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Study on identification and establishment

floral calendar of honey plants

in Atakilty Kebele, Tigray**,** Ethiopia

BY

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Abstract

Identification of nectar and pollen source and the establishment of flowering calendar are important steps in beekeeping development program. Plants were collected using the herbarium techniques and honey pollen analysis was carried out following the methods adopted by Erdtman (1969) and Louveaux (1978). Both botanical collection of pollen and analysis of honey indicated that 39 plant species as nectar and pollen source plants in the area. Pollen analysis showed that ***Aloe berhana***, ***Bidens pachyloma, Cparis erythrocarpus*** and ***Justicia shimperina*** are the major honeybee source plants. Pollen analysis of honey also showed that ***Pterolobium stelatum, Hypostes forskaolii, Acacia abyssinica, Zeziphes mucronata, Senna occidentalis, Olea europeae and Trifolium*** species are minor pollen sources in the area. The result of the respondent farmers, Woreda experts, and Kebele development agents also indicated that 16 honeybee plants were commonly identified as pollen source plants for honeybees. Some of the honey plants identified by the respondents are similar with the honey plants identified through pollen analysis from honey samples. From analysis interview it was possible to identify one flowering season and one honey-harvesting season in the area. The major honey-harvesting season begins from October to December and this is because most areas of the locality are covered by with herbaceous flora of weeds cultivated crops forest trees and shrubs. The trees, herbs and shrubs play major role for honey production and therefore beekeeping should be integrated with the vegetation conservation for livelihood improvement and food security.

1.0.Introduction

The bees of world importance in beekeeping and the basis of the world's beekeeping industry are races and strains of the honeybee ***Apis mellifera.*** Honeybee colony normally has one queen, thousands of workers and hundreds of drones (Seely, 1985, Winston, 1987). Honeybees are dependent on flowering plants because plants provide bees with food in the form of nectar and pollen. Nectar and pollen are primary reward to insect pollinators in general, and to honeybees in particular. As honeybees require large quantities of nectar and pollen at particular time, they utilize particular species of plants for a limited period of time. During the flowering period, there is a considerable movement by honeybees between plants of the same species. This in turn favors the successful cross-pollination of plants (Percival, 1965, Faegeri ***et al***., 1979 and Free, 1970). Not all plant species are however equally good for beekeeping. Some supply both nectar and pollen abundantly when in the bloom and others still provide nectar or pollens for their brood rearing (Free, 1970).

Ideally, a good beekeeping area is the one in which nectar and pollen plants grow abundantly and with a relatively long blooming season. Such areas are however not always available or easy to fined. Beekeepers must know the time and duration of the blooming season of every major honey plant including the environmental factors affecting them and carrying capacity of the area, which includes, the number of colonies that can be put for maximum production (Rajan, 1980). Production of honey and other products depend on availability of floral resources (bee forage) and is a very important field for most beekeepers in the world (Rucker ***et al***., 2002). Most of the methods for

obtaining information about plants utilized in an area are based on direct field observations of foraging honeybees on flowers. The analysis of bee plants, pollen loads and melissopalynological analysis of honey sample (Hepburn and Radloff, 1995) can give a true picture of the honeybee flora of the area (Admasu ***et al***., 2006).

Ethiopia is endowed with various climatic conditions, topography and a wide range of altitude favoring the presence of different natural vegetations that include forests, bushes, herbs, weeds and undergrowth. The flowering plants known in Ethiopia are between 6 and 7 thousand species (Edwards, 1976). The presence of this natural vegetation made the country the best home for honeybees. The forests and woodlands contain diverse species that provide surplus nectar and pollen to foraging bees (Ayalew, 1990). Beekeeping has been and still is widely spread, economically important and integral part of the life of the farming communities of Ethiopia (Verma, 1990, Fichtl and Admasu, 1994). There are an estimated 10 million bee colonies out of which farmers keep about seven million in traditional and modern hives, that the remaining exists in forests and cervices (EMA, 1981) and this represents the highest bee density in Africa. Apiculture is one of the options that help to promote forest conservation and improve crop yield because of cross-pollination services rendered by honeybees (Adjare, 1990, Fichtl and Admasu, 1994). The income supplement at local level from apiculture is also very significant (Ayalew, 1990). In rural areas, any source of food or income that does not need land is potentially important. Apiculture is such an undertaking because beehives occupy minimal space and they can be placed on wastelands. So in relation to agriculture small holders or even landless peasants can do beekeeping. Besides these,

beekeeping does not compete with other branches of agriculture for resources because bees collect pollen and nectar from wild and cultivated plants to make honey and such resources would be important if honey bee hive colonies are established to forage on them (Drescher and Crane, 1982).

Since the practice of modern beekeeping is relatively new in Ethiopia, the compilation of economic bee forages and the identification of areas suitable for beekeeping are still far from complete (Hussien, 2000). Since bees need food all year round, it is clear that they will produce more honey and consume less if they can find natural food most of the time (FAO, 1986). Calendar of flowering plants that have good nectar and pollen sources is a first step towards increasing honey yields. The flowering sequence of honey plants can be anticipated and so hives can be moved to exploit nectar flow. Those plants, which yield nectar or pollen through out the year, can be identified and more of them can be grown to over come dearth periods shown in the calendar (Marden and Kiew, 1984). Land holding of arable land is estimated to be 0.4 hectares to 0.9 hectares per household in Tigray. Since this land holding is not sufficient for realizing food security; developing technologies such as proper beekeeping would play an important role in income generation. In this case, the identification of the important honey bee plants in the development of bee keeping has positive impact. This in turn requires the proper identification of honey bee plants and establishment of floral calendar. This study is thus expected to contribute towards the development of beekeeping, there by contributing to the overall improvement in food security.

Objectives of the study

Major Objectives

To identify plants (shrubs, herbs, weeds and trees) foraged by honeybees and establish floral calendar of the plants in the study area.

Specific Objectives

-To identify the varieties of the plants foraged by honeybees

-To document their sequence of flowering.

-To identify the main flowering and dry seasons and plants utilized by bees during the respective seasons

2.0. Literature Review

2. 1. Honeybee Biology

Understanding of the basic honeybee biology is one of the most important requisites for success in beekeeping. ***Apis cerane*** and ***Apis mellifra*** the fact that they have been kept by man for thousands of years still retain all their natural biological characteristics. Compared with other farm animals, honeybees have not been yet truly domesticated, in that there life history, social organization, behavior, physio-ecological characteristics and genetic composition have not been significantly altered by man (Attfield, 1991).

The honeybees of today are very much like their predecessors of millions of years ago. They live in a tightly - knit social organization in which each individual member of each caste and sex plays a specific role in the survival of the colony and thus improves the chances of perpetuating of the species. An individual honeybee cannot long survive when it is separated from its colony (Crane, 1990).

Anthropomorphically, honeybees may appear to possess social intelligence and a reasoning mind and such misconception often leads to colony mismanagement .The fascinating social behavior of honeybee is uniquely the result of millions of years of evolution through natural selection. Bees behave or react to environmental stimuli in fairly predictable manner. Most of what they do and how they do it is an essence

genetically programmed and only through their proper techniques of manipulation can beekeepers put the colonies to work (Walter, 1976).

2.1.1. Colony Members

Every honeybee colony is a family consisting a single fertile female, the queen that is the mother of the colony, a large number of (ranging from several thousand to tens of thousands) of infertile females (the workers) and at certain time of the year, several male drones taken together. These three categories are referred as castes (Crane, 1990)

2.1.1.1.**The Queen**

Being the sole member of the female reproductive cast, the queen is indispensable for the survival of the colony. A mated queen serves the colony in to essential functions laying fertilized and unfertilized eggs and secreting substances known as pheromones, required for the stability of the colony's social order (Vivian, 1986).

Within a few days of having mated in mid - air with about ten drones, the queen begins to lay eggs and continues to do so until she is physiologically exhausted. The larva of female bees (queens and workers) hatch from the fertilized eggs while the unfertilized eggs yield drone larva. Factors determining whether fertilized or unfertilized eggs are to be laid include the size of the cells in the comb and the mechanism under lying the functioning of the queen's reproductive organs. During the mating process, the queen

stores sperm from the drones in storage organ, the spermatheca within her abdomen. By controlling the opening and closing of the spermatheca, the queen can allow sperm cells to fertilize her egg's or prevent them from doing so. The fertilized eggs are deposited in small workers cells, while the unfertilized eggs are laid in the larger drone cells. The queen can determine cell size and cleanliness by passing her head into the cell and using her front legs to measure its internal width (Winston, 1987).

