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SURVEY OF HONEY PRODUCTION SYSTEM AND HONEY BEE DISEASE AND PESTS IN EJERE DISTRICT, WEST SHEWA ZONE, OROMIA REGIONAL STATE, ETHIOPIA

MVSc Thesis

By

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Addis Ababa University, College of Veterinary Medicine and Agriculture, Department of Clinical studies MVSc program in Veterinary Epidemiology

June, 2017

Bishoftu, Ethiopia

SURVEY OF HONEY PRODUCTION SYSTEM AND HONEY BEE DISEASE AND PESTS IN EJERE DISTRICT, WEST SHEWA ZONE, OROMIA NATIONAL REGIONAL STATE, ETHIOPIA

A Thesis submitted to the College of Veterinary Medicine and Agriculture of Addis Ababa University in partial fulfillment of the requirements for the degree of Master of Science in Veterinary Epidemiology

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As members of the Examining Board of the final MVSc open defense, we certify that we have read and evaluated the thesis prepared by SEGNI SHIMELIS MEGERSA entitled: SURVEY OF HONEY PRODUCTION SYSTEM AND HONEY BEE DISEASE AND PESTS IN EJERE DISTRICT, WEST SHEWA ZONE, OROMIA REGIONAL STATE, ETHIOPIA and recommended that it be accepted as fulfilling the thesis requirement for the Degree of Master of Veterinary Science in Veterinary Epidemiology

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DEDICATION

This thesis manuscript is dedicated to my father Shimelis Megersa and my mother Abebechi Hirkisa for nursing with affection and love and for their dedicated partnership in the success of my life.

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LIST OF ABBREVIATIONS

CI	Confidence interval
CSA	Central Statistical Authority
EARO	Ethiopian Agricultural Research Institute
ETB	Ethiopian birr
FAO	Food and Agricultural Organization of the United Nations
HBRC	Holeta Bee Research Center
Hec	hectare
ILRI	International Livestock Research Institute
LFRDO	Livestock and Fishery resource development Office
LIVES	Livestock and Irrigation Value chain for Ethiopian Small Holders
MoARD	Ministry of Agricultural and Rural Development
NGO	Non-Governmental Organization
OIE	Office International des Epizooties
PA	peasant associations

ABSTRACT

A cross sectional study was undertaken to assess honey production system, identify major beekeeping constraints and determine the association of potential risk factors with occurrence of honeybee diseases, predators and pests at Ejere district of Oromia regional state from November 2016 to May 2017. Questionnaire survey and laboratory diagnostic methods were employed. A total of 90 beekeepers were included in the questionnaire survey. Out of 90 beekeepers interviewed through questionnaire survey, 64.5% had knowledge about honey bee diseases and pests. A total of 384 honey bee colonies were randomly examined for the presence of honeybee external parasites and pathogenic diseases. Regarding honeybee pests and predators, the rank index confirmed that the most important pests and predators affecting honeybee colonies were ants (20.7%), wax moth (18.2%), honey badger (14.4%), spiders (13.1%), termites (12.3%), hive Beetles (7.2%), lizards (7%) and bee eater birds (7%). The major constraints affecting beekeeping development in the study areas in decreasing order were pests and predators (17.5%), high cost of modern hives and accessories (15.5%), agro-chemical application (14.3%), honey bee diseases (11.9%), poor management (10.5%), honeybee colony (10.5%), shortage of bee forage (10.2%) and absconding (9.6%). Out of 384 samples overall prevalence of bee lice, nosema diseases, amoeba diseases, chalk brood diseases were 43.3%, 69.8%, 82.3% and 51.04%, respectively. There was statistically significant ($p<0.05$) variation in overall prevalence of nosema disease and chalk brood disease between hive type and agro-ecologies. Agro ecological zones and types of hives were identified as risk factors for occurrence of honey bee parasites and diseases. The study demonstrated that honey productions in the study area are hampered by several constraints and disease. Therefore, improvement of honey bee hive management, disease and pests prevention are paramount important. Furthermore, large scale and comprehensive research on constraints and honey bee diseases are highly recommended to set appropriate solution.

Key words: *Disease, Ejere, Honeybees, Pests, Prevalence, Risk factors*

1 INTRODUCTION

Ethiopia is famous for its notable variation of agro-climatic conditions and biodiversity which favored the existence of diversified honeybee flora and vast number of honeybee colonies (Nuru, 2007). The country has the largest bee population in Africa with over 10 million bee colonies (CSA, 2009).

The use and contribution of honey bee is diverse including honey, bee wax, queen, bee colonies, and other products such as pollen, royal jelly, bee venom and propolis in cosmetics and medicine. Additional role of beekeeping is pollination of food crops & many plants species used for conservation of the natural environment, and can be integrated with agricultural practices like crop production, animal husbandry & horticultural crops (Gezahegn, 2001).

Bees are essential parts of the agriculture. Although the value of honeybees in crop pollination is under estimated, it has a significant role in increasing national food production and regeneration of plant species. Honeybees are the principal pollinating agents in the world. Their service in pollination is estimated to be worth over 15 times the value of all hive products together, although it is much more difficult to quantify their benefit (EARO, 2000).

The yearly honey production in Ethiopia is estimated to be around 54,000 tones which make the country leading of honey producing in Africa and ninth in the world (CSA, 2012).

In Ethiopia currently, bee keeping is being exercised traditional (Kassaye, 1990). It is characterized mainly by forest beekeeping that is common in forest covered South and Southwest Ethiopia and back yard beekeeping which is practiced in majority of the country (Nuru, 2007). The productivity of traditional hives is extremely low and the

average yield is only about 5–8kg/per colony/per annum (MoARD 2007). The other is transitional system of beekeeping is a type of beekeeping intermediate between traditional and modern beekeeping methods and modern system of Beekeeping have movable- frame hive consists of precisely made of rectangular boxes(hive bodies) superimposed one above the other in a tier(HBRC, 1997).

The major constraints in the beekeeping sub sector in Ethiopia are the behaviors of bees (aggressiveness, swarming tendency, and absconding characteristics), lack of skilled manpower and training institutions, low level of technology used, high price of improved beekeeping technologies, drought and deforestation of natural vegetation, poor post-harvest management of beehive products and marketing constraints, indiscriminate application of agrochemicals, honeybee disease, pest and predators, poor extension services, absence of coordination between research, extension and farmers, shortage of records and up-to- date information, and inadequate research institutions to address the problems. Nevertheless, all these problems may not be constraints to all parts of the country and may not be equally pressing to every place. (HBRC, 1997; Ayalew, 2001; Edessa, 2005).

Bees are found to be infected with different pathogenic organisms such as fungi, virus, bacteria and protozoan organisms. In Ethiopia, several surveys have been made on the existence of honey bee diseases such as Chalk brood, Nosema, and Amoeba. Additionally, pests and predators of bees have previosuly been reported from different parts of the country (FAO, 1989). Honey bees diseases, pests and predators are major bottleneck to the sector and causing a significance economic loss in honey bees and their products.

Recently, the Ethiopian government is intensively working on land conservation in different parts of the country which is forming suitable condition for bee keeping and also organizing jobless urban and land less rural youth and women to engage them in bee equipment production and beekeeping activities. A significant number of people are currently occupied in honey and beeswax collection, T*ej"* (honey wine) making, honey

and beeswax processing and marketing However, despite the probability for the presence of honey bee pests, disease and other problems, the study so far conducted on such problems in Ethiopia were very few. Even though, the areas are well known for their honey production potentials, there is no much detailed documented information on the practical aspects of bee honey production system management, honey bee diseases and the occurrence of pests were limited. Moreover, information on honey production system, utilization and constrains is so scant in Ejere district of Oromia regional state in which honey production is believed to high due to suitable environment and fauna (ILRI, 2013). Again updated information is important to utilize opportunities in this sector as well as device interventions mechanism required to address constraints, detecting the occurrence of harmful diseases, parasites and other pests of honey bee colonies.

Therefore the objectives of this study were:

- To assess honey production systems
- To identify of the major types of pests, diseases and predators of honey bees in the study areas
- To identify potential risk factors associated with honey bee disease and parasites in the study areas

2 LITERATURE REVIEW

2.1 Honey production systems in Ethiopia

Ethiopia is blessed with plenty of water resources and a range of honeybee floras, which make productive ground for the development of beekeeping. Honey hunting and beekeeping have been practiced in the country for the exploitation of honey. In areas where wild colonies of bees living in hollow trees and caves are found, honey hunting is still a common practice in Ethiopia. Presently, in the country Traditional, Transitional and Modern beekeeping methods are exercised.

2.1.1 Traditional Beekeeping

Traditional beekeeping is the oldest and the richest practice in Ethiopia which has been carried out by the people for thousands of years. Several million bee colonies are managed with the same old traditional methods in almost all parts of the country (Mammo, 1973; Fichtl and Admasu, 1994). Traditional beekeeping is of two types: forest beekeeping and backyard beekeeping. In some places, especially in the western and southern parts of the country, forest beekeeping by hanging a number of traditional hives on trees is widely practiced. In other most parts of the country backyard beekeeping with relatively better management is common (Nuru, 2002).

Traditional beekeeping is mostly practiced with different types of traditional hives. The most universal type of traditional hives, known to have been in use is simple cylindrical type. Beekeeping started with traditional or fixed comb hives, so called because the combs are attached to the top and sides of the hive itself and the beekeeper cannot easily remove and replace them.

