SEASONAL AVAILABILITY OF COMMON BEE FLORA IN RELATION TO LAND USE AND COLONY PERFORMANCE IN GERGERA WATERSHED ATSBI WEMBWRTA DISTRICT, EASTERN ZONE OF TIGRAY, ETHIOPIA.

M.Sc. THESIS

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A THESIS SUBMITTED TO THE
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APPROVAL SHEET I

This is to certify that the thesis entitled **"**Seasonal Availability of Common Bee Flora in Relation to Land Use and Colony Performance in Gergera Watershed Atsbi Wenberta District Eastern zone of Tigray, Ethiopia**"** submitted in partial fulfilment of the requirements for the degree of Master of Science with specialization in Watershed Management (Soil and Water Conservation) of the Graduate Program of the Department of Forestry and Natural Resources, Wondo Genet College, and it is a record of original research carried out by Alemtsehay Teklay ID. No MSc 035/08, under my supervision, and no part of the thesis has been submitted for any other degree or diploma. The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, I recommend that it be accepted as fulfilling the thesis requirements.

_____ _____ _____

Name of Major advisor Signature Date

OR

_____ _____ _____

Name of Co-advisor Signature Date

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DEDICATION

This thesis is dedicated to my Mother Eyesay Kidane and my uncle G/her Kidane

LIST OF ACRONYMS

amsl	above mean sea level
ANOVA	Analysis of Variance
BoARD	Bureau of Agriculture and Rural Development
DA	Development Agents
FAO	Food and Agriculture Organization of the United Nations
kg	kilogram
ha	hectare
m	Meter
mm	millimetre
NGO	Non Governmental Organization
OoARD	Office of Agriculture and Rural Development
PA	Peasant Association
SE	Standard Error
SPSS	Statistical Package for Social Science

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Seasonal Availability of Common Bee Flora in Relation to Land Use and Colony Performance in Gergera Watershed Atsbi Wenberta District Eastern zone of Tigray, Ethiopia

Alemtsehay Teklay

ABSTRACT

The seasonal availability of common bee flora in relation to land use and colony performance was investigated by study the common bee flora species, seasonal abundance and diversity. Totally 50 quadrates were established in dry seasons and repeated in wet season in different land use (closed forest area (24) cultivate rain fed (11), cultivated irrigated (5), pasture land (4) and homestead (6)) by means of transect sampling method for collection of vegetation data. In addition to social survey was conducted for identification of common bee flora and their flowering time as well as to assess seasonal forage availability in relation to colony performance (colony strength and honey productivity). The results showed that, a total of 52 common bee flora species belonging to 31 families were identified in the study area. In area enclosure a number of diversified important bee flora species were recorded. The most important bee flora species includes *Leucas abyssinica, Hypoestes forskaolii, Becium grandiflorum and Eucalyptus camaldulnesis.* Enclosure area was good source of bee forage with abundant and diversified important bee flora species than the other land use systems. The availability of bee forage from August to October was relatively high. As a result August to October was peak period of foraging activity with strong colony performance as well as peak time honey flow. However, from the late of December to mid of March there was shortage of bee forage and results weak colony strength. Hence, it needs introducing or multiplication of drought resistant bee flora species and set flowers in dry season especially in cultivated rain fed land.

Key words*:* Abundance, colony strength, bee flora species, diversity, flowering time and forage

1. INTRODUCTION

Apiculture is one of the important agricultural sector that utilize natural nectar and pollen which otherwise would be wasted and contributed to the income of smallholder farmers (Melaku *et al.*, 2008). Apiculture is deeply rooted in the Ethiopian rural life and has a long tradition of beekeeping with about 3-5 million honeybee colonies producing about 21 thousand tonnes of honey annually (Fitchl and Admasu, 1994).

According to Crane (1990), apiculture is floral based industry and bees wholly depend on plants for their food; and from 250000 plants in the world, about 40000 plant species are important for honey bee as a food source. Bee colony performance as well as production of honey, wax and other hive products depends on bee forage plants from which honey bees obtain nectar and pollen as main food. These food sources provide the nutritional requirements of the bee colonies: nectar as sources of honey provides heat and energy for honey bees and pollen provides protein, vitamins, fatty substance, and other nutrients (Amsalu, 2000).

Due to its wide climatic and edaphic variability, Ethiopia is endowed with diverse and unique flowering plants of 6000 to 7000 species thus making it highly suitable for large number of colonies and long practice in beekeeping (Admasu, 1996, Fitchel and Admasu, 1994; Gezhagn, 2007, Gidey and Mekonen, 2010). The diversity of plants species comprises forest trees, bushes, grasses, and cultivated flowering plants that are actually and potentially useful for beekeeping. Tigray region has also various agro ecological zones that are suitable for the growth of different bee flora and development of apiculture. It is estimated that region has about 202, 000 bee colonies across the different ecological zones

(Ayalew, 2004) contributing about 5% of the Ethiopian honey and bee wax production (Melaku *et al.*, 2008). However, the loss of natural plants species or deforestation in Tigray region, has undoubtedly affected the bee forage availability, diversity and flowering pattern, and finally honeybees products and productivity in the region (Ayalew, 2005).

To address these problems of bee flora degradation, a number of interventions have been made in Tigray. For instance, rehabilitation of areas through reclamation and exclosure coupled with soil and water conservation efforts with improving conditions for apiculture (Bedru *et al.,* 2006). According to annual report of Tigray BoARD (2010), most of the degraded lands are rehabilitated with natural vegetation at faster rate than expected and most natural vegetation are suitable for soil and water conservation and most of them are preferred bee flora. Therefore, transforming enclosure or watershed in to apiary is just one example of a possible "win win situation" for poverty alleviation (Jocobs *et al.*, 2006).

Gergera watershed is one of the rehabilitated watersheds in Atsbi wenberta district, and that transformed into a potential area for beekeeping development (OoARD, 2010). In this regard, previous studies also indicated that Astbi wenberta is one of the district of Tigray region with a high potential for beekeeping development (Workneh *et al.,* 2008; Meaza, 2010) provided that the bee flora is well managed. According to Tigray BOANR (2010) the district has 19573 bee colonies of which about 35% have been in modern hive and the rest in traditional hives contributing about Birr 19 million annually to thousands of smallholder households. This is because the quality of 'Atsbi honey' is very high and fetches about Birr 80-120 per kg of honey.

So far, some research works have been reported with regard to bee forage availability and related parameters in some parts of Ethiopia (Admasu and Debissa, 1996, Ayalew, 2005,

Gezhagn, 2007 and Nuru *et al.,* 2003). Besides, Fichtl and Admasu (1994) also documented the honeybee flora of Ethiopia, and about 500 species has been identified, and characterized for their source for pollen and/or nectar. Even though in Astbi Wemberta district as well as Gergera watershed there were no credible studies on the type of common bee flora, their seasonal flowering pattern, abundance and diversity in relation to land use pattern, honey colony strength and productivity.

The documentation of bee flora and related parameters in relation to land use and season as well as colony performance is important to get better insights into the land use based bee forage rehabilitation efforts with the ultimate aim of improving the income of smallholder farmers through beekeeping development. Hence, the result of this study would support where and when to intensify bee forage development in relation to locally known land use patterns and systems as a means to increase beekeeping productivity.

1.1 Objectives of the study

1.1.1 General Objective of the Study

The general objective of the study was to examine the seasonal availability of common bee flora in different land use system to support and maintain that honeybee colony as well as honeybee production in Gergera watershed.

1.1.2. Specific Objective

The specific objectives were to:

- identify the common bee flora in the study area
- estimate the seasonal abundance and diversity of the common bee flora in relation to land use.

- identify the flowering time of the common bee flora and to assess the seasons where the supply of bee flora is in critical shortage
- assess bee colony strength and honey productivity across seasons in relation to forage availability

1.2 Research Questions

- What are the common bee flora species in Gergera watershed?
- What is the abundance and diversity of bee flora species in the wet and dry season and different land use system?
- When is the flowering time of those common bee flora species in the study area?
- What is the relative importance of these bee forage plants for honeybees?
- What is the relative seasonal forage availability as a function of bee colony strength and honey production?
  - When dose the shortage of bee forage happen?
  - When honey bee colonies are strong and a peak time for honey flow?

1.3. Limitation of the Study

In the study area there are a lot of bee flora plants, but due to time and budget constraint, I focused only on the common bee forage species and on those known by the local people. In addition laboratory analysis for honey quality identification in the different harvesting time was not identified during the study. Hence, the quality of honey harvested in the different harvesting time was assessed from the interviewed respondents and focus group discussion only.

2 LITERATURE REVIEW

2.1. Beekeeping and Potential Availability of Bee Forage in Ethiopia

Beekeeping is one of the most important farming activities in Ethiopia (Workneh *et al*., 2008). According the previous studies of Ayalew (2001) and Gezahegn (2007) and Fitchl and Admasu (1994) Ethiopia has longer tradition on beekeeping than any country in the world. "Since the 4th century during the time of king Ezana, Christianity with strong emphasis on nomadic culture had a greater contribution for intensive growth of apiculture; because of the need for wax and honey needed for religious ceremonies and for making traditional beverages" (Fitchl and Admasu, 1994). Hence, bee keeping practice has been estimated that started five thousand years ago in the northern regions.

The favourable and diversified agro climatic conditions of Ethiopia, has endowed with above 7000 plant species estimated, which support foraging bees and many other insects (Admasu, 1996, Gezhagen, 2007, Gidey and Mekonen, 2010). Therefore due to this potential availability of diversified bee flora and other environmental factors, Ethiopia has the highest bee density and is the largest honey producer in Africa and 10th in the world (Fitchl, and Admasu, 1994). Hence, in Ethiopia beekeeping is one of the oldest agricultural practice having passing from generation to generation without modification up to present time. It is only about 3 decades since improved beekeeping has been started in Ethiopia by introducing movable frame hives (Ayalew, 2004); this improvement makes beekeeping one of the good and best agricultural businesses and one of the income streams for rural peoples.

The national average honey yield is about 20-25 kg/hive per annum, whereas the price of one kg pure honey was ETB 35 at farm gate and ETB 50 at nearly regional town, and as a result beekeeper could get ETB 945 -1350 gross benefit per hive/annum (Melaku *et al.*, 2008). However the yield and price of honey depend on the potentiality of the local area for beekeeping and hive management (Gidey and Mekonen, 2010). According to MoARD, (2003) the most important honey and bee wax producing regions in Ethiopia are Oromia, South Nations Nationalities and People regional state (SNNPR), Amhara and Tigray.

The diversified flowering plants in Ethiopia and their blooming season greatly vary from place to place; this enables the country to sustain a large number of honeybee colonies (Admasu, 1996). About 500 honeybee flora species identified by the previous study of Fitchl and Admasu (1994) with their importance for honeybees (as source of pollen and/or nectar). For example species such as: *Eucalyptus camaldulensis, Optica cylinderica, Euphorboum candelabrum* and *Olea europeae* are some of the tree species source of both pollen and nectar. In addition to *Leucas abyssinica, Becium grandiflorum, Carissa edulis, Leucaena leucocephala* etc. are good source of pollen and nectar. While *Zea mays* and *Ocimum basilicum* are some of the honeybee flora plants which are sources of only pollen and nectar, respectively. As Fichtl & Admasu, (1994) honeybee plants can be categorized as major and minor source of bee forage; for instance:

Major bee plants: are those plants, which are visited by honey bees throughout their flowering season. E.g. *Bidens* species (meskel flower), *Trifolium* species. (Clover), *Eucalyptus* species, *Acacia* species, and *Vernonia* species.

