*Anogeissus leiocarpa*	Combretaceae	June-July	N,P
5		*Bridelia micrantha*	Phyllanthaceae	June-July	N,P
6	Lowland	*Dalbergia melanoxylon*	Fabaceae	June-July	N,P
7		*Sesamum orientale*	Pedaliaceae	August-September	N,P
8		*Terminalia brownii*	Combretaceae	June-August	N,P
9		*Terminalia laxiflora*	Combretaceae	April-June	N,P
10		*Ximenia americana*	Oleaceae	May-June	N,P
11		*Ziziphus mucronata*	Rhamnaceae	November-January	N,P
12		*Gardenia ternifolia*	Rubiaceae	May-June	N,P
13		*Pterollobium stellatum*	Fabaceae	October-November	N,P
14		*Croton macrostachyus*	Euphorbiaceae	July-September	N,P
15		*Acacia albida*	Fabaceae	December –February	N,P
16		*Pluchea dioscoridis*	Asteraceae	January-February	N,P
17	Midland	*Trifolium* sp.	Fabaceae	July-October	N,P
18		*Pisumsativum*	Fabaceae	September-October	N,P
19		*Carissa edulis*	Apocynaceae	December-February	N,P
20		*Syzygiumguineense*	Myrtaceae	March-May	N,P
21		*Eucalyptus camaldulensis*	Myrtaceae	Year-round	N,P
22		*Erica arborea*	Ericaceae	November-February	N,P
23		*Bidens* sp.	Asteraceae	August-November	N,P
24		*Guizotia abyssinica*	Asteraceae	September-October	N,P
25		*Cordia africana*	Boraginaceae	October –January	N,P
26	Lowland and	*Brassica rapa*	Brassicaceae	August-October	N,P
27	Midland	*Acacia pilispina*	Fabaceae	June-July	N,P
28		*Dichrostachys cinerea*	Fabaceae	June-August	N,P
29		*Echinops* sp.	Asteraceae	August-September	N,P
30		*Vicia faba*	Fabaceae	August-September	N,P

Note: N = nectar, P = Pollen

Honeybees require nutrients such as proteins, carboydrates, vitamins, minerals and water and these nutrients must be present in their diet. Pollen provides honey bees with a natural source of protein which is needed for larval development and also fulfils other nutrients to bees (Wright et al., 2018). The nectar used as source of honey and provides heat and energy for bees (Fluri and Bogdanov, 1987). Nutritional deficiency leads to decrease in population (Keller et al., 2005). Economically important honeybee plants provide substaintial quantity of pollen, or/and nectar. The

bee colony efficiency, development as well as production of honey, bees wax and other bee products depends on quality and quantity of pollen and nectar obtained from honeybee forage plants (Keller, 2005; Brodschneider and Crailsheim, 2010). According to local beekeepers and honeybee technicians during interview and focus group discussion, the identified common bee flora were grouped into nectar, pollen and both nectar and pollen sources (Table 2). According to data obtained from the study area 84.9% of the bee plants provide both nectar and pollen, 9.4% provide pollen and 5.7% serve as nectar source. The most common 30 bee plant species provide both nectar and pollen.

Conclusion

This study provides valuable insights into diverse honeybee flora in Welkait district, Tigray, identifying 106 plant species across various ecological zones and highlighting the rich indigenous knowledge of local communities. Its novelty lies in combining floristic diversity assessment with an understanding of traditional beekeeping practices, which is crucial for sustainable apiculture development. The findings underscore the importance of conserving native flora to support bee populations and enhance honey production. By bridging traditional knowledge with with scientific data, this research offers a meaningful contribution to addressing the challenges faced by beekeepers in Ethiopia, particularly in promoting biodiversity based conservation and sustainable beekeeping practices amid environmental and ecological constraints.