In its primitive form, only one end of the hive could be open, but in more advanced forms each end of the cylinder will be fitted with a removable closure. The types of hives and the way of keeping bees vary from area to area. Based on locally available materials used

for construction of hives, environmental conditions and positions used to keep bees, the following variants of basic design are found throughout the country: hollowed logs, bark hive, bamboo or reed grass hive, mud (clay) hive, animal dung (mixed with ash) hive, woven straw hive, gourd hive, earthen pot hive and so on. The beekeepers that are experienced and skill full in using these hives could do many operations with less facility. (Gezahegne, 2001a) stated that under Ethiopian farmers' management condition, the average amount of crude honey produced from traditional hive is estimated to be 5 kg / hive / year. On the other hand, based on the survey conducted in West Showa Zone (Edessa, 2005), the amount of honey harvested, from a traditional hive on average was reported to be 6.1 kg/hive/year.

Traditional husbandry is practiced with many millions of fixed comb hives particularly in the remote areas of the country. For the period until modern frame-hives are introduced, these fixed comb hives can yield the modest amount of honey, and also about 8-10% of its weight is beeswax. This harvest is achieved with minimal cost and labor, and it is valuable to people living a marginal existence.

2.1.2 Transitional System of Beekeeping

This type of beekeeping is intermediating between traditional and modern beekeeping methods. It is one of the improved methods of beekeeping practices. The types of hives are Kenya Top Bar Hive (KTBH) and Tanzania Top Bar Hive (TTBH). The hives can be constructed from timber, mud or locally available materials. Each hive carries 27-30 frames on which honeybees attach their combs. The top bars have 3.2cm and 48.3cm width and length, respectively (HBRC, 1997).

Technical and economic reasons, most African countries are not yet in the position to use movable- frame hives, and for them top- bar hive represents a satisfactory compromise (Adjare, 1990; IBRA, 1997).

Although movable frame hives are recommended for experienced beekeepers that want

to optimize honey production, the Kenya top-bar (KTB) hive has been proved to be most suitable because of its low cost and the fact that the beekeepers or local carpenters can easily construct it.

Top-bar hive in an ideal condition can yield about 50 kg of honey per year (Gezahegne, 2001a).

2.1.3 Modern system of beekeeping

Modern beekeeping methods intend to gain the maximum honey, season after season, without harming bees (Nicola, 2002). Modern movable- frame hive consists of precisely made rectangular box hives (hive bodies) superimposed one above the other in a tier. The number of boxes is varied seasonally according to the population size of bees.

Practical movable- frame hive was invented in 1851 by Lorenzo Lorraine Langstroth in U.S.A. (Crane, 1976; Vivian, 1985). Later on different countries developed their own movable frame hives (for instance Zander, Dadant) and Langstroth was the prototype of movable frame hives used today. In many countries Langstroth hive boxes have proved to be convenient for handling and management.

In Ethiopia, about 5 types of movable frame hives were introduced since 1970 (HBRC, 1997) and the most commonly used are: Zander and Langstroth style hives. Based on the national estimate, the average yield of pure honey from frames hive is 15-20 kg/year, and the amount of beeswax produced is 1-2% of the honey yield (Gezahegne, 2001a). However, in potential areas, up to 50-60 kg harvest has been reported (HBRC, 1997). Movable frame hives allow colony management and use of a higher level of technology, with larger colonies, and can Give higher yield and quality honey but are likely require high investment cost and trained man power.

2.2 Honey bee feed source

Plants are the food source of honey bees (Gezahagn, 2007). However, not all plants are important for honeybees, 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). Most reliable nectar producers are: Gallberry, Citrus, Tupelo saw palmetto, Melaleuca, Brazilian pepper and Palm (cabbage) (Delaplane, 2010).

Source of both pollen and nectar some of the tree *species* are *Eucalyptus camaldulensis, Optica cylinderica, Euphorboum candelabrum* and *Olea europeae* are. In addition to *Leucas abyssinica, Becium grandiflorum, Carissa edulis, Leucaena leucocephala* etc. are good source of pollen and nectar. While *Zea mays* the only pollen and *Ocimum basilicum* only Nectar sources these and the Major bee 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*. (Fitchl and Admasu ,1994).

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).

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).

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 Honey bee constraints in Ethiopia

The existing production constraints in the beekeeping development of Ethiopia are complex and to a large extent vary between agro-ecological zones and production systems (EARO, 2000). Most research reports revealed that the pests and predators, shortage of bee forage, lack of skill and knowledge, low level of technology and honey bee disease, agro-chemical, are the top major constraints in most part of the country (Kerealem *et al*., 2009);Workneh and Puskur,2011; Gidey *et al*., 2012).

2.5 Honey Bee Disease

The bees and their products are vulnerable to various diseases, parasites and pests. Honey bees diseases, pests and predators are causing a significant economic loss in honey bees and their products. The most commonly known honeybee diseases reported to exist in Ethiopia are Nosema, Amoeba and Chalk brood diseases (Gezahegn and Amssalu, 1991; Desalegn and Amssalu, 1999; Desalegn, 2006).

Chalk brood is an infectious disease of honeybee larvae caused by a fungus *Ascosphaera apis*, which causes death and mummification of sealed brood of honeybee with consequent weakness of the colony (Root, 1990). The occurrence of this disease in Ethiopia for the first time was reported around Holetta and at Gedo demonstration (Desalegn, 2006). In Ethiopia the study reported an infection rate of 37.12%, 19.89%, 17.93% and distribution rate of 87.50%, 56.56% and 33.33% in Amhara, Oromia and Benshangul- gumuz(Aster *et al*., 2010).

Nosema is caused by *Nosema apis* and *Nosema ceranae*. It is a microsporidian fungal disease that infects the intestinal tract of adult bees. Nosema cause detrimental effects on honey bees, colony development,queen performance and honey production. In Ethiopia Nosema was reported in low infestation rate in the survey conducted by the initiation of FAO (FAO, 1989).and also reports Addis Abeba reported prevalence rate of 53.3% (Desalegn and Yosef, 2005). In Ethiopia Nosema was also reported from different regions with varying prevalence rate such as 58% in Oromia, 60% Benishangul-Gumuz and 47% in Amhara regions (Aster *et al*., 2007).

Amoeba is diseases of honey bee caused by a single celled parasite called *malpighamoeba mellificae.* The parasite affects malpigian tubules of honey bees and shortens the life cycle of bees (FAO, 1989). Survey conducted in the year of 2000, Amoeba was reported in South and South parts of the country (Amsalu and Desalegn, 2001). Diagnosis made on honey bees in field and laboratory at Addis Abeba reported a prevalence rate of 73% of amoeba infestation (Desalegn and Yosef, 2005). The diseases was also reported with high prevalence rate in different regional state of Ethiopia such as; Oromia region with prevalence rate (88%), Amhara region (95%) and 60 % in Benishangul- Gumuz (Aster *et al*., 2007).

American foulbrood (AFB) is an infectious disease of the larval stage of the honeybee *Apis mellifera. It is caused by a* Gram positive bacterium called *Paenibacillus (*Heyndrickx, 1996). European foulbrood (EFB) is caused by the bacterium *Melissococcus plutonius*(Bailey 1983).

2.6 Honey bees pests

Lice are known to infect honey bees in hive. Bee louse are wingless ectoparasite fly which causes significant damage bee colonies. Bee lice larvae feed on honey and pollen by tunneling under the cell capping (Morse and Nowogrodzki, 1990). In Ethiopia infestation of lice in honey bees was reported from the western region of Shoa, Oromia regional state with overall prevalence rate of 42% with highest prevalence rate 70.8% in Gemechis, 50% in Holeta and 17.1% in Jaldu (Gizachew *et al*., 2013). And also in Tigray regional state reported an overall prevalence 4% in brood and 5.5% adult bees (Adeday *et al*., 2012).

Small hive beetle is native to Africa, where it is considered as a minor pest of honey bees. Both adults and larvae are able to be serious pests that weakened honey bee colonies or honey supers. The beetles multiply to vast numbers, their larvae tunnel through comb to eat brood, damage stored honey, and ultimately destroy infested colonies or cause them to abscond. The beetle also defecates in the honey, causing it to ferment and run out of the combs (Lundie, 1940). In Ethiopia the small hive beetle was reported in the south and South-West parts of the country with prevalence rate of 10 % (Amsalu and Desalegn, 2001). The small hive beetle was reported in the Oromia regional state; 60% Jimma and 1.1% in Horo Guduru walaga (Amsalu and Desalegn, 2008) likewise it was reported Southern parts of Ethiopia with prevalence rate ranges from 21% in Konso to 66% in Teltele (Amsalu and Desalegn, 2006)

Ants are most worrying to honey bees and bee keeping sector. Ant eats or carries off any comb contents iike honey, pollen and brood (Smith, 1953). Ant (*Dorylus fulvus*) was one of important honey bees' enemies and causing a serious problem in West and south western Shoa Zones shows that 44 % of the colonies were attacked by Ants(Desalegn, 2001).

Wax moths are serious pests causing damage on wax production in a given colony. The caterpillar of lesser wax moths feed on pollen, cast skins and cocoons, but don't destroy bee colonies. The wax moth pests infest stored equipment and weaken colony by

spending of time in comb maintenance (Amsalu, Desalegn, 2001). The wax moth in honey bees was reported in the South and South West parts of Ethiopia (Amsalu and Desalegn, 2001). Similarly wax moths were reported in Tigray regional state in three district Atsbiewonberta, Aheferom and Kelteawlaleo (Etsay and Ayalew, 2001).