Minor bee plants: are those plants that are visited less often by bees or only when flowers of major bee plants are not in flower. E.g. *Echinopes* species (Koshoshila), *Solanum* species (Imboay), *Dovyalis abyssinica* (koshim) and *Sida* species (chiferge).

2.1.1 Bee Forage and Honey Production in Tigray

"Tigray region is one of the oldest regions and or centre of early civilization as well as beekeeping practice in Ethiopia" (Ayalew, 2005). Beekeeping practice in the region is as old as farming and it has been traditionally practiced for a long period of time (Meaza, 2010). Although the stage of progress in changing the traditional practice is slow and the entire numbers of honeybee colonies are managing in the region is still traditional way (Fichtl and Admassu, 1994). As a result combination of traditional bee culture by farmers and available plant species favouring foraging bees still made the region the home of wonderful honeybee products. Most of the honey coming from Tigray is white, and is the best and highly demanded in both domestic and international markets for years (BoARD, 2010).

The number of bee colonies in Tigray was estimated to be 206,040 (37% and 63 % of which are modern and traditional bee hive, respectively) (BoARD, 2010). In 2009/10 one season honey production was 25,454 quintal and 2008/09 annual production was 31,000 quintal (Meaza, 2010). Though, beekeeping practice in recent years is improving, but the contribution of honey production of the region to national honey production is still small (around 5%) due to higher degradation of natural resource and/or degradation of honeybee flora that affect the diversity of honeybee plant (Girma, 1998, Gidey and Mekonen, 2010, Meaza, 2010 and Melaku *et al.,* 2008).

According the previous studies in Tigray region by Ayalew (2005) about 65 plant species were identified as potential, mid potential and low potential to foraging bees and to beekeeping intervention. Hence identifying the existing honeybee plants resources may help to assess the productivity, adaptability, swarming, absconding and other basic behaviour of the regional bee resource (Gebre, 2009).

Natural vegetation in general forest plants in particular that covers the lands in Tigray have been cut down leaving no remnants that helps to reinstate. The loss of these natural plants species, has undoubtedly affected the life pattern, products productivity of honeybees of the region (Ayalew, 2005). Yet, despite such big challenges, there are a wide variety of plants which are used as honeybee flora (Gidey and Mekonen, 2010).

2.2 Bee Forage and its Role for Honeybees

According to Gezhagn (2007) plants are the food source of honeybees. However, not all plants are important for honeybee, and those plants that supply both nectar and pollen abundantly when in bloom and these are often called honeybee plants (Akratanakul, 1990); honey bee plants are best suited for honey production as well as colony maintenance, in that bees obtain protein from pollen source plants and carbohydrate from nectar source plants (Bista and shivakoti, 2001).

Honeybees with their activity of extending their proboscis into the flowers are considered as nectar source and bees carrying pollen on their hind legs were determined as pollen source (Mbah and Amao, 2004). Based on studies conducted by Hill and Webster (1995) honeybees often forage on leguminous species, whether tree species or ground covers such as clovers (Trifolium spp). Honeybees also collect large quantities of pollen from *zea*

mays, (Mbah and Amao, 2004). Pollen plants are important in beekeeping, especially at the time of colony build-up (Akratanakul, 1990).

Generally, assessing the potential bee flora and their importance as a major or minor for honeybee plant is very important in bee forage management (Mbah and Amao, 2004). According to this study conducted in Zaria northern Nigeria, About 57.1% of the bee visited plants are perennials while 42.9 % are annuals. Sanford (2003), noted that many plants produce pollen for the bees, it is usually nectar producing species that are the most interesting for beekeepers except few plants; and the most reliable nectar producers are: Gallberry, Citrus, Tupelo saw palmetto, Melaleuca, Brazilian pepper and Palm (cabbage). Delaplane *et al.* (2010), revealed that in planning a bee pasture, it is important to choose a collection of plants that will produce unbroken succession of bloom throughout the season. One way is to improve bee nutrition (ultimately, increasing their populations) by planting or encouraging more-or-less permanent bee pasture near the crop of interest, such as trees, bushes and woody perennials.

2.3 Floral calendar of honeybee plants

Floral calendar for beekeeping is a time-table that indicates to the beekeeper; the approximate date and duration of the blossoming periods of the important honey and pollen plants Diver (2002). When we see the flowering time of single species, it begins from the full opening of the first few buds till the start of fruit formation end of flowering (Liseki and Boniphace, 2008*).*

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.

Hence, every region has its own honey flow and floral dearth periods of short or long duration and this knowledge on bee flora helps in the effective management of bee colony during such period (Bista and Shivakoti, 2001).

For instance in Ethiopia honey flow period is after the heavy rain in July through September known as "*Kremt*" and most of the Ethiopian highlands are coloured with golden-yellow because of abundance of flower of *Bidens* species, indigenous oil species like *Guizota* species and red violent with many different colours (Fichtl and Admasu, 1994 and Tessega, 2009). In Bure District also the potential bee floras are studied with their flowering calendar by Tessega (2009), and the flowering time of *Biden spp., Clematis hirusta, Pisum sativum, Zea Mays* was found to be from September to October, and that of *Carissa edulis ans Eucalptus spp* was from March to May whereas for *Croton macrostachy* it was from March to April. From the analysis of the flowering periods of the bee plants and field interviews, it was possible to identify honey flow seasons, accordingly the honey flow season in Rift valley regions of East Shewa zone was found to be occur from September to October as well as from April to June (Admasu and Debissa , 1996).

Generally, flowering calendars can make easier to plan various beekeeping management operations such as the sitting of hives near to particular crops and deciding the best time for honey harvest and/ or colony swarming. Hence adequate knowledge about bee flora including floral calendar is the prerequisite to initiate bee keeping (Bista and Shivakoti, 2001*).*

2. 4 Potential Areas for Bee Forage

According to Akratanakul (1990) assessing floral calendars and evaluation of the colony strength is one of the most accurate ways of assessing the suitability and supporting

capacity of an area for beekeeping. Jacobs *et al.* (2006) also noted that it is important to study the carrying capacity of area up to a radius of 3km around the apiary, which can forage the bees within one flight. Hence beekeepers should select appropriate site that have enough supply of bee forage within the flight range of honeybees (Crane, 1990 and Phillips, 2001). Additionally apiary site is a place where bee colonies are kept; an area which is highly potentiality in forage and water resource is preferred (Ayallew, 2004).

Even though, an area is endowed with bee forage; attention must be given to maintain the existing bee flora and multiplication of multipurpose plant species in order to make it sustainable (Bista and Shivakoti, 2001). Akratanakul (1990) also lists the following guidelines for the exploration and evaluation of potential area for beekeeping, such as:

- Determining whether similar plants are found in the area under study refers to lists of known major honey plants in other countries or regions with similar vegetation patterns, agro-ecosystems, climate, and edaphic conditions.
- Potential for commercial beekeeping of the area is not necessarily specified through the presence of more flowering trees and shrubs in limited numbers rather should be plenty of bee flora which covers large area.
- Honeybee plants having relatively long blossoming periods, generally in terms of several weeks or months are preferable.
- The large-scale planting of honeybee forages should be integrated with other agricultural activities, such as reforestation, roadside plantings, and animal pasture

2.5 Seasonal Colony Strength in Relation to Forage Availability

The colony strength as well as honeybee products mostly depends on the availability and type of bee flora next to level of colony management practice (Bista and Shivakoti, 2001).

The bees foraging at least 1·5 km from their colonies, and the proportion of foragers flying to one field declined, approximately linearly, with radial distance (Osborne, 2007). Hence apiary site should be near by the good bee forage plants in order to obtain good honeybee products and colony strength (Jacobs *et al*., 2006). Akratanakul (1990), also illustrated that in order to survive, prosper and be productive, honeybee colonies must have a supply of both nectar and pollen in adequate quantities. Consequently, the performance of the colony, either weak or strong as well as honey flow period of the colony directly depends on the existing availability of bee flora in each season.

Previous study in Ibadan (south west of Nigeria) by Mbah and Amao (2004), found out that; the main nectar flow is from July to February, with a peak in January when the largest forest trees are in flower, as a result, at this time there is enough nectar flow and the colony is strong with surplus honey to harvest. Other studies by Bista and Shivakoti (2001) at Kabre, Dolakha district also indicated that the peak periods of honeybee foraging activity and abundant bee floral plants were recorded during mid-February and May (spring season); whereas from mid-November to February (winter season) is dearth period and the colony strength can be weak with little or no honey production in addition to the colony may abscond. Therefore honeybees can live only if they have forgeable plants (Ayalew, 2006). Liseki and Boniphace (2008) also explained that the best harvesting period should be before the start of the dearth period when few plants are flowering. This is the time when feeding of bees is advised to prevent absconding, and to ensure the colony remains strong enough for the forthcoming season.

2.6 Watershed Rehabilitation and Bee Forage Improvement

Watershed rehabilitation is recovering and or restoration of the watershed to the previous natural condition; and aims to increase the productivity of agricultural and other natural resources through a combination of re-vegetation and soil and water conservation (Turton, 2000). Watersheds, especially in the developing world, are increasingly being managed for poverty alleviation as well as environmental conservation objectives (FAO, 2006). Bedru et al.,(2006), revealed that a large amount of natural resources in Ethiopia are degraded and or deteriorating due to over utilization and inefficient use of natural resources, specially the forest resource. This deforestation as well as reduction in vegetation cover has negatively affecting the biodiversity of honeybees and/or bee flora plants.

According to the study conducted in Burie District of Amhara Region by Tessega (2009), bee keepers try to overcome the problem of reduction of honey bee plants, hence beekeepers grow different local bee forage plants near by the apiary site. Despite these local efforts, the national beekeeping resource base is deteriorating at a faster rate warranting sustainable intervention progress (Melaku *et al.*, 2008). Hence, to address environmental problems as well as to improve household food security, a number of interventions have been made in Ethiopia; exclosures and other reclamation activities also implementing in a watershed approach to overcome the socioeconomic and environmental problems in sustainable way (Bedru *et al*., 2006).

Descheemaeker *et al.*, (2006) stated that, the main objective of exclosure rehabilitating of the degraded land for the production of fodder, forage, fire wood, and construction wood as well as other related benefited for the community or environment. A study conducted in

eastern zone of Tigray by Emiru *et al.*, (2006) shows that, species richness and ground cover in the area closure is much higher than in the open area, this shows the positive impact of area enclosure in the species biodiversity. In some places of Ethiopia, where the areas are well rehabilitated and increased moisture in the improved forage sites, the duration of bloom period of bee forage plants stayed longer than the none intervention sites" (Berhanu *et al*., 2010).

Furthermore improved forage interventions also makes a significant contribution to other forms of agriculture by effecting or accomplishing the pollination of many economically important plants, slowed down runoff, increased water infiltration to the ground and helped to stabilize gullies and the groundwater table is enriched and springs started to develop down the sites (Shrestha, 2006). The ground water is used for the production of irrigated vegetables and forage which is commonly practiced in Tigray region (Berhanu *et al*., 2010).

Therefore most of the bee forages species are multipurpose for the people as well as for the environment, some of the multipurpose trees that are recommended for planting in reclamation of the area, such as: *Acacia seyal, Cordia africana, Croton macrostachys, Olea europaea* etc. (Nyssen, 2004 cited in Jacobs *et al.*, 2006, and Fichtl and Admasu, 1994).