Healthy, sufficiently mated ***Apis mellifera*** queens can lay as many as 1,500 - 2000 eggs a day provided that the colony is strong, that there is sufficient empty comb space to accumulate the eggs. The workers partially control the queen's egg lying by regulating the amount of food fed to the queen and by their preparation of empty cells and also by cannibalize the eggs when a food shortage occurs (Delaplane, 1993).

Worker bees recognize their queen not by her physical structure, but by her scent given off through the pheromones she secretes. These pheromones consist of about 30 organic compounds and have both direct and indirect effects on the colony's social behaviors. During the nuptial flight, they serve as sex attractants drawing the drones to the queen. Inside the hive, they assist in stabilizing the colony .The workers are aware of the queen's whereabouts by the presence or absence of pheromones. In ***Apis mellifera*** colonies, some workers act as "messengers " in distributing the pheromones they obtain from direct contact with the queen to other workers within the hive. Under certain circumstances, the presence of pheromones within the hives will inhibit the construction of queen's cells. They also inhibit the development of the workers ovaries,

and during swarming they exercise a direct influence on swarm stabilization (Crane, 1990).

Pheromone communication within the colony constitutes one of the most important components of the social life of all honeybee species. Since older queens secrete less pheromones as well as lay less eggs than queens in their primarily age, and although a queen can live for several years before being supersseded by young one, professional beekeepers often requeen their colony every one or two years in order to always have queens at their maximum biological efficiency.

2.1.1.**2.The Drones**

The drones are the male members of the honeybee society reared by the colony shortly before the swarming season begins. Several hundred drones may be reared by the colony emerging from unfertilized eggs the queen lays in larger broad cells. In queenless colonies workers whose ovaries have developed as a result of the lack of inhibiting actions by the queens pheromones can also lay eggs, which are unfertilized, because the worker is unmated, they also yield drones (Winston, 1987)

Drones possess no food gathering apparatus. Their sole biological function is to mate the queen. During the mating season, they are well fed by the workers before taking flight. A drone may make from 4-6 flights a day, but a smaller number is not uncommon. Drones from neighboring colonies all fly to a place known as the “drone congregation

area" where mating takes place. To ensure successful mating, several hundreds of drones must be in the area, although a queen mates with only about ten. The drones die shortly after copulation. When the mating season is nearing its end the colony reduces its drone rearing and when the season is over, the drones remaining in the hive gradually die of old age, negligence by the worker bees or starvation or simply be expelled from the hive (Crane, 1990).

2.1.1.3. The Workers

The workers are an infertile caste of female bees developed from fertilized eggs. Their physiological and anatomical features perform virtually all kinds of chores except reproduction to increase the chances of the colonies survival suit them. Factors determining the type of task to be executed by a worker include its physiological and anatomical state of readiness and environmental stimuli, as well as the requirements of the colony to have a particular job done at particular time (Winston, 1987).

Soon after emerging from its cell, a young worker receives food in the form of either nectar or honey from mature workers, and also helps self to honey and pollen found in the colony storage cells. In the first few days the worker, it is too weak to do anything except inspect and clean empty cells in preparation for food storage by the colony or egg lying by the queen. During this period, the worker consumes a relatively large amount of honey and pollen and this directly affects the development of the hypo-pharyngeal and wax glands (Crane, 1990).

That of all ages in queen cells receiving large quantities of food is referred to as “royal jelly” develops as queens. Larvae in worker and drone cells receive this special diet only during the first days after hatching. During their later larval life they are fed on mixtures of honey and pollen (Walter, 1976). Under normal conditions, a worker bee is physiologically exhausted from the task of secreting royal jelly and wax when she reaches the age of about 14-18 days. A few days after this period are spent packing pollen in storage cells, the mouth-to-mouth retrieval of nectar from returning foragers and occasionally guarding the hive entrance. When she is about 3 weeks old, it ceases to be a house bee and become field bee. At this stage after orientation flights, she collects nectar, pollen, water and propolis and carries them back to the hive until she dies. On the other hand, during a heavy honey flow season younger workers can easily be recruited for foraging as field bees to increase the colonies food gathering capacity (Vivian, 1986)

2 .1. 2. Foraging and bee products

Under normal conditions worker bees begin to forage when they are about 2 –3 weeks old. Foraging is the last chore in the life of a worker. Once it has begun foraging, it continuous this activity for the rest of her life. Foragers are sometimes called “field bees”(Delaplane, 1993). Part of the colony’s stored honey is invested in foraging activity. Before taking off on a flight a field bee consumes certain amount of honey to ensure that she will have a sufficient energy supply for her round trip journey .To obtain a full load of nectar and or pollen in a single trip, she may have to visit several hundred flowers. The

amount of energy she expends related to the amount of food she collects is determined largely by such factors as the species of forage. Floral density per unit area the distance from the hive and weather conditions. Despite options to the contrary, flight productivity does not necessary depend on the capability of the workers bee or of her race.

In collecting of nectar and pollen, there is no specialization or division of labor among foragers. There are however both quantitative and qualitative differences among flowering plant species as regards nectar and pollen production. Not all plant species possess nectars (Waikato, 1995). A forager may appear to prefer to the nectar of one flower species to another. This is because it is to its advantage to visit flowers producing greater quantities of nectar with higher concentration of sugar. If high quality of nectar is available, a forager bee of ***Apis melllifera*** can carry as much as 70-80 Mg of nectar per load (Graham, 1992).

Workers of all honeybee species carry nectar internally in honey-sac .The entire body of a worker bee particularly the thorax is densely covered with fine-branched hairs on which pollen grains are caught when the bee workers visit flowers. Sometimes she uses her mandibles to chew off anthers or deliberately roles over anthers to acquire the pollen. The tibia of the bee's hind legs are equipped with rows of short setae, which are used to scrape the pollen from the body and to form it into pellets .The pellets attached to pollen baskets on the bees rear tibia are carried back to the hives, where the load is deposited by itself in pollen storage cells. In addition to collecting nectar and pollen as

the colony's food, field bees collect plant gum (propolis), water and hive products (Crane, 1983).

Honey

Honey is a well-recognized item in many areas of the world. Honey as found in the hive is a mixture of various kinds of sugar with water. It is flavored by floral essences and contains traces of various minerals, nitrogenous substances and an enzyme. This honey differs from the nectar of the flower from which it is derived. It has reduced water content and transformed to sugar (Walter, 1976).

Bees fed almost entirely on nectar and pollen obtained from the blooming flowers and honey comes from the flower nectar. It is probable that honey taken from a hive is never composed absolutely of one kind of flower nectar. Honeybees collect nectar from a divers range of plants. Not all plants contribute to the production of honey, but are important for the well being of the colony. Robinson and Oertel (1975) listed about 200 important nectar and pollen plants. They also indicated the regions in North America in which these plants are found. Some of the plants regarded as a major source are alfalfa, clovers, cotton, firewood, sour wood, gall berry, goldenrod sage saw palmetto, soya beans, Spanish needles, and tupelo.

Bee Wax

Bee wax is a true secretion produced by four glands on the bottom of the abdomen of worker bees. Bee wax is a chemically complex mixture, consisting of primarily of long chain hydrocarbons, monohydric alcohols, organic and hydroxy acids and diols. There is a huge demand for bee wax in the wax industry. Wax foundation is a sheet of wax that is pressed between metal dies so it comes embossed on both sides with the cell pattern bees follows in constructing cell sized for raising workers .The foundation is expensive, therefore beekeepers should save all capping, old combs, and bits and piece of extra wax scraped from frames and other bee hive parts. These should be stored in airtight containers or frozen to prevent infestation by wax moths. The wax can be melted down to trade for wax foundation. Old combs contain non-wax substances and there fore should not be melted with the almost pure wax capping (Crane, 1990).

There are many other products other than honey that are derived from a beehive. The principal among them are propolis, pollen, bee brood, royal jelly and bee venom (Walter, 1976).

Propolis

Propolis is the resinous substance that is used by the bees to seal ups the hive for winter protection and defense. It comes from the sticky exudates of trees and buds such

as alders, poplars, and some conifers. Propolis is sold in capsules at health food stores as a health supplement (Crane, 1990).

Bee Brood

Bee brood is rich in proteins Honeybee brood is not however used much in our diet though it is used on a small scale as food for birds, reptiles, and fish (Graham, 1992).