Varroa mites are ectoparasites that feed on the hemolymph of immature and adult honey bees The varroa mite, *Varroa destructor,* are the world's most devastating pest *Apis mellifera*. Although the varroa complex includes multiple *species*, *V. destructor* is the *species* responsible for the vast majority of the damage attributed to mites from this genus. Until 2000, it was believed that *V. jacobsoni* Oudemans was the mite responsible for widespread honey bee colony losses. However, taxonomic work indicated that a previously-unidentified *species* of varroa (*V. destructor*) was responsible for the damage, while *V. jacobsoni* was shown to be only moderately harmful to honey bees (Anderson and Trueman, 2000). In Ethiopia, the particular survey which was conducted in Tigray regional state revealed the occurrences of Varroa mite in the country and also established the distributions of the mite in the region (Desalegn, 2014).

2.7 Agrochemicals

Honey bees are large amount important pollinators of agricultural crops but very sensitive insects as they are disturbed by the common environmental factor like pollution (Johnson *et al*., 2010). Pesticides are the chemicals that are most widely used to control pests in crop production. When different chemicals are applied to the crops, they are affecting the pests of the crops but also harm the beneficial insects as pollinators, predators and parasites. This harmful effect disturbs the natural balance between the insects and their natural hosts (Amsalu Bezabeh *et al*., 2012). Older worker bees forage outside the hive for pollen and nectar, and thus are vulnerable to contact exposure to pesticides during foraging as well as dietary exposure during collection or ingestion of pollen and nectar. Workers also serve as a vector for bringing contaminants back to the hive. Young workers clean cells and attend brood, whereas middle aged workers do a variety of tasks mainly within the hive. All the young and middle-aged workers, queen and drone can

have secondary exposure to pesticides through contaminated food brought back to the hive (Fischer and Moriarty 2011).

3 MATERIALS AND METHODS

3.1 Study area

The diagnostic survey was conducted from November 2016 to May 2017 in Ejere District. It is located at a distance of 45 km, West of Addis Ababa. Its center is called Ejere town. It is situated at an altitude ranging from 1,872 to 3,238 meters above sea level with an estimated area of 192.78 Square kilometers. The area receives an average annual rainfall ranging from about 991 to 1,194mm.whereas the minimum and maximum daily temperatures of the area are 11 and 18^{o}C, respectively. Mixed crop and livestock faming system is the mode of agriculture practice in the district. The major crops grown in the district are: - wheat, barley, pea, maize, sorghum and minor crop like tef is produced. In addition to these irrigated vegetables: potato, onion, garlic and cabbage also produced in the area. This district has an estimated total population of 86,934 of whom 42,712 were females and 44,222 were males. The major soils are: lithic leptosols, eutricvertisols, humicnitosols and haplicluvisols(ILRI,2013). The livestock potential of the Woreda is Cattle 93,152, Sheep and Goat 54,115, Poultry 43,125, Equines, 19803 and Bee colonies 4,550 (EDLFRDO, 2014).

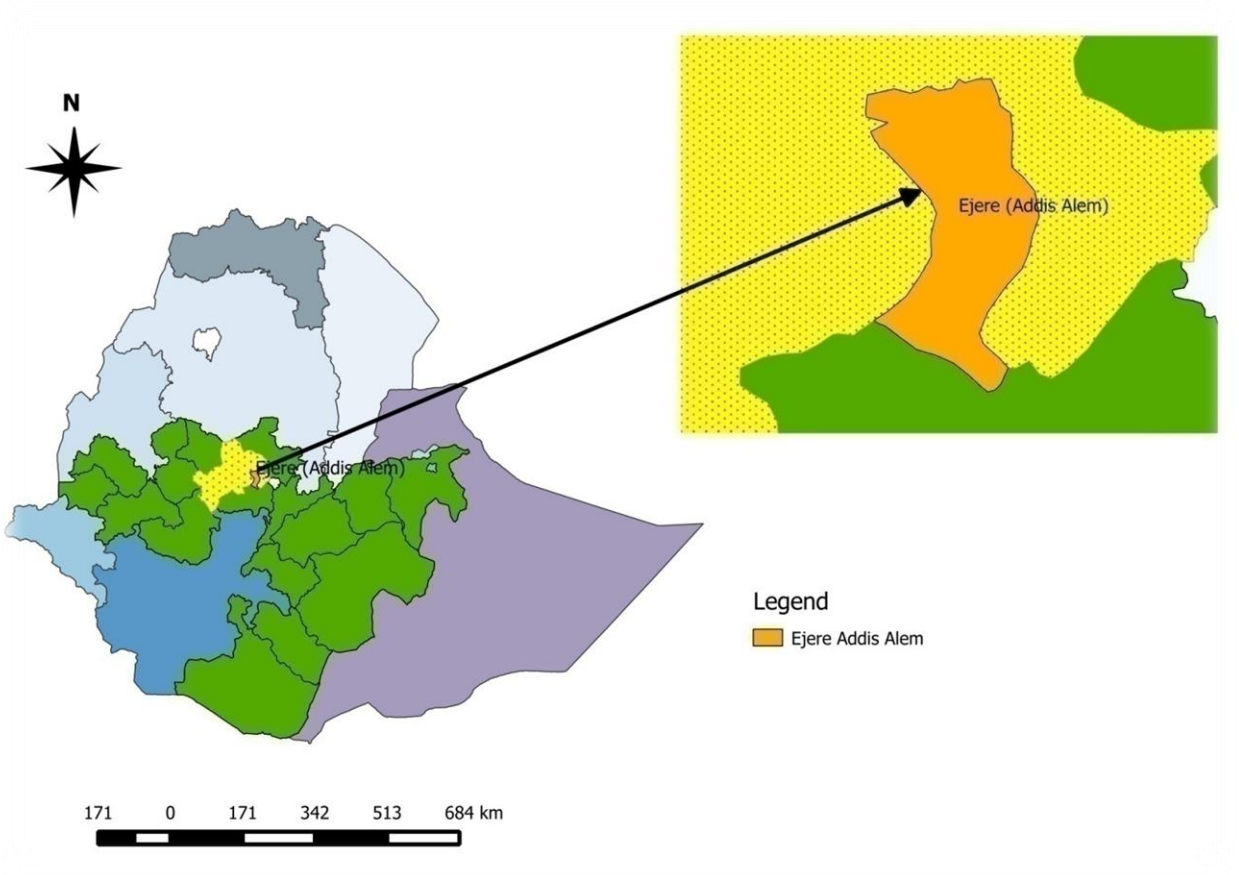

Figure 1:-Map of Ejere district

3.2 Study Design

A cross-sectional study was carried out from November 2016 to May 2017 in West Showa Zone, Ejere District on honey bee colonies managed under traditional, transitional and modern beekeeping methods to investigate the honey production systems and identifying of the major type of pests & disease causes of significant economic loss in honey bees by observing and collecting samples from the colonies. Then, isolation and identification of bee diseases causing pathogens were conducted. Diagnosis was confirmed by integrating clinical and parasitological studies. Questionnaire survey was carried out during the study in order to determine honey production system and its constraint due to pests and predators.

A single beehive was considered as one sample unit. Types of hive and agro-ecology were considered as explanatory variables (risk factors), and tested whether they have an impact on occurrence of honey bee disease and parasites or not. Honeybee hive was categorized as Traditional, Transitional and Modern hives. Three altitude categories were considered highland (>2400 meters), Midland (1800 to 2400 meters) and lowland (<1800 meters) above sea level MoARD, (2009). Finally, prevalence for apiary and colony levels was calculated following the protocols of Vanenglesdorp *et al*., (2013):

Prevalence = Number of positive Cases X 100

Total number of sampled population

3.3 Sampling method and sample size determination

Purposive sampling techniques was used to select 3 PA (Chiri, Endode and Inaftu) based on accessibility to the road, population of the honey bee colony and honey bee colonies managed under traditional, transitional and modern beekeeping methods from the district. Then, 1526 of bee colonies were prepared jointly with the community representatives, village leaders, and the development agents working in the selected PAs. Finally, simple random sampling techniques were employed to select 128 bee colonies from each PA, and a total of 384 bee colonies from the three PAs. This made a total of 384 bee colonies. Since no previous study done in the area, the expected prevalence and absolute precision were set to be 50% and 5%, respectively. Based on this, the sample size was determined according to Thrusfield, (2005) as follows:

$$n=\frac{1.96^2 P_{exp}(1-P_{exp})}{d^2}$$

Where: n=required sample size

P_{exp}=Expected prevalence

d=Desired absolute precision

By using 50% expected prevalence with 95% confidence interval at 5% absolute precision, the number of hives required to estimate prevalence was calculated to be 384.

3.3.1 Sample Collection and questionnaire

In this study, a structured questionnaire prepared and administered to collect information from the identified bee keepers. Both primary and secondary sources of data were used in this study. Secondary data were obtained from reports of Regional, zonal and district livestock and fishery resource development Office, NGOs and other published and unpublished materials. Primary data was collected using questionnaire. In addition, Information about honey production and its constraint due to pests and predators of honeybees was collected through interviews 90 bee keepers using a structured questionnaire. Visual observation to any clinical symptoms from bee, bee cell, larva or pupa was done observed and samples were taken by brushing the bees off the comb through a large mouthed funnel or directly in universal bottle and killed and preserved in 70% methyl alcohol and labeled accordingly. The samples were brought to Ejere district veterinary clinic laboratory and the brood examinations were conducted by random opening of brood cells. The brood was removed from the cell with a fine forceps and the cell was inspected for the presence of pests.