Based on Jacobs *et al.* (2006) during watershed/degraded area rehabilitation through area enclosure and/or reclamation we have to consider and give special attention for the bee flora species and other multipurpose species. Moreover beekeeping should be incorporate into overall land management strategies and farming systems, so as to ensure abundant nectar and pollen for a good and successful apiculture development.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1 Location

The study was conducted in Gergera watershed, which is located in Atsbi Wemberta district, Eastern Zone of Tigray Regional State. Geographically, it is situated between 39º 30' – 39º 45' E and 13º 30' – 13º 45' N (Hailay, 2008). The total area of the watershed is about 620 hectare.

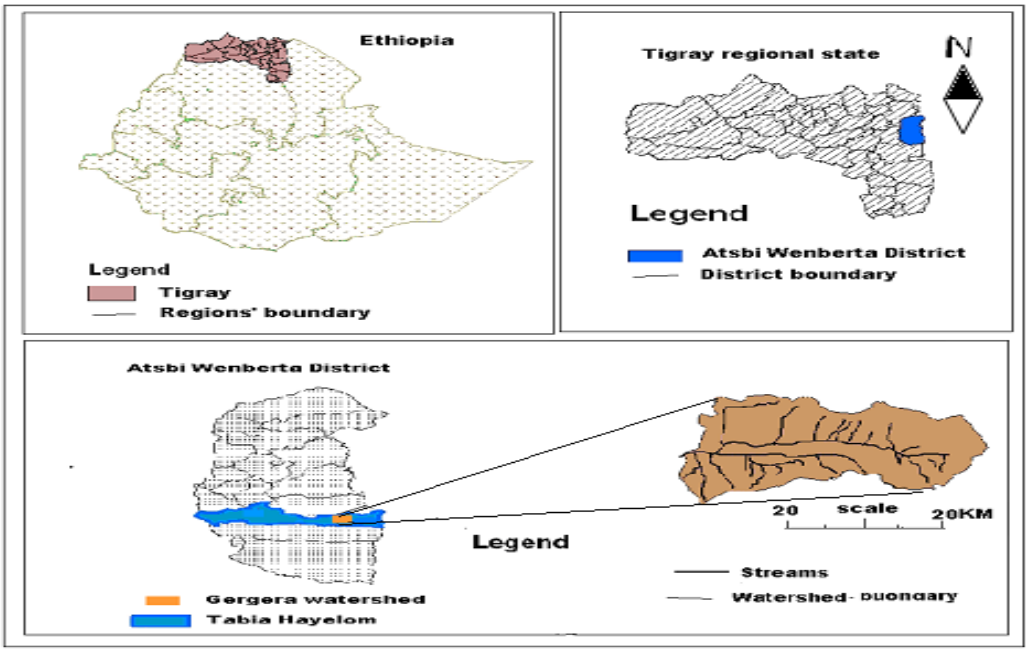

Figure 1: Location map of Gergera watershed Atsbi-Womberta district, Ethiopia.

3.1.2 Climate

The mean annual rainfall of the study area was 609.7mm, and the seasonal distribution of rainfall in Gergera watershed was determined in the previous study by Hailay (2008). Accordingly the rainy season is from late March to mid of September. Although the amount of rain that occurs during the months of late March to mid June and late September

was small, whereas, the heavy rains occur in July and August. Gergera watershed also characterized by two dry seasons. The main dry season starts in late of December and ends in mid March and the second from late of September to mid December. The mean annual minimum temperature of the study area was 8.92 ^{0}c and the mean annual maximum temperature was 25.9^{0}c. Hence, the average annual temperature of the study area was 17.4^{0}c (Hailay, 2008).

3.1.3 Topography and Edaphic Resources

According to Hailay (2008), Gergera watershed consists of small depressed area that extended from South-East to North-West bounds by adjacent highlands. The maximum peak reaches 2560 masl (mater above sea level) in the Asagulo Ridge, which is found in the Southern part of the study area consisted of Adigrat Sandstone unit. The minimum reading (2140 masl) was taken at the low land, which is at the lower part of the area. Generally, the study area is more of plateau, with an average elevation of 2350 m. According to Hailay (2008) Gergera watershed has been classified into six slope classes: 0 -15 % (flatland), 15 -30 % (gentle), 30 – 45 (intermediate), 45 – 60 % (slightly steep) and 60 – 75 % (steep).

The study area also has good source and underground water, with seasonal river (Gergera River); which flows in the rain season only. According to Hailay (2008), in the study area water bearing formations are the most common shallow groundwater aquifers which can be tapped by larger diameter hand dug wells. The farmers use this ground water (hand dug wells) for irrigation.

The soil that is found in the study area is grouped in to four different soil classes: sandy loam, clayey sand and sandy clay loam and clay (Hailay, 2008). Consequently in the basin, sand is found as its pure form, and also in combination with clay and loam. Loams are plastic when moist and water retain easily. The proportions of sand sized particles are also prominent in sandy clay loam and sandy loam soil types.

3.1.4 Vegetation and Land use

Vegetation is the most important for soil conservation and also for fuels formation as well as for bee forage. In Gergera watershed the distribution of vegetation consists of more or less bushes and shrubs, these vegetations cover most of the steep mountains and ridges. However, few indigenous trees like *Juniperus procepa* and *Olea europaea* are found in the north east part of the study area, the area where the springs are found. Eucalyptus trees are found in the settlement areas. Grassland is also found in the central lowland area. According the secondary data obtained from OoARD (2010), the total area of the watershed is about 620 ha (hectare). From this total area 223 ha (36%) is cultivated land (148 hectare is rain fed and 75 ha is irrigated), 303 ha (49%) enclosure forest area, 70 ha (11%) pasture and the rest 24 hectare (4%) is homestead.

Most of the area including the steep mountainous area is covered with forest, bushes, shrubs and some tree species. In addition to small area is covered by forest, around the Gergera Medhanealem Church, which is found at the North-Eastern part of the study area. The pasture land in the study area is found in the downstream close to Gergera Medhanealem Church, some portion of the pasture land is swampy especially in the rainy season.

In the study area most of the residential areas are found in the downstream, only few are located at the upstream or highland area with small area of cultivated rain fed land. The farmers in the downstream cultivate their land using both rain and irrigation water. Some soils like sandy loam and sandy clay loam found on the lowland area are fertile. Hence some of cereals and vegetables are available with good yield. The cereals and vegetables include maize, wheat, barley, tomato, and potato. According to Atsbi Wemberta Distrct OoARD (2010) the dominant cereal crops of the area are barley, wheat, teff, maize and sorghum, where as the dominant pulses are beans and field pea. In addition there are also different vegetables and fruits grown in the irrigated land; such as: tomato, potato, green pepper, guava etc.

According the secondary data OoARD (2010), Gergera watershed is one of the potential areas for bee keeping, with different bee flora species. Hence the total number of honeybee colony in the study area is 555. From this 370 honeybee colonies are in modern bee hive where as the remaining 185 are traditional bee hives**.** There are 240 beekeeper households in the study area, and beekeeping is commonly practiced by the farmers.

3.2. Sampling Procedures and Data Collection Methods

3.2.1 Social Survey Sampling Procedure and Data Collection

The study was conducted in Gergera watershed; and this watershed was selected due to its representativeness and potentiality for bee forage as well as its transport accessibility. To collect the required social data for the study individual interview, key informant interview and focus group discussion were conducted.

Household interview: to select the sample households for the study first 240 beekeepers households were listed with in the watershed according the data obtained from the OoARD (2010). Accordingly 20% of beekeepers households in the watershed were used for the structured questioner interview. Therefore a stratified random sampling method was used to select the respondent households for the study. Accordingly from the total 240 beekeeper households 48 beekeeper respondents have been randomly selected for the interview. Hence to collect information regarding bee forage plants and related parameter (like identification of common bee flora with their flowering time, importance, seasonal forage availability in relation to colony strength and honey production etc.) for the study, the sampled beekeepers were individually interviewed with structured questionnaire (Appendix 5).

Pre-test and recognizance survey were also conducted to see effectiveness of the questionnaire for the study; and then the sampled respondents were interviewed with the help of trained enumerators and house to house visit.

Key informant interview: Key informant interview have been made with Atsbi Wemberta district beekeeping expert, development agents (DAs) of the study area, the watershed community members and some individual beekeeper farmers. The qualitative information collected in interview is used to supplement and crosscheck the data obtained through the household survey. Hence purposive sampling method was used for selecting members for the key informant interview.

Focus Group Discussions: Focus group discussions were conducted in the study area with purposively selected section of community such as watershed members, PA leaders, DAs and bee technician, and some individuals, who are believed to be knowledgeable about bee

flora plants in the watershed were part of the discussion. Hence, purposive sampling method was used for selecting focus group discussion members.

Critical Observation: Field observations were also made on the bee flora species in the different land use systems of Gergera watershed.

3.2.2 Field Survey Design and Vegetation Sampling

To estimate bee flora composition and diversity in the study area, sample have been collected from each land use rain fed and irrigated cultivated land, closed forest area, pasture land and homestead) and in two seasons of main rain season called "Kiremt" (end of June to mid of September) and main dry season "Bega" (end of December to mid March).

To lay quadrates, first the area was stratified based on the land use, and then parallel transect to each other with the east west orientation were taken. The distance between transects was 400 m. Each plot quadrant was laid using systematic random sampling; where the first plot was randomly laid along transects. Then the rest consecutive quadrates were laid at equal intervals along the transects, once the distance between two quadrates were calculated by using the formula total length of transect divided by total number of quadrates. The size of quadrate in the cultivated land and pasture was $25m^2$(5m*5m), while for closed forest area and homestead land was use $100m^2$ (10m*10m) quadrate. The number of sample plots laid in all transect lines were in cultivated land 16 (cultivated rain fed 11 and 5 irrigated), in pasture 4, in homestead 6 and the remaining 24 plot in the closed forest area.

Therefore the total number of quadrate used for the study was 50 (3490m^2) in both wet and dry seasons. 48 percent of the sample plots were laid in closed forest area, because the greater part of the watershed is closed forest area (49% of the total watershed). The field survey works were focus on common Bee flora species abundance, diversity (Shannon diversity indices (H`)), species richness and species evenness (E) were computed. These common bee floras were once identified during the social survey, also recorded during the plot survey with the help of plant identification manual and relevant literatures like Fichtl and Admasu, (1994).

3.2.3 Bee Flora Species Composition and Diversity Estimation

The abundance of bee flora species defined here as the total number of all ndividuals species in all 50 quadrate was estimated in wet and dry season for each land use system. The relative frequency of each bee flora species was calculated by determining the proportion of quadrate in which that species were encountered.

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

To compare bee flora species composition among different land use systems and season, species richness, Shannon diversity index, and Shannon evenness index were calculated. The sum of all species encountered in the plots of in each land use system in both wet and dry season was used to determine the species richness. Shannon diversity (H') and evenness (E') indices are also calculated as a measure to incorporate both species richness and species evenness or measure of heterogeneity (Begone *et al*., 2006).

$$\text{Shannon diversity index, } H' = -\sum_{i=1}^{S} pi \ln pi \text{ ----------1}$$

Where: H' = species diversity index;

ln = natural logarithm

$P_i = \frac{ni}{N}$ is the proportion of individuals found in the ith species (ranges 0 to 1); and

n = number of individuals of a given species; N = total number of individuals found

The Shannon evenness was calculated

$$E' = \frac{H'}{InS} \text{ Or } E = \frac{H'}{H \max} \text{ ----------2}$$

Where S is the total number of species recorded

Equitability (evenness) is calculated to estimate the homogeneous distribution of bee flora species on the plot or the relative abundance. H' is high when the relative abundance of the different species in the sample is even, and decreases when few species are more abundant than the others or measures species or less heterogeneity. H'_{max} is also the maximum level of diversity possible within a given population.