Pollen

Pollen is the protein –rich powder produced by the male parts of flowers. Placing pollen traps on the hives to collect pollen pellets from foraging bees collects pollen. Pollen can be sold to health food stores, pollination business, bee dealers and to allergy victims. Health food stores sell pollen pellets as vitamin supplement, bee dealers use pollen as bee food and allergy victims use it as desensitizing agent (Graham, 1992)

Royal jelly

Royal jelly is manufactured by young nurse bees to be fed to the queens and queens larvae. It is collected and used in the oriental world for medicinal purposes. The uses include cosmetics, lotions, and dietary supplements (Crane, 1990).

Bee Venom

Some components of the bee venom might have more effect than other serums in desensitizing people who are allergic to be venom. It might also be useful for persons with rheumatoid arthritis (Walter, 1976).

2.1. 3. Medicinal properties

Honey has been acclaimed since time immemorial as remedy for sore throat. It is also known for its nutritive value. Honey passes directly into the system without aid for digestive juices. It contains minute quantities of valuable minerals essential for the proper functioning of secretions. Honey with lemon and tea is useful in liver disorders and for complexion blemishes. Added to an infusion of yarrow, honey is used for influenza and as nutrient tonic. Taken with milk it is useful in cases of stomach ulcers and anemia. Glycerin and honey in equal parts is good for bruises, chafing and chaps on face and hands. The combination is also used as a cure for chilblains (Crane, 1990)

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2.2. Floral Calendars

A floral calendar for beekeeping is a timetable that indicates to the beekeeper the approximate date and duration of the flowering periods of the important honey and pollen plants in an area. The floral calendar is one of the most useful tools of the apicultural extension worker. It enables him to inform the beekeepers on what to expect

from bee forage availability so that they can manage their colonies in most rational manner. The experienced beekeeper will have acquired much of this information over the years, but published charts are also available in many areas. Beekeeping in any specific area cannot be developed without an understanding of the calendars for the different foraging zones (Smith, 1960).

Assembling a floral calendar for a specific area is simple but time consuming. It requires complete observation of the seasonal changes in the vegetation patterns and or agro-ecosystem of the area, the foraging behavior of the bees, and the manner in which the honeybee colonies interact with their floral environment (Husien, 1992). The accuracy of a floral calendar and hence its practical value depend solely on the careful recording of the beginning and end of the flowering season of the plants and how they affect the bees. The preparation of an accurate, detailed calendar therefore often acquires several years of repeated recording refinement of the information obtained (FAO, 1986).

The steps normally taken in building up floral calendars are as follows:

1. The beekeeper makes a general survey of the area, drawing up a list of flowering plants. Special attention is paid to plants with high floral population density per unit area or per tree.
2. Placing several strong honeybee colonies in the area, inspecting the hives regularly and observing changes in the amount of food stored within the hive to determine whether it is depleted, stable or increasing. Any food gains or losses can be monitored accurately by weighing the hives.

3. At the same time monitoring the hives food stores, surveys areas in the vicinity of the apiary and within the flight range of the bees to record the species of the plants that the bees visit.

4. By studying the frequency with which the bees visit each flower species in relation to changes in the level of the colony's food stores, if there is a continuous increase in food stores in direct response to the availability of plants visited, then the plants are assumed as good forage sources. When the food stores remain stable the plants can meet the colonies daily food requirements, but they cannot be classified as major honey sources.

5. Carefully recording all changes in the blossoming of the plants visited. When colonies begin to loss weight, the flowering season is over for all practical purposes. Once all the data on forage species have been assembled and repeatedly verified they should be judged as they relate to the actual performance of the honeybee colonies. Then the calendar can be drawn up in the form of circular or linear charts showing the weekly or monthly availability of each plant and their flowering sequence (Adjare, 1990).

2.3. Assessment areas for beekeeping

Productive beekeeping depends on good colony management and good beekeeping areas. In order to promote its profitability, agricultural areas with a good plant potential for beekeeping must be selected or available. For instance, Asia is rich in places inhabited by feral swarms of native honeybees and this fact inspires premature judgments to the effects that beekeeping can be promoted almost anywhere in the continent, where native bees are found (Donovan, 1980)

The truth however is that most feral colony of Asian honeybees are adapted to a migratory strategy moving with the seasons and the availability of forage. Thus, the temporary presence of a few feral swarms of honeybees here and there for short periods of time does not necessarily indicate that there is enough forage in the areas to support year round commercial beekeeping (FAO, 1986).

As in the assembling of floral calendar, weighing the hives is one of the most accurate ways of assessing the suitability and supporting capacity of an area. One major problem in this respect is how to select sites for assessment. The following guidelines for the exploration and evaluation of potential beekeeping areas may be found useful (Bardbear, 2004).

1. Referring to lists of known major honey plants in other countries or regions with similar vegetation patterns, agro-ecosystems, climate and edaphical factors or conditions determine whether similar plants are to be found in the area under study.
2. The seasonal occurrence of usually high number of feral nests of native honeybees can often indicate that there is ample forage in the area at least during the period in question.
3. The mere presence of flowering trees and shrubs in limited numbers or of few hectares of land covered with good honey plants preferred by bees does not necessarily indicate that the area has potential for commercial beekeeping.
4. Practical large-scale beekeeping operations call for large areas, usually hundreds or thousands of hectares of land bearing forage with higher population densities,

vegetation, water, and presence of bees and good weather. Good honeybee plants are characterized by relatively long blossoming periods, generally in terms of several weeks, months and high densities of nectar secreting flowers per plant or unit area, good nectar quality with high sugar concentration and good accessibility of the nectars to the bees. The foraging land should be well proportioned in terms of length and width so as to promote foraging efficiency (Ayers, 1992).

5. The supporting capacity of an area for honey production is best determined by monitoring weight changes in the bee colonies among other factors that affect the economic value.

6. The fact that a flower is brightly colored or that it is a strong scent does not always indicate that it is good for bees, unless the fact is confirmed by criteria indicated above.

7. The large-scale planting of honeybee forages has never been proved to be a profitable approach in terms of net economic return, except in integration with other agricultural activities, such as reforestation, roadside-planting, annual pastures etc. (Drescher, 1982).

2.4. Pollination and bee flora

It is generally known that bees are needed to pollinate our crops. It is not however apparent to many that the economic value of bee pollination is several times more than the value of the worldwide production of honey. About 80 percent of our food animal pollinators pollinate crops and these are mainly bees. It is estimated that one-third of what we eat and drink is produced through service supplied by pollinators. Now days,

we learn more about the role of bees as pollinators. They appear not only to be extremely important for traditionally grown and known crops, but also essential for economically promising tropical and less common crops. It is important to know pollination and bee flora to obtain more knowledge about bee pollinator essentials to improve the production of traditional crops and those crops that after important perspectives (Amsalu, ***et al***., 2003).

The great majority of angiosperm plants depend on animals for their pollination. Of these animals that visit plants and responsible for the spread of the pollen, the majority belongs to the insects, and the most important are the bees. This is attributed largely to their morphological and behavioral adaptations for the collection of pollen. The reason that in particular social bees are so important as flower visitors and pollinators, is based on the existence of their long living colonies (Donovan, 1980).

In order to survive, a typical bee colony needs to exploit a range of food sources at any time of the year. No single food source will be available through out the year, therefore the relatively short lived foraging honeybees do not have genetically determined flower preference, as the case is true for many solitary bees species. Instead individual honeybees develop their own foraging specialization in the field, following the local and temporal availability of the various flowers and other information obtained (Dugan, 1984).

Colony-living bees visit many different plants and this is also the background of the fact to visit even non-native crops and ornamentals to easily manipulate them. Honeybees are generalists (polycentric) at colony level, but to large extent flower specialists (flower constant) at individual level (Donovan, 1980). Certain groups of bees are able to perform specialized pollen collecting behavior, for example buzz- pollination. In the large range of Angiosperm families, pollen can only be released when vibrating bees shake the stamens. Resulting from the available managing technology and the actual pollination value, the honeybee (***Apis melifera***) is considered the most significant tool for seed production (Ayers, 1992).

Production of honey and of other products depends on availability of floral resources (bee flora). This is very important field for most beekeepers in the world. Pollination and bee flora works on the information related to the status of pollen and nectar resources. This includes the obtaining of knowledge concerning special characteristics of honey types from certain regions. It is important to document information on the relative importance of bee food plants and honey producing plants in the different countries (Oneal, 1984)

In principle, all bees feed on pollen and nectar. The honeybee ***Apis melifera*** is known to bring large amounts of pollen and nectar to the nest. The thousands of individuals of honeybee colonies have to collect and store the food in the way that is efficient and effective for the colony. Certain phenomena of the bee behavior are important for foraging strategy of bees. Typical communication systems of honey bees including the

so called bee- dances are developed for the efficient exploitation of the various food plant resources in the environment (Walter, 1976).