3.3.2 Laboratory test

Examination of Nosema and Amoeba diseases were caused by protozoan agent that affects the abdominal contents of adult honeybees, their sampling and diagnostic techniques are almost the same. Therefore, bee samples collected for Nosema and Amoeba diseases can help to tell the condition or status of the other (OIE, 2008b). Therefore, following Fries *et al*., (2013) procedure, a sample of 30-60 worker adult honeybees were collected from the hive entrance. The sample bees were collected in 70% alcohol until laboratory analysis. The abdomen of honeybees from each sample was cut using scissors. The cut abdomens were placed and grounded in mortar containing 5-10 ml distilled water until an even suspension is formed using pestle. The mortar and pestle were thoroughly cleaned before being used again. A loop of suspension were placed on microscopic slid using the sterilized loop and covered with cover slid. The suspension

was examined under microscope using 40-magnification power for the presence of Nosema spores and Amoeba cysts.

Examination the chalk brood mummies were checked at the bottom board of hive entrance, in the comb cells and on the ground beneath the hive entrance. Mummies were moistened with distilled water and the supernants were placed on microscope slid, covered with cover slid and examined under light microscope for spores and/or spore balls and cysts of *Ascosphera apis* (Jenssen *et al*., 2012).

3.4 Data analysis

The collected data were cleared & stored into Microsoft Excel program for further analysis. Stata version 13 statistical package was used to analyze the data. Summarized data was presented in the form of tables and figures. The questioner survey data, obtained in this study were analyzed using descriptive statistics and the ranking of the different types of beekeeping constraints obtained in the study were done by using the rank index formula as described by (Musa *et al*., 2006). Chi-square test was used to assess the association of the risk factors with the prevalence of the disease and pests and logistic regression was also used to assess the strength of association among different factors. Statistical significance was set at $p \leq 0.05$ with 95 % CI.

4 RESULTS

4.1 Questionnaire survey

From the total of 90 sampled households interviewed, about 91.1 % were male headed and the rest 8.9 % were female headed. Beekeepers who involved in honey production had an average age of 43.7 years old. The survey result showed that farmers in the most productive age are actively engaged in beekeeping activities with the average experience of 4.69 years. The mean land holding per the respondents' household was estimated to be 1.25 hec (Table 1).

The beekeepers that have different family size were engaged in beekeeping activity. The minimum and maximum family sizes of the respondents were 1 and 13, respectively. Out of the total households interviewed, 4.4%, 91.1%, 2.2%, and 2.2% were single, married, divorced, and widowers, respectively (Table 1).

Concerning to the educational status, 34(37.78 %) of the respondents were illiterate, 21(23.3%) can read and write,15 (16.67%) attended primary, 11(22.22%) junior and 9(10)% of them went secondary school (Table 1). This reveals that beekeeping is practiced by both groups (literate and illiterate).

Table 1. The proportion of sex, educational status, land holding size, marital status and experience of bee keeping in years of the respondents.

Demographic Variables	Categories	N	Percentage (%)
Sex	Male	82	91.11
	Female	8	8.89
Educational status	Illiterate	34	37.78
	Read and Write	21	23.33
	Primary	15	16.67
	Junior	11	12.22
	Secondary	9	10
Land holding size	<1 hec	56	62.22
	>1hec	34	37.78
Marital status	Single	4	4.4
	Married	82	91.1
	Divorced	2	2.2
	Widow	-	-
	Widower	2	2.2
	>15 years	16	17.78
Experience (in, years)	10-15 years	29	32.22
	5-9 years	40	44.4
	<5 years	5	5.56

According to the survey result, the beekeepers use traditional, transitional and modern (improved frame hive) types. The mean number of traditional hives owned/house hold was 6.57(a minimum 1 and maximum 70) hives where as a mean of 2.2 and 2.95 hives for transitional and modern hives were identified (Table. 2).

Table 2 Types and quantities of beehives owned by the respondents

Variable	Obs	Mean	Std. Dev.	Min	Max
Traditional	86	6.569767	7.386061	1	70
Transitional	34	2.205882	1.701682	1	11
Modern	22	2.954545	2.785631	1	14

According to the survey result, the number of traditional hives 560(80%), transitional 75(10.7%) and modern 65(9.3%) beehives owned by the sampled households. (table 3).

Table 3 Bee hives type and honeybee colonies at selected PAs Ejere District.

PAs	Bee hive type (%)			No. of Honeybee colonies (%)
	Traditional	Transitional	Modern	
Chiri	190(82.3%)	23(10%)	18(7.8%)	196(33.7%)
Endode	150(81.5%)	17(9.2%)	17(9.2%)	144(24.8%)
Enaftu	220(77.2%)	35(12.3%)	30(10.5%)	241(41.5%)
Total	560(80%)	75(10.7%)	65(9.3%)	581

About 83.33 % of the respondents confirmed that, they got their establishing colonies by catching swarms (hanging bait hives on the apex of trees) followed by gift from parents (6.67%) and purchasing from beekeepers (10%) (Fig. 2)

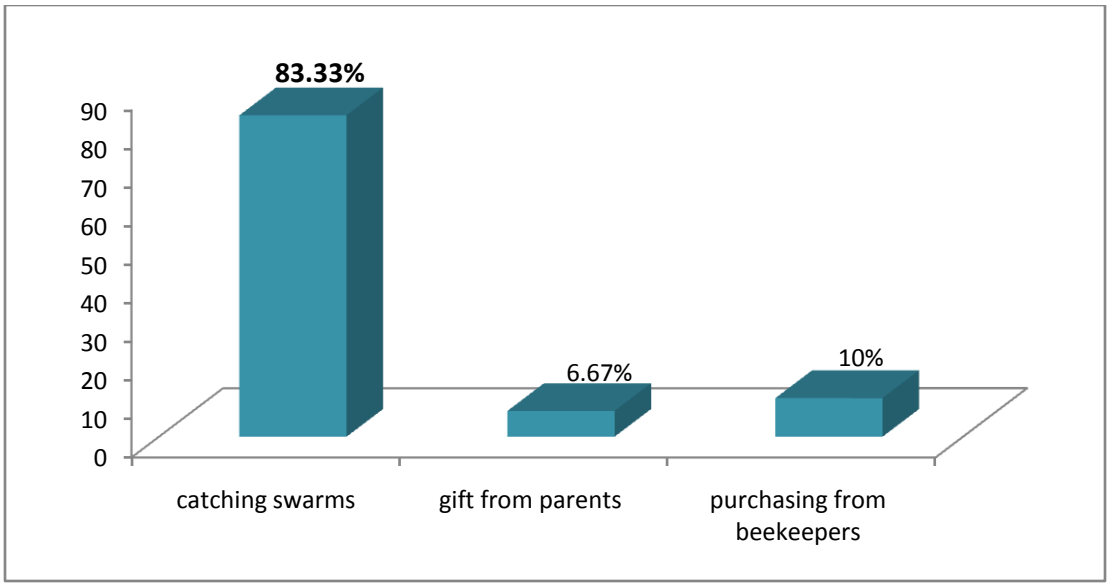

Figure 2 : Source of bee colonies in proportion

Majority of the beekeepers 58.9% in the study areas placed their honeybee colonies at the back yard while about 25.6 % of the beekeepers placed their honeybee colonies placed in inside house, 12.2 % under the eaves of the house and 3% hanged on trees near homestead (Fig. 3).

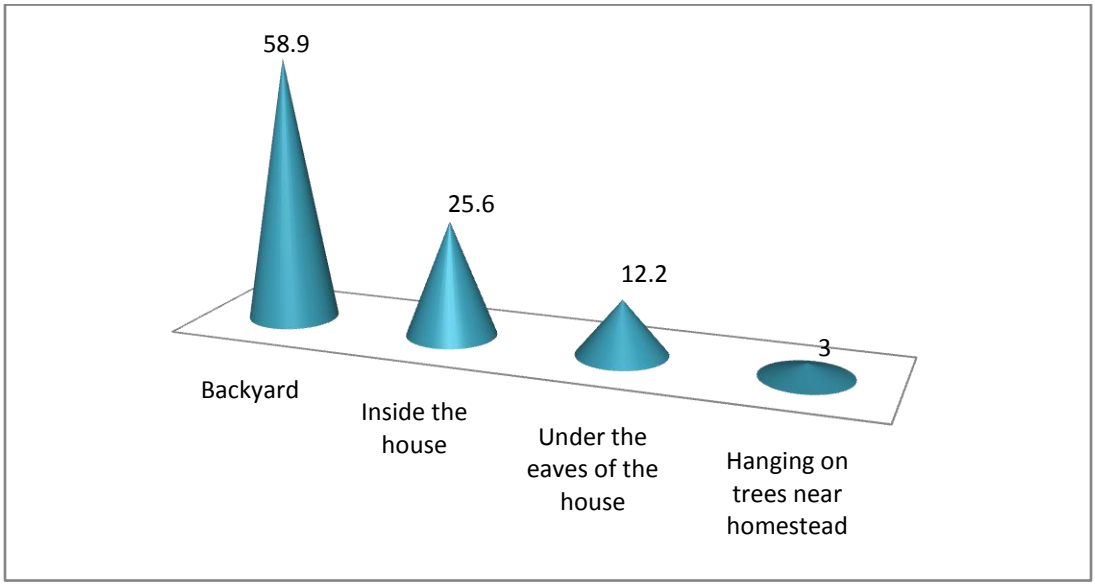

Figure 3 Placement of bee hives

Participated respondents were interviewed to describe the frequency of inspecting their apiary and honeybee colonies. Among them 36.7% of the respondents replied that they take a look externally into the hives frequently, 43.3% sometimes and 20% rarely (Table.4).