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Supplementary material

List of honeybee flora species found in Welkait district, Western Tigray

No	Scientific name	Family	Local name (Tigrigna)	Growth Habit	Flowering period (Months)	Source (P/N)	Agro ecology
1	*Acacia albida*	Fabaceae	Momona	Tree	December -February	N,P	Mid land
2	*Acacia etibica*	Fabaceae	Seraw	Tree	October-November	N,P	Low/Mid land
3	*Acacia pilispina*	Fabaceae	Chea	Tree	June-July	N,P	Low land
4	*Acacia polyacantha*	Fabaceae	Gemero	Tree	June-July	N,P	Low land
5	*Acacia senegal*	Fabaceae	Chea Bereka	Tree	June-July	N,P	Low land
6	*Acokanthera schimperi*	Apocynaceae	Mebtie	Shrub	January-February	N,P	Mid land
7	*Agave sisalana*	Asparagaceae	Eka	Herb	September- October	N,P	Low/Mid land
8	*Albuca abyssinica*	Asparagaceae	Shigurti Zibei	Herb	June-July	P	Low/Mid land
9	*Allium cepa*	Alliaceae	Shingurti/Besel	Herb	Year-round	P	Low/Mid land
10	*Aloe berhana*	Aloaceae	Ire	Herb	August-September	N,P	Low/Mid land
11	*Amaranthus caudatus*	Amaranthaceae	Eshok-mergem	Herb	July-September	N,P	Low/Mid land
12	*Anethum graveolens*	Apiaceae	Kundala Hbey	Herb	August-September	N,P	Low land
13	*Anogeissus leiocarpa*	Combretaceae	Hanse	Tree	June-July	N,P	Low land
14	*Balanites aegyptiacus*	Zygophyllaceae	Mekie	Tree	September-November	N,P	Low land
15	*Bidens* sp.	Asteraceae	Gelgele- Meskel	Herb	August-November	N,P	Low/Mid land
16	*Boswellia papyrifera*	Burseraceae	Meker	Tree	June-July	N,P	Low land
17	*Brassica carinata*	Brassicaceae	Senafich	Herb	August-October	N,P	Low/Mid land
18	*Brassica rapa*	Brassicaceae	Hamli-adri	Herb	August-October	N,P	Low/Mid land
19	*Bridelia micrantha*	Phyllanthaceae	Abetere	Tree	June-July	N,P	Low land
20	*Calotropis procera*	Apocynaceae	Gindiae	Shrub	June-July	N,P	Low land
21	*Calpurnia aurea*	Fabaceae	Hitsawits	Shrub	June-July	N,P	Mid land
22	*Capparis tomentosa*	Capparaceae	Andel	Shrub	November-December	N,P	Low/Mid land
23	*Capsicum annuum*	Solanaceae	Berbere	Herb	July-November	N,P	Low/Mid land
24	*Carduus nyassanus*	Asteraceae	Dander	Herb	August-October	N,P	Mid land
25	*Carica papaya*	Caricaceae	Papaye	Tree	Year-round	N,P	Low/Mid land
26	*Carissa edulis*	Apocynaceae	Agam	Shrub	December-February	N,P	Mid land