At the same time, flower constancy and other bee food plant related behaviors contribute to the dynamic decision making by the colony. Knowledge about when colonies need to switch to new food sources and other behavioral backgrounds specially of bee foraging is important for the practice of commercial beekeeping for honey production and pollination (Winstone, 1987).

In addition to the direct economic importance for agricultural pollination, bees play an essential role as the major pollinator of natural eco-systems. Again the honeybees and in certain areas other species of social bees, do take care of large proportion of the pollination in natural ecosystems. Honey bees are very efficient general pollinators of the natural flora through their numbers and special behavioral features that is highly developed communication and recruitment behavior and their need to store large amounts of food in the nest, they are often more effective than other insect pollinators (Admasu and Nuru, 1999).

The role of honeybees as pollinators of the natural flora is now more than investigated. Conservation and the sustainable management of natural ecosystems should pay attention to the position of pollinating bees that are present in this environment (Smith, 1960).

2.5. BEE KEEPING

Beekeeping is one of the oldest agricultural activities. From the very earliest times, man has been associated with honeybees. Beekeepers have used hives and harvested honey from at least 4550 years (Crane, 1990). Beekeeping evolved long before the true importance and significance of bees were understood and appreciated (Walter, 1976). The honeybee is well distributed over the globe except in the severe cold of the Polar Regions. Africa is blessed with numerous wild honeybees.

2.5.1.BEEKEEPING IN ETHIOPIA

Beekeeping as a component of agriculture has a long history in Ethiopia, most probably prior to all other countries in the world (Fichtl and Admasu, 1994). Studies indicates that 21,000 tones of honey and 2,100 tones of bee wax is produced yearly, which place the country first in Africa and tenth in the world in honey production and fourth from the world in wax exporting and production (FAO, 1995).

Owing to its varied ecological and climatic conditions, Ethiopia is home to some of the most diverse flora and fauna in Africa. Its forests and woodlands contain diverse plant species that provide surplus nectar and pollen to foraging bees (Fichlt and Adi, 1994). Wide climatic and edaphically variability have endowed it with diverse and unique flowering plants, thus making it highly suitable for sustaining a large number of bee colonies and the long established practice of beekeeping. Nevertheless, the bees and

the plants they depend on, like all renewable natural resources are constantly under threat from lack of knowledge and appreciation of these endowments (Fichlt and Admasu, 1994).

There is an ancient tradition for beekeeping in Ethiopia, which stretches back into the millennia of the country's early history. It is an important activity for many rural people - both men and women and is also carried out in home gardens and even houses in all parts of the country (Pol, 2002).

In Ethiopia, for some, beekeeping and the collection and selling of honey and other bee products are a major activity. The density of hives on the land may be the highest at the present moment of any country in the African continent. There are an estimated 10 million bee colonies out of which about 7.5 million are confined in hives and the remaining exist in the forest and cervices .In Western parts of Ethiopia, there are beekeepers who own up to thousand bee colonies. They do not count the numbers of hives any more, but only the number of trees on which the hives are hanging (Amsalu ***et al***., 2003).

The Total estimated honey production of Ethiopia as indicated by the International Trade Center (ITC) in 1986 ranged from 19,400-21,000 tones per annum between the years 1976 –1983. This contributed 23.28 percent to the total African production and 2.03 percent to the total world production in 1976. This went up to 23.58 percent and 2 .13 percent for the total African and world honey production, respectively in the year 1983.

Further more, there has been an increased production of honey over the period 1984-1994, that are from 21,480 tones in 1984 to 23,700 tones in 1994 (FAO, 1995). The current honey production is estimated to be about 24,000 tones per year. The estimate is based on a 65 % and 75% occupational efficiency of 7.5 million traditional hives and 20,000 framed hives, respectively (CSA, 1997, Pol, 2002).

Another valuable hive product obtained from honeybee is bee's wax. It is largely collected from traditional hives rather than the movable framed hives. The annual production of wax is estimated at 3, 200 tones. Thus after China, Mexico and Turkey, Ethiopia is the fourth largest wax producing country with an estimated 3,000 tones per annum (Fichlt and Admasu, 1994).

Honey is almost exclusively used for local consumption to a large extent for brewing mead, while a considerable proportion of wax is exported (Ayalew, 2004). The principal resource base for beekeeping has however become seriously degraded in the course of time. The potential of the Ethiopian landscape for honey and wax production does now undoubtedly only constitutes a small fraction of its farmer wealth. Moreover, the destruction of the remaining resource base can be observed going on a steadily accelerating pace (Poschen, 1987, Azene, 1993).

This unfortunate development is being checked and even reversed in some areas by the active planting of nectar yielding vegetation. The large Eucalyptus plantation that have grown up in some localities constitute anew and compensatory honey resource (Sara,

2002). In many places, the beekeepers themselves have understood to redress the situation by planting good honey plants near their hive colonies, such as Vernonia amygadalina, Salivia species. Despite such local improvements which in some places are spectacular the national beekeeping resource base at country level as a whole is deteriorating unless some major changes are introduced about in general land use systems (Sara, 2002).

In Ethiopia, there are three recognized systems of honey collection or beekeeping, as described below:

1. **Traditional Beekeeping**

Traditional hives are placed high in trees around dwellings in order to attract the bees during harvest time. The container is lowered and the bees killed usually by fire and the hive products taken (inefficient system), a common practice particularly in southern Ethiopia (Fichtl and Admasu, 1994)

It is estimated that there are about 130,710 traditional beehives in Tigray from the 3.5 million traditional beehives in Ethiopia. Thus, Tigray has about 5% of the total estimated number of beehives in Ethiopia (CSA, 1997).

2. Intermediate Beekeeping

This involves low cost traditional technology often using mud top bar hives. Management of these hives is much easier and allows the hive products to be harvested more efficient (Edesa, 2005).

3. **Framed Hive Beekeeping**

This is the most intensive system, which needs comparatively expensive inputs and relatively skilled manpower to manage the colonies successfully. The hives can generate greater quantities of better quality honey, which will command higher prices (Fichtl and Admasu, 1994). The amount of honey produced per hive is very variable. Thus, for traditional hives the average amount of honey produced is approximately 10Kg per hive, while framed hives yield an average of 20Kg/ per hive (EPA, 2003).

3.0. MATERIALS AND METHODS

3.1. Study area

The study was carried out for six months in Atakilty kebele, Kola Tembien Woreda Tigray region Northern Ethiopia located at an altitude of between 1600-2000 masl. The study area includes four villages known as Salka, Wotek, Teamina and Kiazba. The area was selected because of the presence of better-cultivated crops; natural vegetation, climate and bee hive population.

The people's livelihood is entirely dependent on agriculture, of which beekeeping has its own important share supporting food security and cash income earnings. The cultivated land in the Kebele is estimated to be only 919 hectares and the protected vegetation area is 716.8 hectares while the uncultivated area is 1100 hectars. The population of the Kebele is 7402. There are about 600 beehives in the Kebele. Among these 554 hives are traditional and 46 of them are modern beehives

3.2. Interviews on honeybee plants

Information about honeybee plants was collected from 20 local beekeeping farmers, 1 Woreda honeybee expert, and 2 Kebele honeybees' development agents using pre-structured questionnaires (Appendix 3). The farmers were selected randomly among the farmers that do beekeeping. The expert and the development agents are responsible for

the development of beekeeping. The plants were categorized simply from the information obtained from the respondents based on their experiences. The purpose of asking the respondents is to obtain information about the honey plants expected to be found in the study area.

3.3.Plant collection and field observation

A general survey of the area and listing of the flowering plants and the collection of the plants found were conducted for a period of six months from October to March. The bee forage field observations were made on different kinds of plants, which are visited by bees in the study area.

From the study area, the plant samples were collected with necessary botanical features like leaves, flowers and portion of the stem. The plants were pressed using plant press and identified at the National Herbarium of AAU.

3.4. Preparation of reference slides for identification of pollen grains

A complete knowledge of the pollen of the local flora is essential that a reference collection of the main pollen found in the local area was assembled. This helps to identify the features of the pollen found as single pollen grains in the honey.