Table 4 Frequency inspection of apiary by Beekeepers

Inspection frequency	N	Proportion (%)
Ferquently	33	36.67
Somew times	39	43
Rarely	18	20

N=Number

The respondents informed that they have harvested about 4.8±0.9 kg, 10.1 ± 1.8 kg and 18.95 ± 3.29 kg of honey from traditional, transitional and modern beehives, respectively (Table 5). None of the beekeeper of the study area collected crude beeswax. According to the respondents, all beekeepers did not harvest bee wax because of knowledge or awareness about the product and lack of the market.

Table 5 Average Productivity of different hives in kg

	Total sample (n=90)			
Hive Types	Mean	S.D	Min.	Max.
Traditional hive	4.77907	.9126711	3	7
Transitional hive	10.08824	1.831834	7	15
Modern hive	18.95238	3.293572	12	27

S.D Standard deviation

In the study areas, the majority of the respondents (71.1%) collect honey once in a year while 28.9% of the respondent's harvested honey twice in a year.

Beekeepers of the study area sell their honey at different places and have different costumers. Sample respondents who produce and sell honey were asked their main customers. Accordingly, they mostly (85.6%), sell their honey at market found in nearby town followed by farm gate (10%) and Tej house (4%). Respondents indicated that an average sales price of one kg of honey which gained from traditional and transitional hive were around 92.50 ETB where as the honey from modern hive was 178.50 ETB on the average.

Of the participants in this study, 58.9% said that they provided supplementary feed for honey during scarcity of the feed. The supplementary feeds include *shiro, beso,* sugar and honey. In the study area, Honeybees collect water from streams, rivers and water harversting structure with (44.4%), (33.3%) and 22.2%, respectively

Beekeepers reported that different problems affecting the beekeeping activities in their areas. Consequently, considerable participants identified the major problems affecting beekeeping development in the study areas with decreasing proportions were pests and predators (17.5%), high cost of modern hives and accessories (15.5%), agro-chemical application (14.3%), honey bee disease (11.9%), poor management (10.5%), Honeybee colony (10.5), shortage of bee forage (10.2%) and absconding (9.6%) (Table.6). these constraints were ranked according to what the farmers outward the most important factors affecting beekeeping development.

Table 6 Major Constraints that hindered the apiculture development in the study areas

Constraints	Relative level of importance								Index	Over all Rank
	1st	2nd	3rd	4th	5th	6th	7th	8th		
High cost of modern hives and accessories	27	11	15	8	5	10	4	7	0.154577	2
Absconding	0	7	10	13	15	7	12	25	0.096294	8
Pests and predators	36	18	11	5	8	4	2	0	0.175166	1
Shortage of bee forage	0	12	10	10	11	12	18	12	0.101996	7
Honeybee colony	2	8	8	15	16	12	10	15	0.10453	6
Agro-chemicals	12	19	12	15	5	10	12	2	0.143174	3
Disease	5	7	18	10	15	10	18	3	0.1191	4
Poor management	6	8	6	7	15	22	8	15	0.105163	5

Index = sum of (7*ranked 1st+ 6* ranked 2nd+5* ranked 3rd+4* ranked 4th+3* ranked 5th+2*
ranked 6th+1* ranked 7th) for individual and predators divided by the sum of (7*ranked 1st+ 6* ranked 2nd+5* ranked 3rd+4* ranked 4th+3* ranked 5th+2*ranked 6th+1* ranked 7th) for over all Constraints

Modern hives requires accessories like honey extractor and casting mold. In the study area both honey extractor and casting mold were found at district level.

The beekeepers were asked whether their bees get incidence of poisoning or not. Therefore, 71.1% of the respondents know the effect of agro-chemicals on honey bee.

Respondents listed out pests and predators as important in irritating honeybees and their products. After having identified the major pests, farmers were requested to rank them in order of their importance and the result indicated that Ants (20.7%), Wax moth (18.2%),

Honey badger (14.4%), Spiders (13.1%), Termites (12.3%), Hive Beetles (7.2%), Lizards (7%) and Bee eater birds (7%), were the most destructive pests in order of decreasing importance (in Table 7 see ranking index).

Table 7 Rank index for major pests and predators of Honey bees in the study areas

Pests and Predators	**Relative level of importance according to respondents**								**Index**	**Over all**
	1st	2nd	3rd	4th	5th	6th	7th	8th		Rank
Ants(*Dorylus fulvus*)	54	23	12	1	0	0	0	0	0.207	1
Wax moth *(Acheroea grisella)*	20	36	21	9	1	0	0	3	0.182	2
Honey badger *(Mellivera capensis)*	10	16	17	18	15	3	3	8	0.144	3
Bee eating Birds(*meropidae*)	0	1	0	5	16	20	22	26	0.070	8
Hive Beetles *(Aethina tumida)*	0	0	0	6	16	25	21	22	0.072	6
Spiders(*Arachnids)*	1	7	18	36	12	7	3	6	0.131	4
Termites *(Isoptera)*	5	7	22	10	15	10	18	3	0.123	5
Lizard *(Agama agam)*	0	0	0	5	15	25	23	22	0.070	7

Index = sum of (7*ranked 1st+ 6* ranked 2nd+5* ranked 3rd+4* ranked 4th+3* ranked 5th+2*ranked 6th+1* ranked 7th) for individual and predators divided by the sum of (7*ranked 1st+ 6* ranked 2nd+5* ranked 3rd+4* ranked 4th+3* ranked 5th+2*ranked 6th+1* ranked 7th) for over all pests and predators

Regarding training 53.3% of respondents have got training in beekeeping activities on improved beekeeping practices with a mean of one days, whereas as, 46.7 % of the sample farmers had no chance of getting training.

4.2 Prevalence of Honey Bee Disease and Parasite

The overall honey bee lice (*Braula coeca*) infestation was found to be 43.3% (n=167). The current result indicated that honey bee lice infestation was higher in traditional types of hive (50.9%) followed by modern type of hive (48.6%), and the transitional hive was found to be the least infested type of hive(22.3%) and there was statistically significant differences among these hives(P=0.00). The result also indicated that honey bee lice infestation was more common on mid highland (46.1%), followed by highland agro-ecology (38.3%). Although, statistically significant difference was not observed between these agro-ecologies (p>0.05) (Table 9).

Table 8 Prevalence of Honey bee louse with its associated risk factors

Observed risk factors	Categories	No of hive examined	Lice infestation (%)	Chi square	P value
Hive types	Modern	72	35(48.6)	22.8	0.000
	traditional	218	111(50.9)		
	transitional	94	21(22.3)		
Agro-ecology	highland	128	49(38.3)	2.11	0.145
	Mid land	256	118(46.1)		
Overall proportion		384	167(43.5)		

The univariate logistic regression analysis indicated that traditional type of hive was 3.61 times more likely infested by honey bee lice than the Transitional hive (OR=3.61, 95% CI= 2.07- 6.27), and the Modern type of hive was also found to be 3.28 times infested by honey bee lice (OR=3.28, 95% CI= 1.682- 6.427) than the transitional type of hive. Moreover, honey bee was1.37 times more likely to be suffered in midland agro-ecology (OR=1.37, 95% CI= 0.89-2.13) as compared to the highland agro-ecology (Table 10).

Table 9: Univariate Logistic regression analysis of risk factors associated with honey bee lice infestation

variables	level	OR	SE	Z	P>/z/	95% CI
Hive types	Transitional *	1	-	-	-	
	Modern	3.28	1.124	3.48	0.000	1.682- 6.427
	Traditional	3.61	1.017	4.54	0.000	2.07- 6.27
Agro-ecology	Highland *	1	-	-	-	
	Mid land	1.37	0.30	1.45	0.146	0.89-2.13

*Reference category

The overall prevalence of Nosema disease was 268 (69.8%) during the study period (Table 11). The prevalence level of *Nosema apis* in highland and midland were 98(81.7%) and 170(66.4%), respectively. There was also significant difference between agro-ecologies ($p < 0.05$). The overall prevalence of *Nosema apis* was significantly varied among hives types ($p < 0.01$).

Table 10 Prevalence of Nosema disease with its associated risk factors

Observed risk factors	Categories	No of hive examined	Nosema disease (%)	Chi square	P value
Hive types	Modern	72	34(47.2)	29.3721	0.000
	Traditional	218	174(79.8)		
	Transitional	94	60(63.8)		
Agro-ecology	highland	128	98(81.7)	4.17	0.041
	Mid land	256	170(66.4)		
Overall proportion		384	268 (69.8)		

The univariate logistic regression analysis indicated that traditional type of hive was 4.12 times more likely infected by Nosema disease than the modern hive (OR=4.12, 95% CI= 2.502-7.805), and the transitional type of hive was also found to be 1.97 times infected by

Nosema disease (OR=1.97, 95% CI= 1.018-2.682) than the modern type of hive. Moreover, honey bee was 1.65 times more likely to be affected by Nosema disease in highland agro-ecology (OR=1.65, 95% CI= 1.018-2.682) as compared to the mid land agro-ecology (Table 12).