3.3. Statistical Analysis

3.3.1 Social Survey Data Analysis

The data collected during the social survey were summarized using descriptive statistical methods (such as frequencies, percentage and graphs) and summarize data were presented in the form of tables and figures. Descriptive statistical procedures in SPSS version 17 and excel (word 2003) were used to summarized the data.

3.3.2 Bee Flora Species Composition and Diversity analysis

To summarize bee flora species, abundance, frequency, and diversity, once estimated based on the above procedures (section 3.2.3) for each land use and season, excel (word) 2003 was used and presented in the form of table. Moreover to analyze the data of bee flora species diversity, richness, and evenness in the different land use systems in both wet

and dry season univariate analysis were used. Hence the analysis of variance tests were performed to assess the effects of land use systems and seasons on quantitative data of bee flora species. Consequently two way ANOVA was computed with SPSS 17 (SPSS Inc. Chicago, USA, 2008) to test the effect of different land use systems and seasons on Shannon diversity index (H`), species evenness (E) and species richness (number of species/plot) as follows.

$Y_{ijk}= \mu+A_i+ B_j + AB_{ij} + e_{ij}$

Where : Y_{ijk}= values of the respective variables mentioned above (on Shannon diversity index (H`), species evenness (E) and species richness (number of species/plot). Performed to the k^{th} plot, sampled from the j^{th} land use and during the i^{th} season

μ = the overall grand mean value of the respective dependent variable mentioned earlier.

A_i = the effect of the differences between two seasons on the respective dependent variable mentioned (where i= 2, wet season and dry season)

B_j = the effect of differences among the five land use systems studied on the respective dependent variables mentioned above (j=5, closed forest area, homestead, pasture land, rain fed cultivated land and irrigated cultivated land).

AB_{ij}= the interaction effect of the season and land use on the respective dependent variable.

e_{ij}= random error term pertaining to the k^{th} data

Whenever statically significant difference was observed ($P<0.05$ and $P<0.001$) Duncan's multiple range tests were used to separate the means.

4. RESULTS AND DISCUSSION

4.1 The Common Bee Flora Species in Gergera Watershed

A total of 52 commonly grown bee flora species belonging to 31 families were identified by the respondents, key informants interview as well as during focus group discussion and recorded with their local name (Table 1). Accordingly, the common bee flora species in the study area includes *Leucas abyssinica, Hypoestes forskaolii, Becium grandiflorum, Eucalyptus camaldulensis, Bidens spp.***,** *Zea mays, Trifolium spp* and *Opuntia ficus-indica.* Therefore, the different bee flora species in the study area was diversified with different family species.

The information obtained on common bee flora species from the respondents was triangulated during field visit and survey work even for those not appeared in the sampled plot. Hence it was possible to conclude that beekeepers had good knowledge on local bee flora plant species. This agrees with the study conducted by Debissa (2006), and Fichtl and Admassu (1994).

The life form of common bee flora species in the study area, were characterized as shrub (*Leucas abyssinica, Becium grandiflorum* etc), tree (*Eucalyptus camaldulensis, Opuntia ficus-indica, etc) and herbs (Hypoestes forskaolii, Bidens spp., Zea mays and Trifolium spp* etc.) (Table1).

Table 1: Common bee flora species in Gergera watershed according to social survey

No.	Scientific name	Family name	Local name (Tigrigna)	Life Form	Source (P/N)
1	*Acacia pilispina*	Fabaceae	Chea	T	P &N
2	*Achyranthes aspera*	Amaranthaceae	Mechelo	H	P & N
3	*Allium cepa L.*	Liliaceae	Shigurti	H	P &N
4	*Aloe berhana*	Aloaceae	Ire	H	P & N
5	*Andropogon abyssinicus*	Poaceae	Demhale	H	P
6	*Argemone mexicana*	Papaveraceae	Medafe-t`ilian	H	P
7	*Azadirachta indica*	Meliaceae	Nim	T	P &N
8	*Becium grandiflorum*	Lamiaceae	Tebeb	S	P & N
9	*Bidens spp.*	Asteraceae	Gegelle-meskel	H	P & N
10	*Brassica spp.*	Brassicacea	Hamliadri	H	P &N
11	*Calpurnia aurea*	Fabaceae	Hitsawts	S/T	P & N
12	*Capsicum annuum*	Solanaceae	Berbere	H	P &N
13	*Carduus nyassanus*	Asteraceae	Dander	H	P & N
14	*Carica papaya L.*	Caricaceae	Papaye	T	P & N
15	*Carissa edulis*	Apocynaceae	Agam	S	P & N
19	*Cordia africana*	Boraginaceae	Awhii	T	P & N
17	*Cicer arietinum*	Papilionnoideae	Ater	H	P & N
18	*Citrus aurantifalia*	Rutaceae	Lemin	T	P & N
16	*Craterostigma plantagineum*	Scophulariaceae	Fossi Anqrbirt	H	P &N
20	*Croton macrostachyus*	Euphorbiaceae	Tambuck	T	P & N
21	*Cynadon doctylon*	Poaceae	Tehag	H	P
22	*Cyphostemma adenocaule*	Vitaceae	Hareg-Temen	H	P &N
23	*Dodonaea angustifolia*	Sapindaceae	Tahses	S	P &N
24	*Eucalyptus camaldulensis*	Myrtaceae	Kelamitos	T	P& N
25	*Euclea schimperi*	Ebenaceae	Kiliow	S	P & N
26	*Euphorbia candelabrum*	Euphorbiaceae	Kolqwal	T	P & N
27	*Ficus vasta*	Moraceae	Da`ro	T	N
28	*Helianthus annus L.*	Asteracea	Sufferenji	H	P & N
29	*Hypoestes forskaolii*	Acanthaceae	Girbia	H	P & N
30	*Leucaena leucocephala*	Fabaceae	Lucina	S	P &N
31	*Leucas abyssinica*	Lamiaceae	Siwakerni	S	P & N
32	*Lycopersicon esculentum*	Solanaceae	Komidere	H	P & N
33	*Mangifera indica L.*	Anacardiaceae	Mango	T	P & N
34	*Ocimum basilicum*	Lamiaceae	Seseg	S	N
35	*Olea europeae*	Oleaceae	Awlea	T	P &N
36	*Optica cylinderica*	Cactaeae	Limust- beles	T	P &N
37	*Opuntia ficus-indica*	Cactaeae	Ashak- beles	T	P &N
38	*Otostegia integrifolia*	Lamiaceae	Ch`indog	S	P & N
39	*Polyscias fulva*	Araliaceae	Mirkus –zibei	T	P &N
40	*Psidium guajava*	Myrtaceae	Zeytihun	T	P &N
41	*Rhamnus prinoides L.*	Rhamnaceae	Giesho	T	P & N
42	*Rhus glutinosa*	Anacardiaceae	Mengi	T	P & N
43	*Ricinus communis*	Euphorbiaceae	Gul`i	S/T	P & N
44	*Rumex nervosus*	Polygonaceae	Hehot	S	P
45	*Schefflera abyssinica*	Araliaceae	Kot, Getem	T	P & N
46	*Schinus molle L.*	Anacardiaceae	T`qur-berbere	T	P & N
47	*Sida schimperriana*	Malvaceae	Tefreria	S	N
48	*Solanum spp L.*	Solanaceae	Engule	H	P
49	*Solanum tuberosum L.*	Solanaceae	Dnish	H	P
50	*Trifolium spp.*	Papilionnoideae	Messi	H	P & N
51	*Vicia faba*	Papilionnoideae	Alqway	H	P & N
52	*Zea mays*	Poaceae	Mishela bahri	H	P

NB: T=Tree, S=Shrub, H=Herb, P=pollen, N=Nectar

Generally, 40% of the common bee flora species identified in the study area were herbaceous species, 37 % were tree species and the remaining 23 % were shrubs. Hence, herbs are more dominantly appeared followed by trees and shrubs respectively. Debissa (2006) also find out similar result. Herbs can grow easily in the different land use systems, even with shower rain in a short period of time than trees and shrubs; most probably this may be the main reason for dominance of herbaceous bee flora species in the study area.

Generally, Gergera watershed was one of the potential areas for bee forage with different bee flora species commonly grown. According to Hailay (2008) Gergera watershed has also good potential underground water resource. Hence, the availability of potential flowering plants and ample sources of water for bees are the two major factors for an area to be considered as potential for beekeeping (Tessega, 2009).

4.2. Bee Flora Species Abundance and Diversity in Relation to Different Land Use System and Season

4. 2.1 Bee Flora Species Abundance

The abundance of bee flora species in the study area was estimated during the field survey (Table 2). Accordingly, the survey result showed that, in wet season the total number of bee flora species or species abundance was higher in pasture land followed by closed forest area and medium in cultivated rain fed and irrigated land. However, around homestead, relatively lower species abundance was observed. In dry season the species abundance in pasture land, cultivated, closed forest area, and homestead were lower than wet season. However, bee forage species abundance in irrigated cultivated land increased in dry season than the wet.

Therefore, the result showed that the species abundance in the dry season in all land use was decreased, except in irrigated cultivated land. This may be due to most of the herbaceous species in the dry season may not exist unless supplemental irrigation used.

In closed forest area *Hypoestes forskaolii, Becium grandiflorum* and *Bidens spp*.were highly abundant and most frequently available bee flora species in the wet season. Similarly *Opuntia ficus-indica, Hypoestes forskaolii* and *Solanum spp L* (in homestead) *Cynadon doctylon, Andropogon abyssinicus* and *Bidens spp*. (in pasture land), *Zea mays* and *Vicia faba* (in cultivated rain fed land), *Cynadon doctylon* and *Zea mays* (in irrigated land) were abundantly available. Therefore, in the wet season more abundant bee flora species were available, while in the dry season only *Becium grandiflorum* (in closed forest area), *Opuntia ficus-indica* (in homestead), *Cynadon doctylon, Andropogon abyssinicus* (pasture land), *Cynadon doctylon* and *Zea mays* (in irrigated) has been abundantly available.