Flower buds were also collected and their pollen grains were mounted on slides and used as a reference for identification of pollen grains in honey samples from the study area. Flower samples were kept in individual paper envelopes to avoid contamination with pollen grains from other sources. Reference slides were prepared by acetolysis method (Erdtman, 1969). The ripe pollen grains were shaken directly on to microscopic slides. The fat content was washed out using ether and glycerin jelly to enhance the transparency of pollen grains and the slides were then covered with cover slip and examined under microscope using 400x magnification.

3.5. Extraction of pollen from honey samples

Pollen analysis was carried out using Louveaux et al., (1978) .For the identification of the pollen spectrum in the honey, a total of twenty honey samples of from different traditional beehives (five honey samples from each village) were collected from farm of individual beekeepers during the honey harvesting periods. The honey samples harvested on October- December were used for analysis.

From each honey sample, 10 gm of honey was dissolved in 30 mm distilled water and the solution centrifuged for about 10 minutes at 2500-3000 rpm. After decanting the supernatant, the remaining residue was diluted again with 10 mm of water. After centrifuging for further 5 minutes at 2500-3000 rpm, the sediment was transferred on to a microscope for observation. Then glycerin jelly was added to make the pollen grains

clear. After that, the pollen grains were examined under a microscope with a 400x magnification power.

Pollen grains examined and identified were counted under 10 fields under the microscope. Percentage occurrence of pollen was used to determine their frequencies following the system adopted by Louveax ***et al. (***1978) for determining the major and minor honey bee plants.

4.0. RESULTS

4.1. Honeybee plants identified as major honey sources by respondent individual local farmers.

As the respondents were asked to list up honey bee plants in their order of importance for honeybees in the area, 19 flowering plants were identified as the major honeybee plants in Kebelle Atakilty (Table 1).

Table 1:Major honeybee plants as identified by the farmers

Nº	Scientific name of plant	Vernacular name in Tigrigna	Number of respondents.
1	*Cordia africana*	Awhi	20
2	*Zeziphes mucronata*	Giba	20
3	*Maytens senegalenisis*	Qebqeb	20
4	*Bidens pachyloma*	Gelgelemeskel	20
5	*Croton macrostachys*	Tambuch	20
6	*Maruae angolensis*	Koromo	15
7	*Euphorbia candelabrum*	Qulqwal	16
8	*Caparis angustifolia*	Kermed	18
9	Eucalyptus spp	Bahr-zaf	15
10	*Guizotia abyssinica*	Nihug	18
11	Anthum graveolens	Shilan	18
12	*Zea mays*	Meshelabahri	20
13	Ocimum basilicum	Seseg	19
14	*Echinops hispidus*	Dandier	18

15	*Shinus molle*	Tiqurberbere	20
16	*Aloe berhana*	Ire	20
17	*Vicia faba*	Alqway	20
18	Caparis erythrocarpus	Andel	20
19	Ricinus commnies	Guli	20

4.2. Honeybee plants identified as secondary honey sources by respondent farmers

Based on the questionnaires provided the farmers identified 11 flowering plants as secondary source of food plants for honeybees in the area simply by counting the results of the answers given by the farmers according the questionnaire (Table 2).

Table 2. Secondary honeybee plants as identified by the farmers

Nº	Scientific name of plants	Vernacular name in Tigrigna	No of respondents
1	***Acacia etibica***	Seraw	20
2	***Calpurina aurea***	Hitsawtsi	18
3	***Albizia spp.***	Hambahambo	17
4	***Crotolaria spp***	Meratsenteli	16
5	***Olea europeae***	Auli	20
6	***Dodnia angustifolia***	Tahses	15
7	***Acacia albida***	Momona	17

8	***Acacia polycntha***	Gwmero	20
9	***Balannites aegyptica***	Meqi	16
10	***Budlegia polystachya***	Mettere	18
11	***Acacia siberinna***	Che'a	14

4.3. Honey bee plants identified as minor honey sources by individual farmers.

The respondent farmers indicated 5 different types of flowering plants as minor source of bee plants or are not preferred by honeybees (Table 3)

Table 3: Minor honeybee plants as identified by farmers

No	Scientific Name of plants	Vernacular name in Tigrigna	Number of respondents
1	***Azadirachta indica***	Neem	20
2	***Agave sisalna***	Eqa	18
3	***Eragrostis teff***	Teff	20
4	***Trticum sativum***	Sirnay	20
5	***Hordeam vulgare***	Segem	20

4.4. Honeybee plants identified as major honey sources by Woreda and Kebele development agents

Based on the information provided by the Woreda and Kebelle honeybee developmental agents18 flowering plants were identified as major honeybee plants (Table 4).

Table 4. Flowering plants identified as major honeybee plants by Woreda and Kebele developmental services

No	Scientific Name of plant	Vernacular name in Tigrigna
1	***Croton macrostachya***	Tambuch
2	***Cordia africana***	Awhi
3	***Agave sisalanna***	Eqa
4	***Zeziphes mucronata***	Giba
5	***Schinus molle***	Tiqurberbere
6	***Bidens pachyloma***	Gelgelemeskel
7	***Sorghum bicolar***	Meshela
8	***Guizota abyssinica***	Nihug
9	***Brasica carinata***	Gurmba
10	***Vicia faba***	Alqway
11	***Aloe berhana***	Ire

12	***Ocimum basilicum***	Seseg
13	***Parkinsonia aculeata***	Shewithagay
14	***Acacia seyal***	Che'a
15	***Ximenia americana***	Ml'o
16	***Dodnia angustifolia***	TAhses
17	***Acacia albida***	Momona
18	***Pisum sativum***	Ayni-ater

4.5. Honeybee plants identified as secondary honey sources by Woreda and Kebele development agents

The woreda and Kebelle honeybee development agents identified 6 different kinds of flowering plants as a secondary honey sources (Table 5).

Table 5: Flowering plants identified as secondary honeybee plants by Woreda and Kebele developmental Agents

No	Scientific name of the plant	Vernacular name in Tigrigna
1	***Acacia polycantha***	Gwmero
2	***Calpurina aureca***	Htsawtsi
3	Albiziae spp	Hambahambo
4	Crotolaria spp	Meratsenteli

5	Olea europea	Auli
6	Cupiscum annum	Berbere

4.6. Honeybee pants Identified by Woreda and Kebele development agents as minor or not preferred by bees

Based on the information provided, the respondents identified three different kinds of flowering plants as minor or not preferred plants by honeybees (Table 6).

Table 6: Flowering plants identified as minor honeybee plants by Woreda and Kebele developmental services

No	Scientific name of the plant	Vernacular name
1	***Eragrostis teff***	Teff
2	***Triticum Sativum***	Sinde
3	***Azadrachta indica***	Nim

Generally based on the information gathered from both individual beekeepers and developmental agents respondent groups ***Cordia africana, Zeziphes mucronata, Capiiscum annum, Bidens pachyloma, Zea mays, Guizotia abyssinica, Vicia faba***, ***Schinus molle***, ***Croton macrostachys, Ocimum basilicum*** were indicated as major honeybee food plants because they are preferred by honey bees.

Calpurina aurea, Albizia species, Olea europaea, ***Acacia polycantha***, were on the other hand leveled as secondary pollen sources for honey bees.

In addition to this ***Azadirachta indica, Eragrostis teff, Hordeam vulgarae and Trticum sativum*** were identified as minor or not preferred by honeybees.

4.7. Honeybee plants identified through pollen analysis from honey samples

On the basis of the analysis of the honey samples from the Salika village pollens ***of Aloe berhana*** with 75.34%, 73.3%, and 65.22% and 54.51% in the four samples and ***Bidens pachyloma with*** 78.76% were identified as the major honey plants for they represent most of the percentage distribution.

In this village ***Justiciaa shimperina*** (16.3%) and ***Cordia africana*** (21.11%) were identified as the secondary pollen source of honeybees. Similarly ***Echinops hispidus, Buddleja polystachya, Nigela sativa, Olea europaea, Hypostes forskolii, Maytenus senegalensis, Pterolobium stellatum and Acacia etibica*** and were identified as minor honey bee plants (Table7).