Table 11 Univariate logistic regression analysis of risk factors associated with Nosema disease

variables	level	OR	SE	Z	P>/z/	95% CI
Hive types	Modern *	1	-	-	-	
	Traditional	4.12	1.28	5.12	0.000	2.502-7.805
	Transitional	1.97	0.63	2.13	0.033	1.018-2.682
Agro-ecology	Mid land *	1	-	-	-	
	Highland	1.65	0.408	2.03	0.042	1.018-2.682

*Reference category

Three hundred eighty four (384) honeybee colonies were assessed for the presence of Amoeba disease (*malpighamoeba mellificae*). The overall Amoeba disease was found to be 82.3% (n=316). The current result indicated that honey bee Amoeba disease was higher in traditional types of hive (84.9%) followed by transitional hive(79.81%), and the modern type of hive was found to be the slightest diseased type of hive colony(77.8%) although statistically significant difference was not observed between these hives($p>0.05$). The result also indicated that Amoeba disease was more common on highland (85.9%), than by mid land agro-ecology (80.5%) although, statistically significant difference was not observed between these agro-ecologies ($p>0.05$) (Table 13).

Table 12 Prevalence of Amoeba disease with its associated risk factors

Observed risk factors	Categories	No of hive examined	Amoeba disease (%)	Chi square	P value
Hive types	Modern	72	56(77.8)	2.39	0.30
	Traditional	218	185(84.9)		
	Transitional	94	75(79.81)		
Agro-ecology	Highland	128	110(85.9)	1.75	0.18
	Mid land	256	206(80.5)		
Overall proportion		384	316(82.3)		

The univariate logistic regression analysis pointed out that traditional type of hive was 1.6 times more infected by Amoeba infected than the modern hive (OR=1.6, 95% CI= 0.821-3.123), and the transitional type of hive was also found to be 1.13 times infected by Amoeba disease (OR=1.13, 95% CI= 0.533-5.612) than the modern type of hive. As well as, honey bee was 1.49 times more likely to be affected by Amoeba disease in Highland agro-ecology (OR=1.49, 95% CI= 0.825-2.667) as compared to the mid land agro-ecology (Table 14).

Table 13 Univariate Logistic regression analysis of risk factors associated with Amoeba disease

Variables	level	OR	SE	Z	P>/z/	95% CI
Hive types	Modern *	1	-	-	-	-
	Traditional	1.6	0.546	1.38	0.167	0.821-3.123
	Transitional	1.13	0.431	0.31	0.753	0.533-5.612
Agro-ecology	Mid land *	1	-	-	-	-
	Highland	1.49	0.444	1.32	0.188	0.825-2.667

*Reference category

To identify Chalk brood disease (*Ascosphaera apis)* three hundred eighty four (384) honeybee colonies were assessed for the presence of Chalk brood disease. The overall prevalence of Chalk brood disease was found to be 51.04%. The current result showed that Chalk brood disease was higher in traditional types of hive 123(56.4%) followed by transitional hive 44(46.8%), and the modern type of hive was found to be least affected 29(40.3%), and it was significantly varied among hives types ($p < 0.05$). The result also indicated that Chalk brood disease was more common in highland (68.8%) than in mid land agro-ecology (42.8%) and also there was significant difference between agro-ecologies ($p < 0.01$) (Table 15).

Table 14 Prevalence of Chalk brood disease with its associated risk factors

Observed risk factors	Categories	No of hive examined	Chalk brood disease (%)	Chi square	P value
Hive types	Modern	72	29(40.3)	6.538	0.038
	Traditional	218	123(56.4)		
	Transitional	94	44(46.8)		
Agro-ecology	Highland	128	88(68.8)	24.0938	0.000
	Mid land	256	108(42.2)		
Overall proportion		384	196(51.04)		

The univariate logistic regression analysis indicated that traditional type of hive was 1.92 times more infected by Chalk brood disease than the modern hive (OR=1.92, 95% CI= 1.117- 3.300), and the transitional type of hive was also found to be 1.304 times infected by Chalk brood disease (OR=1.304, 95% CI= 0.701- 2.429) than the modern type of hive. Besides this, honey bee was 3.015 times more likely to be infected by Chalk brood disease highland agro-ecology (OR=3.015, 95% CI= 0.825-2.667) as compared to the mid land agro-ecology (Table 16).

Table 15 Univariate Logistic regression analysis of risk factors associated with Chalk brood disease

variables	level	OR	SE	Z	P>/z/	95% CI
Hive types	Modern *	1	-	-	-	
	Traditional	1.92	.531	2.36	0.018	1.117- 3.300
	Transitional	1.304	0.84	.414	0.401	0.701- 2.429
Agro-ecology	Mid land *	1	-	-	-	
	Highland	3.015	.69	4.82	0.000	1.925- 4.721

*Reference category

5 DISCUSSION

The participation of women in beekeeping activities in the study areas is much lower than males, of 90 sampled households interviewed, about 91.1 % were male headed and the rest 8.9 % were female headed. This might be due to the fact that even though women are able to work, beekeeping is considered as the work of men in the study areas. The limited number of female participants in beekeeping activity is agreed with Mujuni *et al.,* (2012), Haftu and Gezu, (2014). Getu and Birhan**, (**2014) this is because of the fact that traditionally cultural norms in Ethiopia consider beekeeping as men's job only. Tessega, (2009) also described that participation of women in beekeeping activities is very low mainly because of fear of bee stings and lack of experience. However, the study result indicated that the participation of women in beekeeping is better than the finding of Awraris *et al*., (2012) in Southern part of Ethiopia.

Majority of the respondents (37.8%) who had been engaged with beekeeping were illiterate. Empowering beekeepers with knowledge and skills ensures availability of modern technologies Mujuni *et al*., (2012). Similarly, Workneh, (2011) reported that education increases the access to information and thereby possible knowledge of beekeepers regarding modern hive. It also increases the understanding of the technology and practice of facilitates. Therefore, education is an important factor which if lacking can negatively impact on future improved beekeeping and adopting new technologies. The study result agreed with the findings of Dabessa and Belay, (2015), who reported 42.9% of beekeepers in Oromia special zone Walmara district cannot read and write. Were as result is disagreed with the report of Tessega, (2009) in which most of the respondents were capable of read and write in his study area (Burie district of Amhara region)

In this study, age of respondents was also considered as important factor and average age of 43.7 years old which the productive ages in Ethiopia. In attribute to this Beyene and

Verschuur , (2014) also reported from Wonchi district of south west Shewa zone that farmers in the most productive age are actively engaged in beekeeping activities.

The current result showed traditional hive was the leading (80%) hive type that had been used in the Ejere District where as only 10.7% transitional and 9.3% modern hives constitute, respectively, In the traditional beekeeping method, beekeepers understood from experienced beekeepers with the knowledge being passed from generation to generation. Hence, majority of beekeepers had been using traditional hive types. Beekeepers also preferred local traditional hives for its convenience to construct and cost effectiveness and less dependency on external inputs. However, these findings disagreed from the study by Haftu *et al.,* (2015), in central zone of Tigray who reported 41% household heads use both traditional and modern beehives and the rest 27.7%, 30.1% and 1.20% only owns traditional, modern and transitional beehives, respectively.

Larger part of the beekeepers (58.9%) in the study areas placed their honeybee colonies at the back yard while about (25.6 %) of the beekeepers placed their honeybee colonies placed in inside house. This finding is agreed with the research finding of other workers Tessega, (2009) Gidey *et al*., (2012); Nebiyu and Messele, (2013); Niguse, (2015), who reported that most beekeepers placed their honeybee colonies at back yard and inside the house.

In the study areas the respondents declared that they harvest about 4.8 kg of honey from the traditional beehives, 10.1 kg from transitional and 18.95 kg from modern (improved movable frame hives per harvest). This is similar to the result Beyene and Verschuur, (2014) who reported 5.22, 10.83 and 15.2 for traditional, transitional and modern hive respectively. The greater parts of the respondents (71.1%) collect honey once in a year while 28.9% of the respondent's harvested honey twice. Kajobe, *et al*, (2009) stated that frequency and amount of honey harvested varied depending on seasonal colony management practices (skill of beekeepers); flowering condition of major bee forage (rainfall) and type of beehive.

The major problems affecting beekeeping development in the study areas in decreasing order were pests and predators, high cost of modern hives and accessories, agro-chemical application, honey bee disease, poor management, honeybee colony, shortage of bee forage and absconding,the current result is in agreement with others Assefa, (2009); Kerealem *et al*., (2009); Tesega, (2009); Workneh and Paskur, (2011); Adeday *et al*., (2012); Assemu *et al*.,(2013); Nebiyu and Mesele, (2013); Haftu *et al*., (2015); Haftu and Gezu, (2014) who reported that honeybee pests and predators are the major problems of beekeeping in all regions of Ethiopia. Also other studies Gidey and Kibrom,(2010); Adeday, (2012); Kerealem *et al*., (2009) reported the effect of agrochemical application around the crop field as the main bottleneck constraints of the beekeeping sectors in Tigray and Amhara Regions, respectively.