27	*Carthamus tinctorius*	Asteraceae	Suf	Herb	September-October	N,P	Low/Mid land
28	*Cicer arietinum*	Fabaceae	Shimbra	Herb	September-October	N	Low/Mid land
29	*Cissus populnea*	Vitaceae	Ga'at shiro	Herb	June-July	N,P	Low/Mid land
30	*Citrus limon*	Rutaceae	Lomin	Tree	Year-round	N,P	Low land
31	*Clerodendrum myricoides*	Lamiaceae	Surbetri	Shrub	March-April	N,P	Low/Mid land
32	*Cordia africana*	Boraginaceae	Awki	Tree	October -January	N,P	Low/Mid land
33	*Craterostigma plantagineum*	Linderniaceae	Fowsi Anqrbit	Herb	June-July	N,P	Low/Mid land
34	*Crotalaria* sp	Fabaceae	Meratsenteli	Herb	August-September	N,P	Mid land
35	*Croton macrostachyus*	Euphorbiaceae	Tambok	Tree	July-September	N,P	Low land
36	*Casimiroa edulis*	Rutaceae	Dimma	Tree	June-July	N,P	Mid land
37	*Cucumis dipsaceus*	Cucurbitaceae	Hafaflo	Herb	June-August	N,P	Low land
38	*Cucurbita pepo*	Cucurbitaceae	Duba	Herb	July-September	N,P	Mid land
39	*Cynodon dactylon*	Poaceae	Tehag	Herb	August-October	P	Low/Mid land
40	*Cynoglossum lanceolatum*	Boraginaceae	Dekik teneg	Herb	September-October	P	Mid land
41	*Dalbergia melanoxylon*	Fabaceae	Zibe	Tree	June-July	N,P	Mid land
42	*Datura stramonium*	Solanaceae	Mezerabea	Herb	August-September	N,P	Low land
43	*Dichrostachys cinerea*	Fabaceae	Gonok	Shrub	June-August	N,P	Low/Mid land
44	*Diospyros abyssinica*	Ebenaceae	Kumel	Tree	August-September	N,P	Low/Mid land
45	*Diospyros mespiliformis*	Ebenaceae	Aye	Tree	December-January	N,P	Low/Mid land
46	*Dodonaea angustifolia*	Sapindaceae	Tahses	Shrub	Year-round	N,P	Low land
47	*Echinops* sp,	Asteraceae	Koshashle	Herb	August-September	N,P	Mid land
48	*Erica arborea*	Ericaceae	Atkaro	Shrub	November-February	N,P	Low/Mid land
49	*Eucalyptus camaldulensis*	Myrtaceae	Kelamintos	Tree	Year-round	N,P	Mid land
50	*Euphorbia candelabrum*	Euphorbiaceae	Kolonqual	Tree	September-November	N,P	Mid land

51	*Euphorbia tirucalli*	Euphorbiaceae	Kinchib	Tree	Year-round	N,P	Mid land
52	*Flueggea virosa*	Phyllanthaceae	Ayehada	Shrub	June-August	N,P	Low/Mid land
53	*Gardenia ternifolia*	Rubiaceae	Hatsinay	Tree	May-June	N,P	Low land
54	*Grewia ferruginea*	Tiliaceae	Tsenquayt	Shrub	June-July	N,P	Low land
55	*Guizotia abyssinica*	Asteraceae	Nihug	Herb	September-October	N,P	Low/Mid land
56	*Hypoestes forskaolii*	Acanthaceae	Eshok-adgi	Herb	August-September	N,P	Low/Mid land
57	*Ipomoea aquatica*	Convolvulaceae	Bilsit	Herb	July-August	N,P	Mid land
58	*Jacaranda mimosifolia*	Bignonioaceae	Chigono	Tree	September-October	N,P	Low land
59	*Jasminum abyssinicum*	Oleaceae	Habi-tselim	Shrub	September-December	N	Mid land
60	*Lepidium sativum*	Brassicaceae	Shinfae	Herb	September-October	N,P	Low/Mid land
61	*Linum usitatissimum*	Linaceae	Telba	Herb	August-September	N,P	Mid land
62	*Lycopersicon esculentum*	Solanaceae	Komidere	Herb	August-December	N,P	Mid land
63	*Mangifera indica*	Anacardiaceae	Mango	Tree	December-March	N	Low/Mid land
64	*Maytenus arbutifolia*	Celastraceae	At-at	Shrub	October-December	N,P	Mid land
65	*Maytenus senegalensis*	Celastraceae	Argudi	Tree	June-July	N,P	Low land
66	*Maytenus undata*	Celastraceae	Tselumey	Tree	June-July	N,P	Low/Mid land
67	*Ocimum basilicum*	Lamiaceae	Seseg	Herb	September-October	N,P	Mid land
68	*Ocimum sanctum*	Lamiaceae	Rihan	Herb	July-September	N,P	Mid land
69	*Olea europaea*	Oleaceae	Awlio	Tree	April-June	N,P	Mid land
70	*Phaseolus vulgaris*	Fabaceae	Adegura	Herb	August-November	N,P	Low/Mid land
71	*Piliostigma thonningii*	Fabaceae	Dabda	Tree	June-July	N,P	Low land
72	*Pisum sativum*	Fabaceae	Ayni-ater	Herb	September-October	N,P	Mid land
73	*Pluchea dioscoridis*	Asteraceae	Shitonie	Tree	January-February	N,P	Mid land
74	*Polygala persicariifolia*	Polygalaceae	Shitora	Tree	June-July	N,P	Low land
75	*Polyscias fulva*	Araliaceae	Mirkus-Zibei	Tree	June-August	N,P	Low/Mid land