Table 7: Percentage distribution of pollen of honey plants in honey samples collected from Salika village

No	Species name	Number of pollen in honey samples									
		Sk1		Sk2		Sk3		Sk4		Sk5	
		No	%	No	%	No	%	No	%	No	%
1	***Aloe berhana***	320	75.34	115	73.30	45	65.22	235	54.51	-	-
2	***Pterolobium stellateum***	20	4.6	-	-	-	-	7	1.61	6	4.0
3	***Hypostes forskolii***	4	0.83	7	4.60	6	8.70	2	0.46	2	1.32
4	***Bidens pachyloma***	9	2.11	12	7.70	1	1.45	76	17.13	118	78.75
5	***Justicia shimperina***	68	16.01	-	-	-	-	-	-	-	-
6	***Echinops hispidus***	3	0.6	14	8.90	4	5.79	-	-	1	0.66
7	***Plantago***	-	-	4	2.55	-	-	-	-	-	-
8	***Dodnia angustifolia***	-	-	2	1.28	1	1.45	4	0.92	-	-
9	***Mateynes senegalensis***	-	-	2	1.28	4	5.79	6	1.38	3	1.87
10	***Acacia etebica***	-	-	-	-	7	10.24	-	-	-	-
11	***Caparis erythrocarpus***										
12	***Brasica carinata***	-	-	-	-	-	-	8	1.84	-	-
13	***Rumex nervosus***	-	-	-	-	-		7	1.62	1	0.66
14	***Cordia africana***	-	-	-	-	-	-	91	20.11	-	-
15	***Buddleja polystachya***	-	-	-	-	-	-	-	-	5	3.3
16	***Nigela sativa***	-	-	-	-	-	-	-	-	7	4.65
17	***Olea eurpea***	-	-	-	-	-	-	-	-	7	4.65
18	***Unidentified***	-	-	1	0.63	1	1.45	2	0.46	-	-

Sk= Salika village

No= number of pollen

Analysis of honey sample collected from the Wotek village shows that ***Bidens pachyloma*** was the major honey plants as it contained 53.8%, 48.5%, and 48.14%. 62.5% and 48.23% pollen in five of the honey samples analysis.

Cordia africana and ***Brasica carinata*** were identified as secondary pollen sources in the village as they contained 16-45% of pollen in the honey samples collected.

In addition, ***Lepidgathis lalycina, Ocimum bacilicum, Caparis angustifolia, Trifolium*** species, ***Acacia abyssinica, Rumex nervosus, Hypostes forskolii***, and ***Maytenus senegalensis*** were identified as minor honeybee plants (Table 8).

Table 8: Percentage distribution of pollens of honey plants in the honey samples collected from Wotek village.

	Name of plant	Number of pollen in honey samples									
		Wt1		Wt2		Et3		Wt4		Wt5	
		No	%	No	%	No	%	No	%	No	%
1	*Guizotia scabra*	1	0.5	-	-	-	-	2	0.49	-	-
2	*Lepidgathis lalycina*	6	3.5	6	4.45	-	-	2	0.49	-	-
3	*Bidens pachyloma*	106	53.8	66	48.4	65	48.14	243	59.41	218	48.23
4	*Acacia abyssinica*	8	4.07	3	2.2	-	-	1	0.25	-	-
5	*Acacia pentagona*	32	16.25	24	17.6	22	16.29	-	-	-	-
6	*Ocimum bacilicum*	4	2.03	6	4.81	4	2.98	-	-	32	7.07
7	*Cordia africana*	37	18.8	25	18.27	27	20.0	27	6.61	-	-

8	*Nigela sativa*	1	0.5		-	-	-	-	-	-	-
9	*Zeziphes mucronata*	-	-	3	2.1	-	-	-	-	-	-
10	*Senna occidentalis*	-	-	3	2.1	-	-	-	-	54	11.84
11	*Rumex nervosus*	-	-	-	-	10	7.40	13	3.18	6	1.32
12	*Maytenus senegalensis*	-	-	-	-	5	3.72	24	5.86	-	-
13	*Hypostes forskolii*	-	-	-	-	-	-	7	1.71	19	4.20
14	*Poacea species*	-	-	-	-	1	0.76	2	0.49	4	0.85
15	*Caparis angustifolia*	-	-	-	-	-	-	21	5.13	21	4.55
16	*Brasica carinata*	-	-	-	-	-	-	65	16.38	78	17.25
17	*Trifolium species*	-	-	-	-	-	-	-	-	15	3.31
18	Unidentified	2	1.01	-	-	1	0.76	-	-	5	1.10

Wt= Wotek village

No=number of pollen

According to the analysis of the honey samples collected from the village Teamina, ***Caparis erythrocarpus*** (53.01%) and ***Bidens pachyloma*** (47.47% and 45.19%) were identified as major honey plants as they contained higher proportion of pollen in the analyzed sample .The secondary pollen sources in the village includes ***Senna occidentalis and Hypostes forskolii.*** At the same time ***Brasica carinata, pterolobium stellatum, Acacia abyssinica, Trifolium species, Rumex nervosus, Olea europaea*** and ***Ocimum bacilicum*** were identified as minor honeybee plants (Table 9).

Table 9: Percentage distribution of pollens of honey plants in honey samples collected from Teamina village

NO	Scientific name of plant	Number of pollen in honey samples									
		Tn1		Tn2		Tn3		Tn4		Tn5	
		No	%	No	%	No	%	No	%	No	%
1	*Pterolobium stellatum*	3	3.69	7	7.07	4	2.97	10	7.40	-	-
2	*Rsa abyssinica*	1	1.96	-	-	-	-	-	-	-	
3	*Ocimum Bacilicum*	2	2.59	12	12.12	10	7.4	-	-	11	6.62
4	*Caparis erythrocarpus*	20	25.7	17	17.17	23	17.03	54	40.00	88	53.0
5	*Bidens pachyloma*	36	46.5	47	47.47	61	45.19	25	18.61	34	20.48
6	*Brasica carinata*	6	7.30	1	1.01	10	7.4	2	1.58	-	-
7	*Senna occidentalis*	5	6.20	8	8.08	-	-	23	17.13	-	-
8	*Poaceae species*	2	2.41	-	-	-	-	-	-	1	0.61
9	*Hypostes forskolii*	-		2	2.03	-	-	9	6.70	28	16.86
10	*Olea eurpea*	-	-	5	5.05	-	-	-	-	-	-
11	*Trifolium species*	-	-	-	-	9	6.67	5	3.80	-	-
12	*Acacia abyssinica*	-	-	-	-	8	5.93	1	0.84	1	0.61
13	*Rumex nervosus*	-	-	-	-	10	7.5	-	-	3	1.81
14	*Maytenus senegalensis*	-	-	-	-	-	-	3	2.32	-	-
15	Unidentified	2	2.59	-	-	-	-	3	2.32	-	-

Tn= Teamina village

No=number of pollen

According to the analysis result of the honey samples analyzed, collected from Kiazba village ***Caparis, erythrocarpus*** (51.57%, 46.72% and 47.29%) and ***Justicia shimperina*** (46.15) were identified as the major honey plants as they contained higher percentage of the pollens in the samples.

Based on the honey sample analysis ***Aloe berhana***, ***Cordia africana*** and ***Bidens pachyloma*** were identified as secondary honey plants in the village.

H***ypostes forskaolii, maytenus senegalensis, Ocimum bacilicum, Brasica carinata, Zeziphes mucronata, Acacia pentagona*** and ***Olea europaea*** were identified as minor honeybee plants (Table 10)

Table 10: Percentage distribution of pollen in honey samples collected from Kiazba village

No	N Scientific name of plant	Number of pollen in honey samples									
		Kb1		Kb2		Kb3		Kb4		Kb5	
		No	%	No	%	No	%	NO	%	No	%
1	*Caparis erythrocarpus*	94	31.22	96	47.29	-	-	82	51.53	57	46.72
2	*Bidens pachyloma*	40	13.24	-	-	25	14.48	32	20.12	31	25.4
3	*Acacia abyssinica*	5	1.65	-	-	2	1.39	-	-	2	1.63
4	*Hypostes forskolii*	3	0.99	-	-	9	6.29	12	7.54	6	4.9
5	*Maytenus senegalensis*	19	6.29	8	3.94	8	5.69	-	-	-	-