Table 2: Abundance (AB) and relative frequency (RFR) of common bee flora species in relation to season and land use system in Gergera watershed.

land use	Species Name	Wet season		Dry season	
		AB	RFR	AB	RFR
Closed forest area	*Hypoestes forskaolii*	2302	92	-	-
	Becium grandiflorum	639	79	639	79
	Bidens spp.	349	33	-	-
	Ocimum basilicum	141	17	-	-
	Aloe berhana	113	33	113	33
	Dodonaea angustifolia	93	33	93	33
	Carduus nyassanus	69	25	69	25
	Achyranthes aspera	65	33	35	33
	Leucas abyssinica	59	21	59	21
	Rumax nervosus	27	25	27	25
	Euclea schimperi	24	17	24	17
	Olea europeae	23	42	23	42
	Carissa edulis	15	21	15	21
	Acacia pilispina	7	17	7	17
	Eucalyptus camaldulensis	6	8	6	8
	Rhus glutinosa	5	13	5	13
	Schefflera abyssinica	1	4	1	4
	Total	**3938**	**513**	**1116**	**371**
Homestead	*Opuntia ficus-indica*	88	67	88	67
	Hypoestes forskaolii	72	50	-	-
	Solanum spp L.	71	50	-	-
	Eucalyptus camaldulensis	33	33	33	33
	Rumax nervosus	8	33	8	33
	Euphorboum candelabrum	5	17	5	17
	Argemone mexicana	4	67	-	-
	Becium grandiflorum	3	17	3	17
	Croton macrostachys	3	50	3	50
	Optica cylinderica	3	17	3	17
	Olea europeae	1	17	1	17
	Total	**291**	**418**	**144**	**251**
Pasture land	*Cynadon doctylon*	3200	75	2400	75
	Andropogon abyssinicus	2200	75	1800	75
	Trifolium spp.	1574	50	1200	50
	Bidens spp.	1221	50	-	-
	Rumax nervosus	3	25	3	25
	Achyranthes aspera	2	25	2	25
	Argemone mexicana	1	25	5	25
	Total	**8201**	**325**	**5410**	**325**
Rain fed cultivated	*Zea mays*	1355	55	-	-
	Vicia faba	1256	45	-	-
	Capsicum annuum	10	9	-	-
	Argemone mexicana	5	9	12	9
	Hypoestes forskaolii	5	27	-	-
	Carduus nyassanus	1	9	1	9
	Total	**2632**	**154**	**13**	**9**
Irrigation cultivated	*Cynadon doctylon*	1795	60	1795	60
	Zea mays	555	60	350	60
	Bidens spp.	40	20	-	-
	Capsicum annuum	15	20	45	20
	Psidium quajava	2	20	2	20
	Lycopersicon esculentum	-	80	740	80
	Total	**2407**	**260**	**2932**	**240**

The abundance of bee flora species also triangulated with the social survey or respondents view , which was almost similar with field survey result. Hence, the relative abundance of bee flora species was grouped in to five relative abundance ranks: such as highly abundant, abundant, medium abundant, rare and very rarely abundant (Appendix1). According to social survey, the species relative abundance of *Becium grandifforum, Bidens spp., Rumex nervosus*, and *Trifolium spp*. are highly abundant in the study area. Next to these, *Andropogon abyssinicus, Hypoestes forskaolii, Dodonaea angustifolia* and *Leucas abyssinica* etc. were abundant. The other species grouped in to medium relative abundance including Achyrathes *aspera, Otostegia integrifolia, Zea mays, Olea europea* etc. Whereas the remaining bee flora species such as, *Cicer arientinum, Rhus glutinosa, Aloe berhana* etc. were found rarely. Moreover, the respondents also viewed that *Croton macrostachys* as a very rarely available in the study area.

4.2.2 Bee Flora Species Diversity in Relation to Season and Land Use System

The Shannon diversity indices for the common bee flora species in the study area were estimated in the two seasons (wet and dry season) and different land use systems (Table 3). Accordingly bee flora species diversity in closed forest area was relatively higher in both dry (1.65) and wet season (1.69), and relatively lower in cultivated rain fed land (0.74 and 0.28 for wet and dry season respectively). In addition to bee flora species diversity in dry season was lower than wet season in all land use systems.

In this study species richness (S) was computed as, the observed number of bee flora species for each land use system, and in both dry and wet season (Table, 3). As a result, the number of species observed in the wet season in closed area were relatively higher

(17), followed by homestead (11) than the other land uses, such as pasture land (7) and cultivated rain fed and irrigated (6).

Table 3: Shannon diversity index for bee flora species in the wet and dry season as well as different land use system in Gergera watershed

	land use				
Bee flora species diversity index	Closed forest	Home stead	Pasture land	Cultivated rain fed	Cultivated irrigated
Wet season					
Number of individual (N)	3966	285	8200	2632	2850
Observed number of species (S)	17	11	7	6	6
Shannon diversity (H')	1. 69	1.5	1.33	0.74	1.22
Shannon evenness (E)	0.53	0.71	0.68	0.42	0.68
Dry season					
Number of individual(N)	1174	145	5484	13	2912
Observed number of species (S)	14	9	6	2	5
Shannon diversity (H')	1.65	1.30	0.75	0.28	1.05
Shannon evenness (E)	0.63	0.59	0.42	0.40	0.65

However, in the dry season relatively less species richness than wet season in all land use was observed. As a result the observed number of bees floras species in the closed forest area were 14, followed by homestead (9) and pasture (6) as well as irrigated land (5). Therefore the result shows that the number of species observed in all land use were lower in dry than the wet season.

The mean diversity of bee flora species (Shannon diversity indices) in different land use system were also computed (Table 4). As a result, there was significant difference in means of species diversity in the different land uses ($P<0.001$). Accordingly the maximum Shannon diversity index (H') was observed in closed forest area followed by pasture, homestead and irrigated cultivated land. In the rain fed cultivated land the mean of H' was lower than the other land use systems. Hence, the result shows there was more diversified

bee flora species in the closed forest area. However, the ANOVA test result for the interaction of season and different land use systems on flora species diversity (Shannon diversity indices (H')), as well as the mean bee flora species diversity in the wet and dry season was not significant ($P>0.05$) (Appendix 2). This may be due to the fact that, life form of the most perennial bee flora species exist in both seasons. In addition some of the herbaceous species were found in both seasons of wet and dry season (irrigated and pasture land).

Enclosures are free from human interfere and this creates good opportunity natural regeneration of species as well as good vegetation cover; most probably this may be main reason for higher species diversity in closed forest area. The previous study conducted in Biyo and Tiya , central and northern part of Ethiopia by Tefera (2002) similarly find out that, higher value of Shannon diversity indices (H') in closed forest area, and noted that enclosures have more species and important for the conservation of important plant genetic resource.

The mean of species richness was computed as the mean number of bee flora species per plot in wet and dry season and different land uses (Table 4). Even the species richness was higher in wet season than dry season, the effect of season on species richness (the mean number of species richness in wet and dry season) was not significant ($P>0.05$). However the mean number of bee flora species per plot in the different land use systems was significantly different ($P<0.001$). Accordingly the mean number of species per plot was higher in closed forest area and lower in rain fed cultivated land; as a result closed forest area was richer in bee flora species.

Table 4: Mean (SE) Shannon diversity indices (H`), species evenness (E) and species richness (S) of bee flora in the different land use systems in wet and dry seasons.

Category	Sample size(n)	Mean(± SE)		
		H'	E	S
Wet season				
Rain fed cultivated	11	0.16 (0.12)[a]	0.23 (0.09)[a]	1.36 (0.5)[a]
Irrigation cultivated	5	0.21 (0.18)[a]	0.3 (0.13)[a]	1.4 (0.7)[a]
Pasture land	4	0.43(0.16)[b]	0.53(0.15)[b]	2.8(0.7)[b]
Homestead	6	0.59 (0.2)[b]	0.31 (0.12)[a]	3(0.8)[b]
Closed forest area	24	0.89 (0.08)[c]	0.56 (0.06)[b]	4.9 (0.3)[c]
Dry season				
Rain fed cultivated	11	0.01(0.01)[a]	0.02(0.01)[a]	0.45(0.03)[a]
Irrigation cultivated	4	0.27 (0.2)[b]	0.330 (0.15)[b]	2.2 (0.7)[b]
Pasture land	5	0.47(0.18)[c]	0.570 (0.15)[c]	2.3 (0.7)[b]
Homestead	6	0.54(0.18)[c]	0.398 (0.13)[b]	2.25 (0.8)[b]
Closed forest area	24	0.86 (0.09)[d]	0.645 (0.06)[c]	3.44 (0.3)[c]
Seasonal average				
Wet season	50	0.45(0.07)	0.43 (0.05)	2.5 (0.28)
Dry season	50	0.43 (0.08)	0.4 (0.06)	2.05(0.28)

1 Column mean values with different superscript letters are significantly different from each other (P<0.001(H' and S) and P<0.05(E)).

Species evenness is the relative diversity or proportion of observed diversity (H') in relation to maximum species diversity (lnS). Hence the mean species evenness were computed and statistically tested (Table 4). The interaction of season and land use as well as the mean species evenness in wet and dry season was not significant (P>0.05) (Appendix 3). Whereas, the mean of species evenness between different land use was significant (P<0.05). The maximum species evenness was observed in closed forest area (60%) and lower in cultivated rain fed land (23%). Hence, Duncan's test of means of species evenness in the different land use showed that only closed forest area was different, whereas the other remaining land use had similar mean of species evenness.

In general, the mean of bee flora species diversity, richness, and evenness in wet and dry season was not significant. This may be since most of the bee flora species in the study area are perennials (trees and shrubs) and some herbs in irrigated and pasture land are available in the dry season. Perennials were the best bee plants than annuals, although some annuals provide quick and relatively abundant bee forage, as a result perennials herbs are superior bee forage plants (Delaplane, 2010).

In addition, bee forage species diversity, richness and evenness was higher in closed forest area than the other land use systems of the study area. This indicated that closed forest area was good source of bee forage covered with diversified bee flora species. Similarly, Kindeya (2004) and Emiru (2002) also noted that enclosing areas had been play great role in increasing species biodiversity as well as maintaining biodiversity in the dryland areas.

4.3. Flowering Time of the Common Honeybee Flora Species

The flowering time of common bee flora species in the study area were identified by the responded households, key informants as well as during focus group discussion (Table 5). Local beekeepers, extension agents, and horticulturalist are good source of information about the important bee plants in an area and their historic bloom times (Delaplane, 2010). Accordingly, the flowering time of these common bee flora plants were characterized in to common and rare flowering time. For example the common flowering time of *Leucas abyssinica, Trifolium spp.* and *Becium grandiflorumis* was from August to September, whereas *Hypoestes forskaolii* and *Bidens spp.* commonly flower from September to October and August to October respectively**.** Surprisingly *Eucalyptus camaldulensis* commonly flower the whole year round. The previous studies by Gebre (2009), Melaku *et*

al., (2008) and Fichtl and Admassu (1994), similarly find out that *Eucalyptus camaldulensis* commonly gives flower the whole year and as main source of bee forage.

In the study area the common flowering time of *Zea mays* was in August (cultivated rain fed land) and from February to March (in irrigated land). According to the previous studies in Kilte-Awlaelo and Burie district by Gebre (2009) and Tessega (2009) respectively, the flowering period of *Zea mays* was August to September and September to November respectively; this somewhat different from the study area. The flowering time of *Cordia africana and Azadirachta indica* was from December to February. In addition to *Croton macrostachys* commonly flower from September to October, and March to April. While the previous studies conducted by Melaku *et al*., (2008) and Tessega (2009) in Oromia and Amhara regional state respectively, the flowering period of *Croton macrostachys* was from March to April. Generally, the same species found in the different area may differ their flowering time; most probably this may be due to variation in climate and topography. Similarly Bista and Shivakoti (2001) noted that the flowering time of bee flora may differ from one place to another due to variation in topography, climate, and other cultural and farming practices.

The flowering time of most of shrub bee flora species like *Becium grandifforum, Carissa edulis and Leucas abyssinica* was commonly from March to October. While most of the herbaceous species commonly flowered from August to October, but

Table 5: Flowering time of the common bee flora species in Gergera watershed

Species Scientific Name	Flowering time (month)											
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Acacia pilispina												
Achyrathes aspera												
Allium cepa L.												
Aloe berhana												
Andropogon abyssinicus												
Argemone mexicana												
Azadirachta indica												
Becium grandifforum												
Bidens spp.												
Brassica spp.												
Calpurnia aurea												
Capsicum annum												
Carduu hyassanut												
Carica papaya L.												
Carissa edulis												
Cicer arientinum												
Citrus aurantifalia												
Cordia africana												
Craterostigma plantagineum												
Croton macrostachys												
Cynodon doctylon												
Cyphostemma adenoccaule												
Dodonaea angustifolia												
Eucalyptus camaldulensis												
Euclea shimperi												
Euphorbium candelabrum												
Ficus vasta												
Helianthus annuus L.												
Hypostes forskaolii												
Leucaena leucocephola												
Leucas abyssinica												
Lycopersicon esculetum												
Mangifera indica L.												
Ocimum basilicum spp												
Olea europea												
Optica cylinderica												
Oputia ficusindica												
Otostegia integrifolia												
Polyscias fulva												
Psidium quajava												
Rhamnus prinoides L.												
Rhus glutinosa												
Ricinus communis												
Rumex nervosus												
Schefflera abyssinica												
Schinus molle L.												
Sida schimperriana												
Solanum spp L.												
Solanum tuberosum L.												
Trifolium spp.												
Vicia faba												
Zea mays												

NB: Rarely flowering time; Common flowering time

some of herbaceous species like *Argemone mexicana, Capsicum annum, Lycopersicon esculetum* commonly flowered from December to March. Hence, the flowering time of shrubs and herbs was related with availability of rain, especially the herbaceous species commonly in bloom in the rain season.