The district farmers are producing mainly wheat, barley, *teff*, chick pea and different horticultural crops. They use chemical spray such as pesticide and herbicide for pests and weed controlling without considering damage it cause on bee colonies. The interviewed farmers stated that a number of bee colonies either die or absconded from their hive due to extensive use of agro-chemical in the district. The chemical spray used by district farmers is also destroying bee forage like herbs and shrubs which is used as sources of bee forage. The use of pesticides that kill bees and herbicides are not toxic to bee colonies but destroy many plants that are valuable to bees as sources of pollen and nectar. Insecticides have more devastate effect on bee colonies compare to herbicides Kerealem *et al*, (2009); Beyene and Verschuur, (2014)

The occurrence of pests and predators, honey badger, ants, wax moth, bee-eater birds, spiders and lizards were reported in Atsbi-Womberta Workneh, (2011), These pests and predators were also reported from Bure district Tesega , (2009), Kilte-Awlaelo district were reported Adeday *et al*., 2012). Gomma district by Chala *et al.*, (2013), Central zone of Tigray by Haftu *et al*., (2015) and from Walmara district Dabessa and Belay, (2015). The same authors listed out ants and wax moth top ranked predators and pest of honeybees. In Ethiopia, more than 15 honeybee pests were identified and recorded

Desalegn (2001); Desalegn and Amssalu, (2001); Desalegn and Yosef, (2005). According to these studies, ant, wax moth, mice, birds, honey badger, wasps, death's head hawks moth, bee lice (*braula coeca*), beetles , lizards, toads, prey-mantis, spiders, pseudo scorpions were among the major honeybee pests and predators registered locally. In this study, ant was found to be the first ranked pest in the study areas. Same results were reported from different areas of Ethiopia like Addis Abeba Desalegn and Yosef, (2005), Atsbi-Womberta Workneh, (2011), Bure district Tesega, (2009), Keffa, Shako and Bench- Maji zone Awraris *et al*., (2012), Gomma district Chala *et al.*, (2013) and Central Tigray Haftu *et al*., (2015).

The overall prevalence of bee lice observed in the study was much greater than the previous reports in Wukro District Adeday *et al*., (2012) which is 5.5% in adult honey bees. However, the current finding was in line with the report by Gizachew *et al*., (2013), who found 42% lice prevalence in and around Holeta. The examination result revealed higher prevalence of bee lice in mid land (46.1%), than highland agro-ecology (38.3%), this finding was in line with the report of Gizachew *et al*., (2013) who suggested that the difference in environmental factors like temperature, which might affect multiplication or survival of bee lice.

The overall prevalence of Nosema disease was 69.8% greater than the previous reports in Ethiopia Diagnosis made on 152 honeybee colony at Addis Ababa reported prevalence of 53.3% Desalegn and Yosef,(2005). In Ethiopia Nosema was also reported from different regions with varying prevalence ranges such as 58% in Oromia, 60% in Benishangul-Gumuz and 47% in Amhara regions Aster *et al*., (2010). In the central highlands of Ethiopia, Nosema infection rate was reached up to 82 % Amsalu, (2012). The overall prevalence level of *Nosema apis* 81.7% in highland and 66.4% midland was recorded. This might be due to the effect of temperature and humidity that affect the spread of *Nosema apis*. The current finding is in agreement with the finding of Amsalu, (2012) who stated that increase in humidity and rainfall limit honeybees to fly out for cleansing, which in turn enhances spread of the disease among the members and autoinfection. The overall prevalence of *Nosema apis* have significant variation between hives ($p < 0.01$), it

was higher in traditional than both modern and transitional hive types. The highest prevalence of *Nosema apis* observed in traditional hive might be associated with the difference in the management practice. Traditional beehives are difficult to easily manipulate and control honeybee pests and diseases and would become susceptible to the pests and disease.

The overall Amoeba disease was found to be 82.3%. This finding is higher than diagnosis made on honey bees in field and laboratory at Addis Ababa reported a prevalence rate of 73% of amoeba prevalence. The diseases was also reported with high prevalence rate in different regional state of Ethiopia such as; Oromia region with prevalence rate (88%), Amhara region (95%) and 60 % in Benishangul- Gumuz Aster *et al*, (2010).

The overall prevalence of *malpighamoeba mellificae* in highland was (85.9%) and in mid land agro-ecology (80.5%). The present result was similar to the findings of Guesh *et al.,* (2015) who recorded 85% in case highland agro ecology. The idea was supported by FERA, (2013) explaining that bees are unable to retain the large accumulation of water in their bowels, resulting in diarrhea. Fermented stores also stimulate dysentery, as will acid-inverted sucrose.

The overall chalk brood disease was found to be 51.04%. The current result was lower than the previous reports conducted in different part of Ethiopia at different times. During the first time of its discovery in Ethiopia by Desalegn, (2000), 61.5% of apiaries and 17.4% honeybee colonies were infected with the *Ascosphaera apis*. Afterward, the research conducted around Shoa and Arsi zones of Oromia region, about 56.5% was reported Desalegn, (2001). The current result was greater than result conducted at around Addis-Ababa also revealed about 43% prevalence Desalegn, (2006). The diagnostic Chalk brood survey in all beekeeping potential regions of the country Aster *et al*., (2010), 37.12%, 19.9% and 17.9 % prevalence were reported for Amhara, Oromia and Benshangul-Gumuz regional states respectively. The risk factors for chalk brood disease considered during the study were agro-ecology, colony hive type. Taking into consideration agro-ecology, the highest prevalence rate was recorded in highlands

(68.8%) in mid land agro-ecology(42.8%). This observation agrees with the work of Desalgn, (2000) reported that a chalk brood disease is more prevalent in damp and cool conditions and *Ascosphaera apis* grows best when the brood is chilled. Additionally, Aster, (2010) reported that most *dega*, *woinadega* and wet *woinadega* climatic zones remarkably suitable for the growth of *Ascophera apis*.

Although there are many constraints in the study area, there are also opportunities for future honey production improvement in the study area were Presence of huge number of bee colonies, High demand for local honey from honey traders and consumers and Proximity of the area to big city and towns,

According to the Ejere district Livestock and fishery resource development office, there are about 4121 traditional, 384 transitional and 255 modern bee hives in the district. The availability of these huge number of bee colonies in the area will give great opportunities for the district beekeepers for those who want to expand and produce more honey in the future.

The utilization of honey increase with the income of people. Currently, the incomes of local people have been improving and the demand for honey consumption is also increasing. These in turn will create good opportunities and anticipate in the future for those beekeepers living in the area to expand beekeeping activities.

Ejere district is close to big city such as Addis Ababa and big towns such as Holeta and Ambo. Beekeepers that produce honey easily can take and sell their honey in these towns and city. This will create good market for the district beekeepers.

6 CONCLUSION AND RECOMMENDATIONS

Questionnaire survey of this study illustrated that the participation of women in beekeeping activities in the study areas is much lower than males. The current study showed that honey productions are hampered by several constraints namely pests and predators, high cost of modern hives and accessories, improper application of agrochemical, honey bee diseases, poor management, shortage of bee forage and absconding in the study areas. Moreover, insufficient knowledge and skill transfer about transitional and modern bee-hives, unavailability of bee-hive accessories, and lack of encouragement of farmers to participate in beekeeping and enhancing the capacity. The study revealed that Ants, Wax moth, Honey badger, Spiders, Termites, Hive Beetles, Lizards and Bee eater birds were found harmful pests and predators of honey bee in the study area. The disease investigation result showed that parasites and pathogens such as, bee lice, nosema diseases, amoeba diseases and chalk brood diseases found major honey bee parasite and disease. Finally, agro ecological zones and types of hives were identified as risk factors for occurrence of honey bee parasites and diseases. Based on the above conclusive remarks the following recommends are forwarded:

- Efforts should be geared to alleviate the main constraints that hindered beekeeping development in the district. Therefore, there is a great need for attention in providing beekeeping equipment and their accessories.
- Increasing the productivity, production and quality of honey by improving the management of the traditional hives and introducing improved (Modern) bee hives the effect of agrochemicals application on honeybees and means of minimization their effect should be addressed.
- Awareness creation and assistance is needed to empower women in the beekeeping activity.
- Agro ecological problems should be solved through reduction of humidity and good ventilation of the bee-hives which creates unfavorable

environment for most of honeybee pathogens and hence increases productivity.

- Utilize the existing beeswax of the area through provision of training on collection of the crude bees -wax and extraction of it.
- Large scale and comprehensive research on constraints and honey bee diseases are highly recommended to set appropriate solution.

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8 APPENDICES

Appendix table 1 Major pests and predators of bees in Ejere district as ranked by respondents and preventive and control measures Total sample (n=90)

Pests and predators	**Summarized major traditional local prevention methods**
Ants	Place ash as natural repellent and clean apiary, plastering hives stands with plastics and burning the ants with fire, destroying ant's home and queen, engine oil around the hive stands. Fumigation, plastering of thin rubber sheets and metals between the hive and hive stands.
Wax moths	Clean apiary, remove old comb and strengthen the colony.
Honey badger	Using dog, strong fencing around the hives and killing.
Spiders	Clean apiary, removal of spider's web and killing.
Termites	Cleaning apiary, destructing its home and killing their queen, application of ash under the hive
Hive beetles	Clean apiary, narrowing the hive entrance, hand picking and killing.
Lizards	Clean apiary, use spin around and killing.
Bee eater Birds	Placing a pole seems the image of human around the hive (by using cloth, plastic Materials and bones), spin around the hive, killing using stone or other material.