6	*Cordia africana*	-	-	37	18.22	-	-	-	-	-	-
7	*Ocimum bacilicum*	11	3.65	7	3.44	10	7.98	-	-	7	5.73
8	*Aloe berhana*	101	33.54	-	-	-	-	-	-	-	-
9	*Olea eurpea*	4	1.42	-	-	-	-	7	4.4	-	-
10	*Brasica carinata*	8	2.64	12	5.93	-	-	8	5.03	8	6.55
11	*Unidentified*	4	1.42	-	-	-	-	4	2.52	-	-
12	*Justicia shimperina*	-	-	23	11.33	66	46.15	-	-	-	-
13	*Zeziphes mucronata*	12	3.97	8	3.95	-	-	6	3.78	8	6.55
14	*Parkinosnia aculeate*	-	-	4	1.97	-	-	-	-	-	-
15	*Trfolium species*	-	-	6	2.96	-	-	-	-	-	-
16	*Maruae angolensis*										
17	*Pterolobium stellatum*	-	-	2	0.98	-	-	4	2.52	3	2.44
18	*Jesminum floribundum*	-	-	-	-	3	2.09	4	2.52	-	-
19	*Acacia pentagona*	-	-	-	-	20	13.98	-	-	-	-

Kb= Kiazba village

No=number of pollen

Generally based on the analysis of the pollen samples in the four villages the major honey plants identified were ***Aloe berhana, Bidens pachyloma Justicia shimperian*** and ***Caparis erythrocarpus*** as they contained higher percentage of the pollen in the samples. The secondary pollen sources of bees were ***Cordia africana, Acacia pentagona, Caparis angustifolia, Senna occidentalis, Hypostes forskolii and Brasica carinata.***

Where as ***Echinops hispidus, Budlleja polystachya, Nigela sativa, Olea europaea, Rumex nervosus, Maytenus senegalensis, Dodonia angustifolia, Pteolobium stellatem, Acacia etebica, Lepidgathis lalycina, Ocimum bacilicum, Trifolium species,*** and ***Zeziphes*** are the minor honeybee plants in the area.

4.8. Flowering plants identified from field observation and their floral calendar

In the six-month field observation 39 different species of flowering plants were collected from the area. Based on the bee plant field observation, plant sample collection and pollen analysis from honey samples only 25 species of plants were identified as sources of honey bee plants and their floral calendar is set as follows (Table11).

Table 11: Flowering calendar of honey bee plants species at Kebele Atakilty

Plant family	Scientific name of plant	Duration of flowering time					
		Oct	Nov	Dec	Jan	Feb	Mar
Aloaceae	***Aloe berhana***	****	***	****	****		
Fabaceae	***Pterolobium Stellatum***	****	****	****			
Astraceae	***Bidens pachyloma***	****					
Acanthceae	***Hyposte forskolii***	****	****	****			
Acanthaceae	***Justicia shimperina***	****	****	****			
Astraceae	***Echinpos hispidus***	****	****	****	****	****	
Sapindaceae	***Dodnia anggustifolia***	****	****	****	****		
Plantaginaceae	***Plantago lanceolatal***	****	****				
Celastraceae	***Maytenus senegalensis***	****	****	****	****		
Fabaceae	***Acacia etebica***	*****	****				
Caparidaceae	***Caparis erythrocarpus***			****	****		
Brassicaceae	***Brasica carinata***	****	****				
Polygonaceae	***Rumex nervosus***	****	****	****	****		

Boraginaceous	***Cordia africana***		****	****	****			
Buddlejaceae	***Buddleja polystachya***			****	****			
Ranunculaceae	***Nigela sativa***		****					
Oleaceae	***Olea europaea***							
Astraceae	***Guiztia scabra***		****	****				
Acanthaceae	***Lepidgathis lalycina***			****	****	****		
Fabaceae	***Acacia abyssinica***			****	****	****	****	
Lamiaceae	***Ocimum bacilicum***		****		****			
Rhamnaceae	***Zeziphez mucronata***		****	****	****	****		
Fabaceae	***Senna occidentalis***		****	****	****	****		
Poaceae	***Graminae species***							
Caparidaceae	***Caparis angustifolia***		*****	*****				
Rapilionidaceae	***Trifplium species***		*****	*****	****			
Roaceae	***Rosa abyssinica***			****	*****			
Fabaceae	***Acacia albida***		****	***	****			
Fabaceae	***Parkinsonia aculeata***			****	****			
Caparidaceae	***Maeruae angolensis***		****	****	****	****		
Oleaceae	***Gesminum floribundas***		***	****	****			
Fabaceae	***Acacia pentagona***						*****	****

4.5. Discussion

The result of the interview of the respondent beekeepers, Woreda honey experts and the kebele developmental agents showed that most of the plants identified by both groups were similar and identified in the honey samples as a source of pollen for the honeybees. This shows that they have knowledge of the plants utilized by honeybees in the area. On the honey bee plant field observations and pollen analysis from honey samples, 25 species of flowering bee plant species were identified of which 46.15% were trees, 30.76%were herbs and 23.07% were shrubs.

According to the sample study and pollen spectrum of honey sample trees and herbs represent the largest number of plant species, while shrubs were generally low. This agrees with the work of Admasu, Debissa, and Amsalu in the Rift valley of Eastern Showa (2004)(Appendix 1). This is due to a better coverage and of natural trees and undergrowth plants which are potential for honeybees. This also implies that beekeeping could be important for plant conservation since the area has the potential for honey production. In the area, the major honey flow season is during October to December. This is due to the availability and flowering of different types of field crops and natural forest plants such as ***Biden pachyloma***, ***Aloe berhana, Caparis erythrocarpus, Cordia africana*** etc. They provide abundant nectar and pollen for the foraging honeybees at the mentioned time. Similarly Fichtl and Admasu (1994) recorded the honey bees are foraging pollen and nectar from these plants. Based on the response of respondents, wheat and barley were not preferred, for they are nectarless and have only pollen

source. This was also indicated in the work of Desalegn (2004). However, neem is not preferred either. This is probably due to its nature of insecticidal property. From honey samples analysis 25 plant species were identified and the percentage occurrence of the pollen grains of the predominant honey source plants found in the honey samples were as indicated in the tables (7-10). Nuru and Admasu (2001) indicated honeybees collect pollen and nectar frequently from the same plant species and the plants are important bee plants producing surplus of honey (Fichtl and Admasu, 1994).

During the major honey flow periods ***Aloe berhana, Bidens pachyloma, Caparis erythrocarpus*** and***, Justicia shimperina*** are the major (greater than 45%) honey sources plants because of their abundance, high nectar and pollen as well as massive flowering and long duration of flower period in Atakilty Kebele in Central Zone of Tigray.This coincides with findings ofAdmasu, Debissa and Amsalu (2004) who mentioned these plants are heavy nectar yielding and a major source of pollen for honeybees that particular area.

The secondary pollen sources (16-45%) identified were Acacia ***pentagona, Cordia africana, Brasica craniata, Senna occidentalis,*** and Hypostes forskoalii and Caparis ***angustifolia.*** This agrees with the reports of Admasu, Debissa and Amsalu (2004), Fichtl and Admasu (1994) and Admasu and Hepburn (2006) that these plants supply abundant pollen and nectar for bees, which forage all day.

The minor important pollen sources (3-16%) plant species identified were ***Pterolobium stellatum, Acacia abyssinica, Zeziphes species, Buddleja polycantha, Nigela sativa,***

Ocimium basilicum, Lepydgathis lalycina Acacia etebica, Rumex nervosus, Echinops hispidus Mytenus senegalensis, Olea europae and ***Trifolum species.*** This is due to less abundance and foraging preference of honeybees. In addition pollen of ***Olea europea*** and Poeceae species were identified in the honey sample even though these plants ***were*** not included in the collection time***.*** Similarly, Hepburn and Radolf (1995), Fichtl and Admasu (1994) indicated the same types of plants are good sources of pollen and nectar for honeybees***.***

Some of the plant species collected and found more frequent in the study area including ***Crolotaria*** species, ***Hipocrata goetzey, Euphorbia candelabrum and Calotropis procera*** did not appear in honey samples This might be due to their less importance for honey bees or their nectar and pollen are very low to attract honey bees and limited nectar, pollen, less abundant and short flowering duration and I found no written reference to support this idea when writing this report.

The season of pollen collection by bees varied considerably from family to family and from species to species of plants. The plant species collection was done from October to March 2006. At family levels, the honeybees visited the Fabaceae family during the whole flowering season (six month) without interruption. Pollen from Astraceae was collected for five months. Similarly this coincides with the work of Marden and Kiew (1984).