In the study area as respondents explained, the rare flowering time of bee flora species was related with availability of rain especially in the dry season. So, if there is good availability of rainfall, and the blooming period of bee flora plants become longer (extended) and/or give flower even if not common flowering time. For instance, in the study area the rare flowering time of *Capsicum annum* was from August to October and April, *Leucas abyssinica* and *Trifolium spp.* was from April to July etc. In addition to some of the bee flora plants in the study area have long blooming period (*Eucalyptus camaldulensis, Rumex nervosus, Leucaena leucocephola*, etc.), while some species have short blooming time (*Bidens spp., Vicia faba, Rhus glutinosa*, etc.).

In the study area the peak periods of honeybee foraging activity and abundant bee floral plants were recorded from August to October, with 30 bee flora species are commonly in flower. As a result, this peak period (August to October) was the main honey flow season in the study area. A study conducted in Ethiopia by Fichtl and Admasu (1994), also shows similar result. In addition, some species also bloom from mid March to May. Therefore flowering calendar helps to identify dearth times of the local area as well as harvesting (Delaplane, 2010).

According to Liseki and Boniphace (2008*)* flowering calendars of bee flora species is important to plan various beekeeping management practices like, harvesting time, a time when shortage bee forage is happen, bee forage improvement practices etc. Delaplane,

(2010), also revealed that in planning a bee pasture, it is important to choose a collection of plants that will produce unbroken succession of bloom throughout the season**.**

4.4 Relative Importance of Common Bee Flora Species

In Gergera watershed, the respondents scored the relative importance of the 31 common bee floras species (Table 6). Accordingly, in the study area *Becium grandifforum, Hypoestes forskaolii, Leucas abyssinica Eucalyptus camaldulensis and Bidens spp.* were very important bee forage species for honeybees and main source of pollen and nectar (Figure 2). Whereas, *Acacia pilispina,* Opuntia *ficus indica, Schefflera abyssinica* etc. were some of the other important bee flora species recognized by the respondents.

The previous study conducted in Kilte-Awloelo district by Gebre (2009) found out similar results. In addition Fitchl and Admasu (1994), also stated that these bee flora species are important for honey bee, especially *Eucalyptus camaldulensis* was one of the major source of pollen and nectar and provides good honey yield. According to the study conducted in Southeast by Delaplane (2010), compared to annuals, perennials are rich nectar sources. Whereas, in the study area there were also very important annual bee flora species like *Hypoestes forskaolii*, but in general perennials are major sources of bee forage plants.

Figure 2: Some of the very important bee forage plants in Gergra watershed: (a) Bidens spp., (b) Hypoestes forskaolii, (c) Becium grandiflorum and (d) Leucas abyssinica

The respondents also characterized the remaining 15 bee flora species as relatively less important bee flora species than the other species described above; such as *Psidium quajava, Olea europea, Rhus glutinosa, etc.* However, according to Jacobs *et al.*, (2006), honeybees collect pollen and nectar from the flowers of *Olea europea* and *Leuceana leucocephala*; and characterized as important bee flora species.

The common bee floras identified in the study area also described as source of pollen and/or nectar from the previous studies conducted in Ethiopia by Fitchl and Admasu (1994) (Table 1). Accordingly, from the total 52 bee flora species in the study area 44 bee flora species are source both pollen and nectar, which includes *Leucas abyssinica, Hypoestes forskaolii, Becium grandiflorum, Eucalyptus camaldulensis, Bidens spp* etc.

Whereas, the remaining 6 species (*Zea mays, Cynadon doctylon, Andropogon abyssinicus, Argemone mexicana, Solanum spp. and Solanum tuberosum L.)* were source of pollen plants. The two species (*Ficus vasta* and *Ocimum basilicum)* were also only source of nectar. Honey bees also suck juice of the ripe fruits from *Ficus vasta* and in the dry season, a solution of crushed fruits and water are valuable bee feed *(*Jacobs *et al*., 2006*).* Therefore, honeybee plants are the main source of pollen and nectar that honeybees are depend on. Furthermore, Bista and Shivakoti (2001) noted that honeybee plants are the first and basic factor for honeybee's life. However, the degree of bee flora species importance for honeybee may differ from species to species.

Table 6: The relative importance (%) of bee flora species as ranked by respondents (n=48) in Gergera watershed

Species of bee flora	% of households			
	VI	I	LI	%OWA
Becium grandifforum	67	33	-	89
Hypoestes forskaolii	66	17	17	83
Leucas abyssinica	22	78	-	77
Eucalyptus camaldulensis	34	58	8	75
Bidens spp.	27	55	18	70
Acacia pilispina	-	92	8	64
Euphorbium candelabrum	8	75	17	64
Schefflera abyssinica	12	62	25	62
Opuntia ficusindica	-	89	56	78
Croton macrostachys	-	73	27	58
Andropogon abyssinicus	-	80	20	60
Carduu hyassanut	-	67	33	56
Aloe berhana	-	61	38	53
Trifolium decorum	-	56	44	52
Vicia faba	-	53	47	51
Psidium quajava	-	50	50	50
Olea europea	-	47	53	49
Rhus glutinosa	-	44	56	48
Carissa edulis	-	56	44	52
Capsicum annum	-	43	57	48
Dodonaea angustifolia	-	40	60	47
Lycopersicon esculetum	-	40	60	47
Cicer arientinum	-	37	63	46
Ocimum basilicum	-	20	80	40
Leucaena leucocephola	-	37	63	46
Achyrathes aspera	-	34	66	45
Argemone mexicana	-	-	100	33
Eeuclea shimperi	-	12	88	37
Zea mays	-	9	91	36
Otostegia integrifolia	-	17	83	39
Rumex nervosus	-	7	93	36

NB: OWA= Overall Weighted Average Rank (%), VI= Very Important, I=Important, LI=Less Important

4.5 Relative Availability of Bee Forage as a Function of Land Use and Season

The seasonal availability of bee forage in the different land use was examined from the respondents view (Table 7). Accordingly, in the main rain season most of the respondents agreed that, there was sufficient availability of bee forage in homestead, pasture land, and cultivated rain fed and abundant availability in closed forest area. Despite in cultivated irrigated land the majority of the respondents reported that there is poor availability of bee forage in the main rain season.

Table 7: Relative availability of bee forage plants as a function of land use during the different seasons in Gergera watershed (n=48)

Season		% of households responded			
	Land use	AA	SA	LA	PA
Main rainy season (late of June to Mid Sept)	Homestead	-	54	46	-
	Pasture land	4	58	37	-
	Closed Forest land	67	33	-	-
	Cultivated rain fed land	-	67	33	-
	Cultivated irrigated land	-	-	4	96
Harvesting season (late Sept to mid of December)	Homestead	-	54	46	-
	Pasture land	-	80	20	-
	Closed forest area land	75	25	-	-
	Cultivated rain fed land	-	46	54	-
	Cultivated irrigated land	-	-	42	58
Main dry season (late December to mid of march)	Homestead	-	-	38	62
	Pasture land	-	-	25	75
	Forest area land	-	-	75	25
	Cultivated land (rain fed)	-	-	-	100
	Cultivated land (irrigated)	-	70	30	-
Small rainy season (late March to mid June)	Homestead	-	29	62	8
	Pasture land	-	17	83	-
	Closed forest land	-	12	71	17
	Cultivated rain fed land	-	-	-	100
	Cultivated irrigated land	-	25	75	-

AA=Abundantly Available, SA= Sufficiently Available, LA=Lowly Available, PA=Poorly Available

In the harvesting season the majority of the respondents illustrated that there was abundant availability of bee forage in the closed forest area. In addition, in homestead and cultivated rain fed land there was relatively sufficient availability of bee forage. While the majority of respondents viewed the availability of bee forage in cultivated irrigated land was poor.

In the main dry season the respondents indicated that the availability of bee forage in homestead, pasture land and closed forest area ranges from low to poor availability. Particularly in cultivated rain fed land all of the respondent viewed that the availably of bee forage was poor. But in cultivated irrigated land the majority of respondents say that the availability of bee forage in the main dry season was sufficient. In small rain season the majority percentage of the respondents regarding the availability of bee forage was low in all land use except in cultivated rain fed land where it was poorly available. Hence, according to the respondents as well as the focus group discussion the availability of bee forages in the small rain season relatively higher than the dry season.

Generally, closed forest area from the late June to mid of December relatively contributes relatively higher bee forage for the honeybees. This means in closed forest area more species are in flower especially in the main rainy season. This agreed with the field survey result, as discussed above, in closed forest area there were relatively rich and with more diversified bee flora species.

4.6 Relative Forage Availability and Honeybee Colony Strength

In Gergera watershed the availability of bee forage in the different months was viewed by the respondents (Table 8). Hence, the majority of respondents agreed that there was critical shortage of bee forage in dry season (January to March). In addition, in June, December,

and April the majority of the respondents viewed that there is also moderate shortage of bee forage**.** On the other hand, in July and November there was less/mild shortage of bee forage.

Honeybees store honey for their own consumption during dearth period, whereas the beekeepers are harvesting honey, which the honeybees store for themselves. Hence shortage of bee forage happens in the dearth period and the availability of flowering bee forage plants is low (Workneh, 2007**).** However, in the study area all of respondents illustrated that there was no shortage of bee forage from August to September next to October. Hence in the main rain season there was enough availability of bee forage and most of the important bee forage species were in bloom.

Table 8: Shortage level of bee forage plants in different months of the year at Gergera watershed as viewed by respondents (n=48)

Month	% of household responded			
	Critical Shortage	Moderate Shortage	Less Shortage	No Shortage
June	33	54	12	-
July	8	12	62	17
August	-	-	-	100
September	-	-	-	100
October	-	-	21	79
November	-	4	83	12
December	19	81	-	
January	64	36	-	-
February	62	37	-	-
March	58	42		-
April	33	54	12	-
May	29	50	21	-

Correspondingly, the colony strength in the different months of the year was ranked by the respondents (Table, 9). The overall weighted average rank of colony strength in August and September was very strong, as well as from July and October the colony strength was strong. As discussed above, from August to October there was no shortage of bee forage or

there was enough availability of bee forage, that was the underlying factor for the strength of bee colony. In November, May and June the colony strength was medium. While the colony strength from December to March was weak, especially from February to March was very weak. Hence, it was possible to conclude that, honeybee colony strength was directly related with forage availability. In addition, during the focus group discussion, participants explained that when the colony was very weak (in the dry season), sometimes abscond of bee colony happened. Ayalew (2006), similarly noted that honeybees can live only if they have forgeable bee flora.

Table 9:The level of bee colony strength in different months of the year as viewed by respondents in Gergera watershed (n=48).

Month	% of household responded					OWA(%)
	VS	S	M	W	VW	
August	83	17	-	-	-	97
September	83	17	-	-	-	97
October	38	58	4	-	-	87
November	33	17	50	-	-	77
July	17	33	50	-	-	73
May	-	12	62	17	8	58
June	-	12	42	42	4	52
December	-	-	50	46	4	49
April	-	4	12	79	4	43
January	-	-	29	50	21	42
February	-	-	17	54	29	37
March	-	-	8	62	29	36

VS= Very Strong, S= Strong, M= Medium, W=Weak, VW=Very Weak, OWA= Overall weighted average rank (%).