76	*Pterocarpus lucens*	Fabaceae	Tsara	Tree	May-July	N,P	Low land
77	*Pterolobium stellatum*	Fabaceae	Qonteftafe	Shrub	October-November	N,P	Mid land
78	*Rhamnus prinoides*	Rhamnaceae	Gesho	Tree	Year round	N,P	Mid land
79	*Rhus glutinosa*	Anacardiaceae	Tetahm	Tree	September-December	N	Mid land
80	*Ricinus communis*	Euphorbiaceae	Gulei	Shrub	September-October	N,P	Mid land
81	*Rosa abyssinica*	Rosaceae	Kega	Tree	February-May	N,P	Mid land
82	*Rumex abyssinicus*	Polygonaceae	Moqmoqo	Herb	August-September	N	Low/Mid land
83	*Rumex nervosus*	Polygonaceae	Ambacho	Shrub	December-January	P	Mid land
84	*Ruta chalepensis*	Rutaceae	Chena-adam	Herb	Year round	N,P	Mid land
85	*Securidaca longipedunculata*	Polygalaceae	Shitora	Tree	February-March	N,P	Low land
86	*Senna singueana*	Fabaceae	Hambohambo	Shrub	December-January	N,P	Low/Mid land
87	*Sesamum orientale*	Pedaliaceae	Selit	Herb	August-September	N,P	Low land
88	*Sida cordifolia*	Malvaceae	Dekidaero	Herb	August-September	N,P	Mid land
89	*Smithia abyssinica*	Fabaceae	Kelewlawe	Herb	August-September	N,P	Low land
90	*Solanum incanum*	Solanaceae	Engule	Herb	August-September	P	Low/Mid land
91	*Solanum tuberosum*	Solanaceae	Dnish	Herb	August-September	P	Low/mid land
92	*Sorghum bicolor*	Poaceae	Meshela	Herb	September-December	P	Low/Mid land
93	*Sterculia setigera*	Malvaceae	Darlie	Tree	April-May	N,P	Low land
94	*Stereospermum kunthianum*	Bignoniaceae	Rziganay	Tree	December- February	N,P	Mid land
95	*Syzygium guineense*	Myrtaceae	Liham	Tree	March-May	N,P	Mid land
96	*Tamarindus indica*	Fabaceae	Humer	Tree	November-December	P	Low land
97	*Terminalia brownii*	Combretaceae	Weyba	Tree	June-August	N,P	Low land
98	*Terminalia laxiflora*	Combretaceae	Akuma	Tree	April-June	N,P	Low land
99	*Trifolium* sp.	Fabaceae	Magets	Herb	July-October	N,P	Mid land
100	*Triunfetta anua*	Malvaceae	Chegogot	Herb	August-September	N,P	Low/Mid land
101	*Verbascum sinaiticum*	Scrophulariaceae	Tirnaka	Herb	September-October	N	Mid land

102	*Vicia faba*	Fabaceae	Balengua	Herb	August-September	N,P	Low/Mid land
103	*Ximenia americana*	Oleaceae	Mileo	Tree	May-June	N,P	Low land
104	*Zea mays*	Poaceae	Erif	Herb	August-September	P	Low/Mid land
105	*Zehneria scabra*	Cucurbitaceae	Hareg Eressa	Herb	June-July	N,P	Mid land
106	*Ziziphus mucronata*	Rhamnaceae	Gaba	Tree	November-January	N,P	Low land

N = nectar, P = pollen