Pollen from Acanthaceae, Spinodaceae, Celastraceae, Cparidaceae, Capiondaceae, Brassicace, Polygonaceae, Rhamnacee and Caparidaceae families collected for four

months. The other families appearing in the collection were collected for either three or two months (Table 11). At species level, ***Maytenus senegalensis, Dodonia angustifolia, Aloe berhana, Echinops hispidus, Acacia abyssinica, Rumex nervosus, Zeziphes mucronata, Maeruae angolensis, and Senna occidentalis*** were collected for relatively long period of five or four months, while ***Cordia africana, Lepidgathis lalycina, Trifolium*** species ***and Jesminium floribundam*** were collected for at least three months. This is due to adaptations of the plants to local climate, soil, rainfall and other factors. This is in agreement with the reports of Fichtl and Admasu (1994).

The monthly prevalence and importance of identified plants varies from month to month as pollen source to honeybees. In October, only 18 families were used for pollen collection. Fabaceae and Acanthaceae families were the most dominant showing most of the collection where as at species level from different types collected fabaceae alone accounts for 38% of that whole collection. In November, pollen of 24 different species under 11 families were collected. However Fabaceae is the dominant family in the month from which pollen was collected. In December 18 species of flowering plants under 8 families were used for pollen collection. Fabaceae family was the most dominant showing most of the collection. In January only eight families were collected and almost all families have the same prevalence. In February only two families Fabaceae and Astraceae were collected as pollen source for bees. In the month of March only two species of Fabaceae family were collected and only one of the species was found as a source of pollen for bees

6.0. Conclusion and recommendation

6.1. Conclusion

The botanical inventory of bee plants and melissopalynological analysis of honey have identified from includes ***Aloe berhana, Bidens pachyloma, Caparis erythrocarpus*** and ***Justicia shimperina*** as the major honeybee source plants. The honey analysis also indicated that honey production is mainly from trees and herbaceous flora and few shrubs owing to their abundance and rich nectar and pollen source.

Even though there are not significant variations in plants from year to year in the region or the study area there is only one major rainy season. The rainy season occurs from the beginning of June to the mid of September followed by warm temperature which is suitable for plants to bloom.

Following the rainy seasons, the majority of honey plants noted to flower and honey flow is expected once a year from mid October to December .The major honey flow period begins from October to December. This is because most areas of the locality are covered with herbaceous flora of weeds, cultivated d crops, forest trees and shrubs as comparable .The extent to which a given honey sample derived from different source can be deduced from its frequencies of honey pollen analysis (Louveaux, ***et al.1978***).

In the present study pollen analysis of honey also revealed that a number of anemophilous pollen grains were found in honey samples. These plants even if they are not important for honey production, they remain useful for strengthening of bee colonies.

The present investigation showed that there is one harvesting season; more over, during this flowering season, major and minor honey plants were categorized based on pollen analysis from honey samples.

6.2. Recommendation

The present results indicates that phenology of bee plants of the area shows that there is one major honey harvesting season and hence seasonal management of the honey bee colonies should be adjusted with flowering periods of bee plants in the area. That is more emphasis should be given conservation of bee plants at their respective agro-ecology and training should be given in management of colonies in relation to the flowering phenology of the area

This study shows the trees, herbs and shrubs play major role for honey production and therefore beekeeping should be integrated with vegetation conservation program for both livelihood improvement and natural resource conservation. Research should be promoted to conserve the honey bee plants and beekeeping and in order to boost honey production on a sustainable basis.

Although major and minor bee plants were identified in a single season, it does not represent the full picture of honey bee plants of the area and further study is required to make a full floral calendar

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Appendix 1. Honeybee plants grouped as herbs, shrubs and trees

	Herbs	Shrubs	Trees
	Aloe berhana	***Pterolobim stelatum***	***Maytenus senegalensi***
	Bidens Pachyloma	***Dodenia angustifolia***	***Acacia etebica***
	Hypostes forskaolii	***Rumex nervosus***	***Caparis erythrocarpus***
	Justicia shimperina	***Lepidgathis lalycina***	***Crdia africana***
	Echinops hispidus	***Rosa abyssinica***	***Buddleja polystachya***
	Plantago lanceolate	***Maerua angolensis***	***Olea europea***
	Brasica carinata		Acacia abyssinica
	Nigela sativa		***Zezipes mucronata***
	Guizotia scabra		***Caparis angustifolia***
	Ocimum bacilicum		***Zcacia albida***
	Senna occidentalis		***Parkinsonia aculeata***
	Trifolium spp		***Jesminium floribandum***
			Acacia pentagona

Appendix 2. Honeybee plants collected at Keble Atakilty

Plant family	Name of plant	Vernacular name in Tigrigna
Aloaceae	***Aloe berhana Reynolds***	***Ire (Herb)***
Fabaceae	***Pterolobium Stellatum Brenan***	***Qunteftef (Shrub)***
Astraceae	***Bidens pachyloma Oliv***	***Gelgelemeskel (Herb)***
Acanthceae	***Hyposte forskolii R.sch.***	***Saeri (Herb)***
Acanthaceae	***Justicia shimperina Nees***	***Simeaza (Herb)***
Astraceae	***Echinpos hispidus Fresen***	***Dadier (Herb)***
Sapindaceae	***Dodnia anggustifolia L.Filt***	***Tahses (Shrub)***
Plantaginaceae	***Plantago lanceolatal L.***	***Mandeledo (Herb)***
Celastraceae	***Maytenus senegalensis (Lam.) Exell***	***Qebqeb (Tree)***
Fabaceae	***Acacia etebica Schweinf.***	***Seraw (Tree)***
Caparidaceae	***Caparis erythrocarpus Ispeat***	***Andel (Tree)***
Brassicaceae	***Brasica carinata A. Braun***	***Gurmba (crop)***
Polygonaceae	***Rumex nervosus Vahl.***	***Hehot (Shrub)***
Boraginaceous	***Cordia africana Lam.***	***Awhi (Fruit and Tree)***
Buddlejaceae	***Buddleja polystachya Fresen***	***Mettere (Tree)***
Ranunculaceae	***Nigela sativa L.***	***Awostata (Herb)***
Oleaceae	***Olea europaea Cifferri.***	***Auli (Tree)***
Astraceae	***Guiztia sacbra Baaggoe***	***Nehukas (Herb)***
Acanthaceae	***Lepidgathis lalycina Benth.***	***No name (Shrub)***
Fabaceae	***Acacia abyssinica Hochst.***	***Che'a (tree)***

Lamiaceae	***Ocimum bacilicum L.***	***Seseg (Herb and Crop)***
Rhamnaceae	***Zeziphez mucronata Willd.***	***Giba (tree and Fruit)***
Fabaceae	***Senna occidentalis Forssk.***	***Teklay-tegegne (herb)***
Poaceae	***Graminae species***	***Saeri (Herb)***
Caparidaceae	***Caparis angustifolia L.***	***Kermed (tree)***
Rapilionidaceae	***Trifplium species Fresen.***	***Mesi (Herb)***
Roaceae	***Rosa abyssinica Lindley***	***Gaqa (Shrub)***
Fabaceae	***Acacia albida Del.***	***Momna (Tree)***
Fabaceae	***Parkinsonia aculeate L.***	***Shewit-hagay (Tree)***
Caparidaceae	***Maeruae angolensis DC.***	***Koromo (***
Oleaceae	***Jasminum floribandum Frexen***	***Tselimoy (Tree)***
Fabaceae	***Acacia pentagone Hoofif***	***Sibkana (Tree)***
Poaceae	***Poaceae spp.***	***Saeri (Herb)***
Euphorbiaceae	***Euphorbia candelabrum Trem.***	***Qulkwal (***
Asclepiadaceous	***Callotropis procera Ait.f.***	***Gendae***
Bignoniaceous	***Jacaranda mimosofolia D.Don***	***Astsede (Tree)***
Fabaceae	***Acacia siberina DC.***	***Tseada-che'a (Tree)***
Celastraceae	***Hippocrata goetzey***	***Hareg (Shrub)***
Fabaceae	***Albizia spp***	***Hambehambo (***
Fabaceae	***Crotolaria cambumifolia L.***	***Meratsen-teli (Herb)***

Appendix 3

A questionnaire for beekeepers, Woreda and Kebele developmental services

Name of the respondent_____

Age_____

Education status

Illiterate_____ Literacy_____ 1 -6 grade_____ 7-12 grade_____

2. Address

Kebele_____ Village_____

3.Do you have bee colonies? Yes_____ No ____

How many? _____

Traditional_____

Modern_____

4.What is the amount of yield per year?

Maximum_____

Minimum_____

5.What honey plants are targeting the bees?

Major_____

Secondary_____

Minor_____

6.What is the approximate number of honey harvesting seasons? _____

End of questionnaire: Thank you for completing this questionnaire. The information you have given will be kept strictly confident