When there was critical shortage of bee forage in the study area, the beekeepers try to solve using different mitigation practices. As a result, the beekeepers used different supplementary food, in the dry season when there was critical shortage of bee forage especially from January to March. Hence, the supplementary food included sugar, toasted and floured barley (Beso), and toasted and floured beans (Shiro). Previous studies by Workneh (2007) and Gebre and Tessega (2009) also find out similar result.

In addition to supply of artificial food, bee keepers in the study area grew different bee forage plants in order to cope up with shortage of forage that was the usual case during the dry season. As a result from the total interviewed households, majority of the respondents (58 %) practiced planting of bee forage plants (Figure 3).

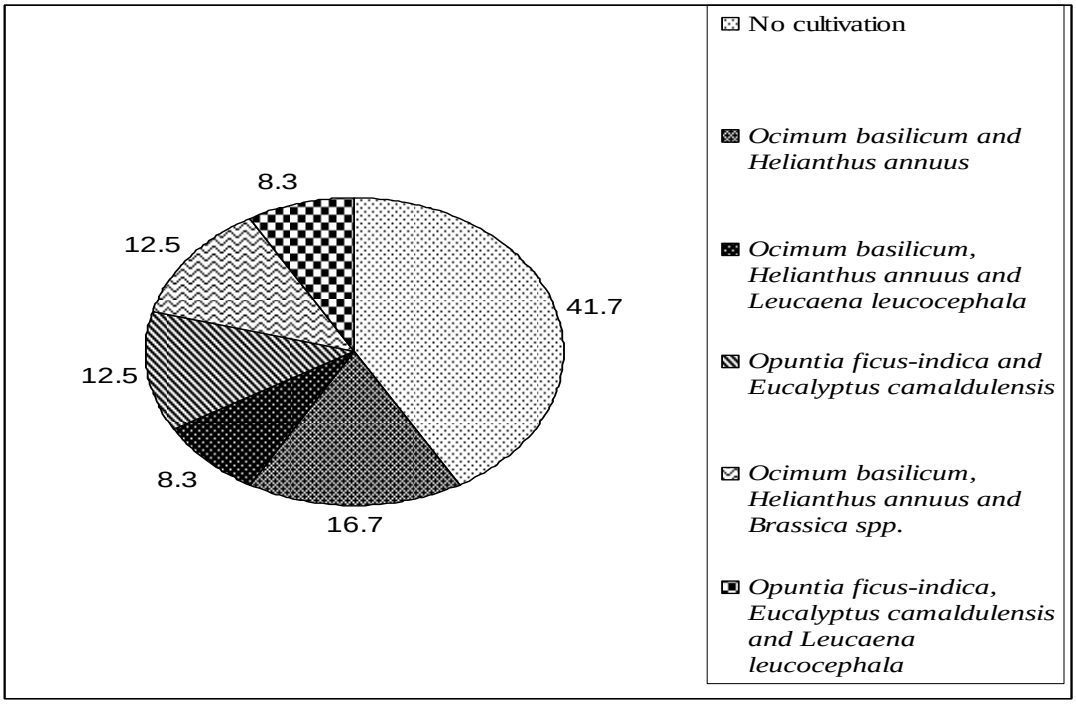

Figure 3: The practice of cultivating bee forage plants in Gergera watershed as reported by respondents. Values shown are percentage of households that cultivate the bee forage plants

Hence, in the study area the bee forage plants that commonly practiced by the households and identified by the respondents included *Ocimum basilicum*, *Helianthus annuus, Leucaena leucocephala, Eucalyptus camaldulensis, Opuntia ficus-indica* and *Brassica species.* The extension activity in the study area also encourages beekeepers to grow local bee forage species, such as *Hypoestes forskaolii, Becium grandiflorum* etc. **(**Workneh, *et al.* 2008**).**

The study conducted in Burie District of Amhara Region by Tessega (2009), also similarly results that , 82.5% of beekeepers grow different local bee forage plants near by the apiary site. Despite the other previous studies conducted in Kilte-Awlaelo district by Gebre (2009) indicated that the majority (60%) of the sampled households did not plant any type of bee flora. So it was possible to say that, there was good bee forage practice in the study area. However, there was a need for farther investigation on the bee forage and cultivation by all bee keepers as well as by the community to solve the problem and to maximize honey bee production.

4.7 Honey Productivity and Quality as a Function of Forage Availability

The common and occasional harvesting time of honey in the study area was assessed (Figure 4). As a result, the common harvesting time of honey in Gergera watershed was August, September and October. In addition, the majority of respondents occasionally harvest in May, and some of the respondents also in June, July and November. The occasional or rare harvesting time mostly depend on the rainfall and bee forage availability in the dry season.

According to other previous studies by Melaku *et al*. (2008), conducted in Oromia region of Ada`a-Liban results that the major honey flow season was from October to November and the minor flow season was from May to June. Hence, honey harvesting time may differ from place to place; most probably this may be due to difference in seasonal availability of bee forage.

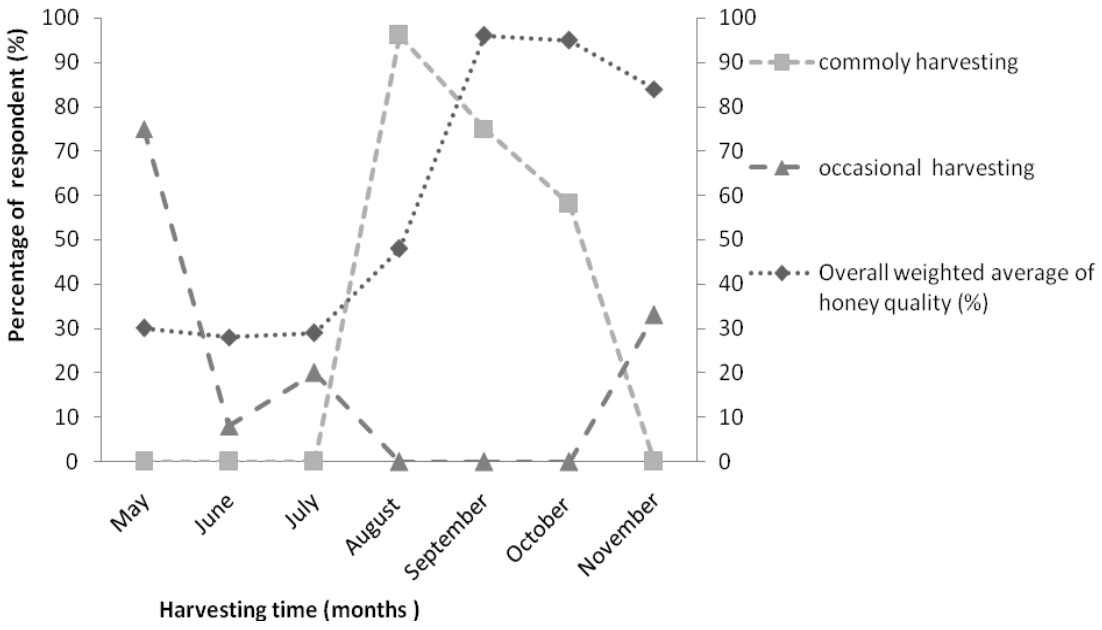

Figure 4: Honey harvesting time and quality as viewed by the respondents in Gergera watershed.

In Gergera watershed both traditional and modern bee hives was commonly practiced. During the study the respondents average honey production per bee hive colony from traditional and modern bee hive in each harvesting also estimated (Table 10).

The majority of the respondents, from August to November harvest relatively medium honey from modern beehive (5 to 15 kg of honey per modern bee hive). Some of the respondents also harvest relatively maximum honey (15 to 25 kg and above per hive) from modern bee hive in October, September and November. Whereas, from May to July the majority of the respondents harvested relatively lower honey from modern beehive (1 to 5 kg/colony). Similarly most of the respondents harvested from 1 to5 kg per colony of traditional bee hive from August to November and May. While in September and November harvest 5 to 15 kg. Therefore, in both modern as well as traditional bee hive honey yield was higher from September to November.

Table 10: Quantity of honey harvested from modern and traditional beehive during different months of harvesting time by the responded households (%)

Harvesting time	Modern beehive/colony/ Kg				Traditional bee hive/colony/kg			
	1- 5	5 -15	15 – 25	>25	1-5	5 -15	15- 25	>25
May	92	8	-	-	100	-	-	-
June	100	-	-	-	-	-	-	-
July	83	17	-	-	-	-	-	-
August	33	67	-	-	83	17	-	-
September	-	57	21	22	50	50	-	-
October	-	73	13	13	75	25	-	-
November	-	75	13	13	50	50	-	-

Generally, honey yield from both modern and traditional was higher in the harvesting time, of August to November. So that, honey production can be affected by bee forage availability assuming other factors were constant. Most probably the main reason for this honey yield difference in the different harvesting time was due to the different availability of bee flora species in the different harvesting time. For instance, from August to November there was good availability of bee flora than the other months of the year and that's way there was good honey yield.

The amount of honey produced from one bee hive per year also may vary from places to places, in most cases that was determined by the existences of plenty pollen and nectar source plants and the level of management and input used (Tessega, 2009). Similarly the study conducted by Melaku *et al.* (2008) Ada`a-Liban district indicated that the average production of honey from traditional and modern beehives was 4.61 kg and 14.4 kg per beehive per harvest respectively, and the frequency of harvest was average twice a year.

According the respondents view, in Gergera watershed there was honey quality difference that harvested in the different harvesting time (Figure 4). The quality honey was ranked by

the respondents based on some local criteria's of honey quality like colour, market demand and price. As a result, the rank quality of honey harvested in September and October was very good with higher overall weighted average. This means, the quality of honey harvested in September and October was pure and white in colour and with high market demand as well as price. The quality of honey harvested in November also relatively good, while honey harvested from May to June was with relatively lower quality. The price of honey during the main harvesting time and rare harvesting time, may somewhat different, because in the main harvesting there was higher production. However, even there was more honey yield during main harvesting time, but the beekeepers does not sale their product during the main harvesting time; they simply store it. It is obvious that honey is not perishable and can store for a long time, that's way the farmers sale their product when there was good price.

As discussed above there was honey quality difference that harvested in the different harvesting time. The main reason for the honey quality difference was also described by the respondents. In general the majority of the respondents agreed that the main reason for honey quality difference was the type and availability of bee forage, for instance from August to October there was enough availability of bee forage. In addition, important honey bee plants that gives good honey quality, like *Leucas abyssinica*, *Hypoestes forskaolii* and *Becium grandiflorum* were in bloom. Whereas some of the respondents also described that the reason for honey quality difference was both forage availability and type as well as hive management.

The general overview of trend in honey production in the recent years viewed by the respondents as well as from focus group discussion, suggested that there was good, and increasing from time to time especially in the recent 10 years. The main reason for

increasing trend of honey production was improvements in bee forage next to hive management (like use of modern bee hive) in the recent years. This finding was in agreement with the previous study conducted in the district by Workneh (2007), which indicated that forage was one of the important factors and play a pivotal role in the increment of honey yield. Similarly, the study conducted in Bure district by Tessega (2009), honeybee products was in a decreasing trend due to shortage of bee forages and other factors. Hence, it was possible to conclude that the availably of bee forage in the study area especially in the wet season was relatively good with positive trend and improving from time to time.