Appendix figure 1 Different types of hives

Modern hive

Traditional hive

Transitional hive

Appendix figure 2 Different honeybee pests

Honey bee comb affected by Wax moth

Hive Beetles

Appendix table 2 Questionnaire for beekeepers

1. **Personal Information**

1.1. Name of enumerator_____

1.2. Name of respondent ----------

1.3. PA/Kebele ----------

1.4. Village (Got) ----------

1.5. Sex ----------

1.6. Age ----------

1.7. Marital status 1. Single 2.Married 3. Divorced 4. Widow 5. Widower

1.8. Education of the interviewee

1. Illiterate
2. Can read and write
3. Primary education (1-4)
4. Junior (5-8)
5. Secondary education (9-12)
6. College
7. Other (specify)----------

1.9. Total family size 1= below 3

2= 3-8

3= Above 8

2. **Livestock Production**

2.1. Which livestock *species* do you have? How many?

Cattle					Shoats		Equines			
Ox	Cow	Bull	Heifer	Calves	Sheep	Goat	Donkey	Horse	Mule	Chicken

2.2.What are the major livestock production constraints to you?

2.2.1. Shortage of feed 1.Yes _____ 2. No_____

2.2.2. Shortage of grazing land 1.Yes _____ 2. No_____

2.2.3. Shelter and housing 1.Yes _____ 2. No_____

2.2.4. Lack of drinking water 1.Yes _____ 2. No_____

2.2.5. Parasites 1.Yes _____ 2. No_____

2.2.6. Diseases 1.Yes _____ 2. No_____

2.2.7. Low productivity 1. Yes _____2. No_____

2.2.8. Market unavailability 1.Yes _____ 2. No_____

2.2.9 Others (specify): _____

3. Land utilization

3.1.1 Total land holding _____

3.1.2 Farmland _____

3.1.3 Forest land _____

3.1.4 Grazing land _____

3.1.5 Others _____

4. Beekeeping

4.1. Do you keep bees? Yes _____ No_____

4.2. When did you start beekeeping? _____Years

4.3. How did you start beekeeping?

1. By catching the swarm
2. Gift from parents
3. By purchasing the honeybee colony
4. Through inheritance
5. Any other (specify)_____

4.4. If the answer for question 4.3 is buying, does the bee colony sale in your locality? 1. Yes _____ 2. No_____

4.5. If yes, what is the price of one colony? _____ ETB

4.6 How many honeybee colonies you owned?

1. Traditional_____
2. Transitional_____
3. Modern_____

4.7. Where did you keep your bee colonies?

No	Site or placement of hive	Traditional	transitional	modern
1	Backyard			
2	Under the eaves of the house			
3	Inside the house			
4	Hanging on trees near homestead			
5	Hanging on trees in forests			
6	Others (specify)			

4.8. Do you have empty beehives? 1. Yes _____ 2. No_____

4.9. If yes, list the number of empty hives you have.

No	Types of beehives	Numbers	Reasons (use causes in question4.8)
1	Traditional		
2	Transitional		
3	Modern		

4.10. What are the major pests and predators found in the area that threat your colonies? List in order of importance.

No	Pest	Rank	Local control methods
1	Ants		
2	Wax moth		
3	Honey badger		
4	Bee eating Birds		
5	Hive Beetles		
6	Spiders		
7	Termites		
8	Lizard		
9	Others (specify)		

4.11. Do you use agrochemicals/chemicals in your locality? 1. Yes ____ 2. No____

4.11.1. If yes, why agrochemicals/chemicals do you apply?

1. Crop pests control 1. Yes _____ 2. No_____
2. Weeds control 1. Yes _____ 2. No_____
3. Malaria control 1. Yes _____ 2. No_____
5. Others (specify): _____

4.11.2 What type of agrochemicals/chemicals are farmers using?

_____

4.11.3 When do you use agrochemicals/chemicals (months)?

_____

1. Insecticide_____
2. Herbicide_____

4.11.3 Stage of crop when agrochemicals/chemicals are used

1. pesticides

1.1 Pre-sowing and pre-emergence_____

1.2 Before flowering_____

1.3 Whenever pest occur for insects_____

2. Herbicide

1.1 Pre-sowing and pre-emergence_____

1.2 Before flowering_____

1.3 Whenever herb occur _____

4.11.4 Do agrochemicals/chemicals affect your honeybees? 1. Yes ____ 2. No____

1. If yes, how many colonies did you lost due to chemicals? _____

When? (Year and months):_____

2.What measures did you take to protect your bee colonies from agrochemicals /chemicals? _____

4.12. Does water available for your honeybees at all the time? 1. Yes_____ 2. No_____

4.12.1. If yes, where do your honeybees get water? (Circle one or more)

1. Streams 4. Ponds
2. Rivers 5.Water harvesting structures
3. Lakes 6. Others: specify_____

4.12.2. If your response is no, how do you provide water to your bee colonies?

1. Yes_____ 2. No_____

4.13. Which of the following beekeeping equipments and protective materials you have or available to you when ever required?

No	Materials	Yes	No
1	Hives		

2	Smoker		
3	Veil		
4	Gloves		
5	Overall		
6	Boots		
7	Water sprayer		
8	Bee brush		
9	Queen catcher		
10	Queen excluder		
11	Chisel		
12	Knife		
13	Embeder		
14	Frame wire		
15	Honey presser		
16	Beeswax (pure)		
17	Casting mold		
18	Uncapping fork		
19	Honey extractor		
20	Honey strainer		
21	Honey container		
	Others		

4.13.1 .If no, why?

1. Not found
2. Expensive
3. I use traditional
4. Any other_____

4.14 .Do you provide supplementary feed to your honeybee during feed shortage period?

Yes _____ No _____

4.14.1. If yes, what do you feed your honeybees?

1. Sugar
2. Barely flour (beso)
3. Shiro
4. Honey
5. Any other _____

4.15. What are the characteristic features of your honeybees?

Behaviour: 1. Docile_____ 2.Aggressive _____ 3. Very aggressive

4.16. Do you visit and inspect your beehives and colonies? 1. Yes____2. No_____

4.18.1. Frequency of inspection

A. frequently B. sometimes C. rarely

4.18.2. If no inspection, what is the reason?_____

_____

___

4.17. Do you clean your apiary? 1. Yes 2. No

If no why? _____ 4.18. D

4.18.1 If your response is yes, what is the frequency?

1. Every season 1. Yes _____ 2. No_____
2. Every year 1. Yes _____ 2. No_____
3. Once in two years 1. Yes _____ 2. No_____
4. Others, specify: _____

4.18.2.Do you control / prevent/ swarming? 1. Yes_____ 2.No_____

4.18.3. What methods do you use to control / prevent/ swarming?

1. Removal of queen cells 1.Yes _____ 2. No_____
2. Harvest or cut honey combs 1.Yes _____ 2. No_____
3. Return back to the colony 1.Yes _____ 2. No_____

4. Supering 1.Yes _____ 2. No_____

5. Using large volume hive 1.Yes _____ 2. No_____

6. Others, specify: _____

4.19. What kind of beehive products you produce?

No	Products	Traditional	Transitional	Modern
1	Honey			
2	Crude beeswax			
3	Propolis			
4	Others, specify			

4.19.1. List the amount of your beehive products and frequency of harvest per annum.

No	Types of beehives	Honey production		Crude beeswax		Propolis	
		Kg/hive	Frequency	Kg/hive	Frequency	Kg/hive	Frequency
1	Traditional						
2	Transitional						
3	Movable-frame						

5. **Market**

5.1 Is there ready market for your hive products Yes _____ No_____

5.1.1 If yes, where do you sell your honey?

1. At market found in nearby town
2. At farm gate
3. Cooperative
4. Tej house
5. Any other (specify)_____

5.1.2.What are the sale prices of your beehive products?

No	Products	Traditional		Transitional		Modern	
		Amount	Price(Birr)	Amount	Price(Birr)	Amount	Price(Birr)
1	Honey						
2	Beeswax						
3	propolice						

6. Constraints of beekeeping

6.1.What are the major constraints of beekeeping in the area? (Rank them)

No	Constraints	Rank	What measures will be taken?
1	High cost of modern hives and accessories		
2	Honeybee colony		
3	Shortage of bee forage		
4	Shortage of water		
5	Drought (lack of rainfall)		
6	Absconding		
7	Pests and predators		
8	Diseases		
9	High temperature		
10	High wind		
11	High rainfall		
12	Agro-chemicals		
13	Death of colony		
14	Migration		
15	Swarming		
16	Poor management		

17	Marketing		
18	Others (specify)		

6.2.Does beekeeping profitable to the area? 1. Yes _____ 2. No_____

6.3.Do you participating in beekeeping extension packages? 1. Yes ____

2. No___

6.4.Do you get beekeeping training? 1. Yes _____2. No__

6.4.1.If your response is yes:

No	Places of the training	Duration	Organized by	remark
	1			
	2			

6.4.2. If your response for question 6.4 is no, do you need beekeeping training?

1. Yes _____ 2. No_____

Compiler: Name _____

Signature _____

Date _____

Duration: Starting time _____ **Ending time** _____

Thank you