In addition, during the group discussion the participants described that, a decade ago Gergera watershed was degraded, but due to recent watershed management practices, the area was rehabilitating as well as vegetation cover was improving from time to time. As a result , the availability bee forage in Gergera watershed was improved, especially in the closed forest area. According to Tsega and Bachmann (2009) soil and water conservation activities in Gergera watershed started in 1992 /93 (1985 EC), and then in 1996 (1988 EC) it began to be conducted in a more organized way. As a result the upper-catchments of the watershed was well rehabilitated and protected. Hence, due to reforestation and area enclosure (mainly on slopes) the vegetation cover of forested land has been increased over the past 17 years. Once the vegetation cover of the watershed improved, at the same time the availability of bee flora also improved. This was one of the multiple benefits of watershed rehabilitation.

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

In Gergera watershed total of 52 common bee flora plants species, that represented 31 families were recorded. The common bee forage species identified includes *Leucas abyssinica, Hypoestes forskaolii, Becium grandiflorum, Eucalyptus camaldulensis, Bidens spp., Zea mays, Trifolium spp and Opuntia ficus-indica.* Though there were difference in bee flora species diversity and abundance in different land use system, divers bee flora plants in the study area were found in all land use types. Hence closed forest area was good source of bee forage; with more diversified species of important bee flora plants and relatively less in cultivated rain fed lands.

In the study area *Becium grandifforum, Hypoestes forskaolii and Leucas abyssinica* were the three top very important bee forage species for honeybees and main source of pollen and nectar. Hence, most of the important bee flora plants were in bloom from August to October, and this is peak period honey bee foraging activity with strong colony strength as well as peak time of honey harvest. Due to shortage of bee forage was in dry season particularly from January to March and the colony strength was very weak.

Generally in the study area there was good potential availability of bee forage in the rain season. This was one of the positive impacts of watershed rehabilitation on bee flora biodiversity. However, in the dry season only few bee flora plants were in bloom and this affected the colony performance.

5.2. Recommendations

In Gergera watershed there was good potential availability and diversified bee flora plants especially in closed forest area, this could be an input of watershed rehabilitation. In addition, soil and water conservation was handled in a good manner; as a result the availability bee forage was improved in recent years. Generally, the experiences of Gergera watershed with good bee flora availability and area enclosure activities should be introduced to other areas to improve forage availability as well as honey bee productivity.

Although Gergera watershed enriched by bee flora species, due to short rain season most of the important bee flora plants set their flower from August to October. Especially the contribution of cultivated rain fed land for bee forage in the dry season was very low. Hence there were seasonal shortage bee forage from late December to mid March. This is an obstacle of production of honey throughout the year as well as colony strength.

Therefore to solve this problem beekeeping based agro forestry practices on cultivated rain fed land, and selection of plant species that can resist drought and bear (set) flower for a long season should be introduced in all land use types.

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APPENDICES

Appendix 1: Relative abundance of bee flora as reported by the respondents during the survey

LF	Species of bee flora	% of respondents					O.WA (%)
		Highly abundant	Abundant	Medium	Rare	Very rare	
S	*Becium grandifforum*	87	13	-	-	-	97
H	*Bidens spp.*	87	13	-			97
S	*Rumex nervosus*	50	42	8	-	-	88
H	*Trifolium spp.*	37	37	25	-	-	82
H	*Andropogon abyssinicus*	37	12	50	-	-	77
H	*Hypoestes forskaolii*	30	39	13	17	-	76
S	*Dodonaea angustifolia*	-	75	25	-	-	75
H	*Cynodon doctylon*	50	-	25	25	-	75
T	*Eucalyptus camaldulensis*	27	14	59	-	-	74
T	*Opuntia ficusindica*	-	65	35	-	-	73
H	*Lycopersicon esculetum*	14	29	57	-	-	71
S	*Leucas abyssinica*	9	43	39	9	-	70
H	*Achyrathes aspera*	11	28	50	11	-	68
S	*Otostegia integrifolia*	25	25	-	50	-	65
H	*Zea mays*	10	20	45	25	-	63
T	*Olea europea*	12	19	25	44	-	60
S	*Carissa edulis*	14	14	29	43	-	60
S	*Euclea shimperi*	-	-	87	12	-	57
H	*Cicer arientinum*	7	7	27	57	-	53
H	*Rhus glutinosa*	-	-	63	37	-	52
H	*Aloe berhana*	-	30	10	50	10	52
H	*Carduu hyassanu*		8	42	50	-	52
T	*Acacia pilispina*	10	10	30	20	30	50
T	*Psidium quajava*	-	-	50	50	-	50
H	*Capsicum annum*	-	-	40	60	-	48
T	*Euphorbium candelabrum*	-	-	36	64	-	47
S	*Leucaena leucocephola*	-	-	43	43	14	46
H	*Vicia faba*	-	-	27	73	-	45
T	*Schefflera abyssinica*	-	-	40	40	20	44
S	*Argemone mexicana*	-	-	50	-	50	40
S	*Ocimum basilicum*	-	-	-	100	-	40
T	*Croton macrostachys*	-	-	12	25	62	30

LF=Life Form, T=Tree, S=shrub, H=Herb, OAW(%)= Over All Weighted Average in percent.

Appendix 2: Analysis of variance test result regarding the effects of land use systems and season on bee flora density (number of plant per hectare).

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	3.606E12	9	4.006E11	10.926	.000**
Intercept	2.451E12	1	2.451E12	66.854	.000**
Season	7.700E10	1	7.700E10	2.100	.151
Land use	3.402E12	4	8.504E11	23.193	.000**
season * Land use	1.547E11	4	3.868E10	1.055	.384
Error	3.300E12	90	3.667E10	-	-
Total	7.753E12	100	-	-	-
Corrected Total	6.906E12	99	-	-	-

** = Significant at 0.001 level

Appendix 3: Analysis of variance test result regarding the effects of land use systems and season on diversity of bee flora expressed in terms of Shannon diversity index (H`).

Source	Type IV Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6.972[a]	8	.872	5.595	.000**
Intercept	13.463	1	13.463	86.432	.000**
Season	.001[b]	1	.001	.006	.940
Land use	4.587[b]	4	1.147	7.362	.000**
season * Land use	.410	3	.137	.878	.457
Error	11.838	76	.156		
Total	52.240	85			
Corrected Total	18.811	84			

** = Significant at 0.001 level

Appendix 4: Analysis of variance test result regarding the effects of land use systems and season on species evenness (E') of bee flora expressed in terms of Shannon diversity index.

Source	Type IV Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.889[a]	8	.236	2.639	.013
Intercept	10.051	1	10.05	112.353	.000**
Season	.041[b]	1	.041	.462	.499
Land use	.839[b]	4	.210	2.345	.042*
season * Land use	.235	3	.078	.877	.457
Error	6.709	75	.089		
Total	28.288	84			
Corrected Total	8.598	83			

** = Significant at 0.001 level ; *= significant at 0.05 level

Appendix 5: Analysis of variance test result regarding the effects of land use systems and season on bee flora species richness expressed in terms of number of species per plot

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	236.705[a]	9	26.301	10.114	.000**
Intercept	375.270	1	375.270	144.307	.000**
Season	6.964	1	6.964	2.678	.105
Land use	198.919	4	49.730	19.123	.000**
season * Land use	11.776	4	2.944	1.132	.347
Error	234.045	90	2.601	-	-
Total	1283.000	100	-	-	-
Corrected Total	470.750	99	-	-	-

**= Significant at 0.001 level

Appendix 5: Social survey questionnaire

A) Region _____ Zone_____ Wereda _____ Kebele_____
B) Age_____ C) Sex _____

1. It is known that Gergera watershed is potential area for bee keeping with different bee flora species, so can you list the major bee flora species in your local area? Yes No
If yes list the major and common bee flora and their flowering period in the table below.
Table 1 local bee flora species and their flowering time

Life form	Local name of bee flora	Flowering time(months)											
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May

1.1. Can you rank the above bee forage species in order of their important source for bee forage and to give good honey yield as well as colony performance? Yes No , if yes rank in the table below
Table 2 Rank of bee forage species based on their importance for bee forage

Life form	Local name bee forage species	Rank of bee forage

1.2. From the above bee forage species which of them have more abundance and which is less abundance in your local area? Classify in the table below.
Table 3 bee flora species and their relative abundance.

Life form	Local name of bee flora	Species abundance				
		More abundant	abundant	medium	Rare	Very rare

2. It is obvious these bee flora species are distributed in different land use types; hence can you classify the above major bee floras in which land use are commonly found?
Yes No , if yes classify in the table below
Table 4 bee flora distribution and land use classification

Life form	Bee flora species	Different land use types				
		Home stead	Pasture land	closed forest area	Cultivated land	
					rain fed	irrigated

2.2. Can you rank which land use has more supply bee forage and which is less supply /potential for bee forage? Yes No , if yes classify in the table below.

Table 5 land classification and level potentiality for bee forage in the different season?

Different land use types	Level of supply			
	Main rainy season (late of June to Mid Sept)	Main dry season (late of December to mid of march)	Harvesting season (Late Sept to mid of December)	Small rainy season (late of March to mid June)
Home stead				
Closed forest area				
Pasture land				
rain fed cultivated				
Irrigated cultivated				

3. Did you plant bee forage species purposely for your bees? Yes No

If yes list them

_____
_____
_____

4. Do you think that there is shortage of bee forage in your local area? Yes No

If yes in which month/season is the most critical shortage of bee forage happen? mark in the table below.

Table 6 the time for when shortage of bee forage is happen

Season	Months of the year	critical shortage	shortage	Less shortage

4.1. When this shortage of bee forage is happen how do you solve this problem?

_____4.2.

Do you feed your bee's supplementary food other than local bee forages mentioned above? Yes No

If yes what are these supplementary food source you use?

_____

5. In which month /season do you observe that there is more as well as less supply of bee forage?

Table 7 the supply level of bee forage in different seasons

Season	Months	More than Enough supply	Enough supply	Less supply

6 How many bee colonies do you have?

Table 8 Total number bee colonies

S.N	Type of beehive	Number of colonies
1	Modern	
2	Traditional	
Total		

7. How many times do you harvest?

Table 9 harvesting time of honey bee in the local area of Gergera watershed

	Harvesting time											
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Most common												
Rare												

7.1. How much honey (kg) do you harvest per colony?

Table 10 level honey harvest per colony in each harvesting time

Harvesting time In months	Honey yield (kg)					
	In modern beehive			Traditional bee hive		
	maximum	medium	lower	maximum	medium	Lower

8. Is there change in honey quality in different harvesting time? Yes No , if yes classify the quality of honey /harvesting time in the table below.

Table 11 Rank of honey quality in different harvesting time

Honey quality	Harvesting time											
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Very good												
good												
medium												
Low												

8.1 What do you think the main reason for this quality difference?

_____

_____

9. Have you noticed colon's performance difference in the different seasons of the year?

Yes No , if yes rate them

Table 12 the rate of colony performance in the different seasons

colony strength	Months											
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Very strong												
Strong												
Medium												
Weak												
Very weak												

10. From your point of view how do you see the trend honey bee production in relation to forage availability?

_____

_____

_____

BIOGRAPHY

Alemtsehy Teklay was born 1987 in Ahferom which is located in central zone of Tigray Ethiopia. She received her primary education in Edaga Arbi, and secondary school in Mekelle Fre-Abiot secondary school as well as preparatory in Atse Yohannes high school. Later on she obtained her BSc degree in Natural Resource Economics and Management (NREM) Mekelle University 2007. After graduation, she was employed in Office of Agriculture and Rural Development (OoARD) Wukro district Eastern zone of Tigray as an expert for three years.

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