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Research Article

Diagnostic Survey of Honeybee Diseases, Pests and Predators in Selected Districts of West Hararghe Zone of Oromia, Ethiopia

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Abstract

The study was conducted in Darolabu, Ciro and Gemechis Districts of West Hararghe Zone with the objective of determining the occurrence and prevalence of honeybee diseases, pests and predators and their effects on honeybee colonies and bee products in selected districts of West Hararghe Zone. Three districts were purposefully selected based on their relative beekeeping potentials in highland, midland and lowland agro–ecologies. Three Kebeles from each district and ten beekeepers from each Kebeles were selected for the interview. For major honey bee diseases and pest examination, a total of 68 suspected bee colonies were sampled. Out of the total respondents, 58% and 77.4% of beekeepers replied that honeybee colonies and honey yield, respectively, were decreasing from time to time. The respondents listed a lack of bee forages, disease, pest and predators as the major constraints of beekeeping in the study area in their decreasing orders. Wax moth, honey badger and hive beetles were more commonly occurring pests and predators, while nosema and amoeba were among the important diseases. The prevalence all bee diseases and pests including nosema, amoeba, varroa mite, bee lice, wax moth, and small hive beetle, was not associated with either agro-ecology or hive type. The factors contributing for their prevalence across all agro-ecologies and hive types need further study.

Keywords

West Hararghe, Honeybee, Diagnostic, Disease, Pest and Predator

1. Introduction

Ethiopian overall economic performance is inextricably linked to the performance of its agricultural sector. Apiculture is among the effervescent agricultural enterprises practiced throughout the country. It has multifaceted advantages and plays important role in increasing the productivity of food and cash crop and conservation of natural resources through pollination. Furthermore, it is a means of income for landless and low income individuals. Thus, beekeeping contributes to food security and poverty reduction. Moreover, it contributes to the country's foreign currency earnings through the export of the products.

Honeybees, especially honeybee broods, are attacked by a range of disease causing organisms and parasitic mites worldwide. For instance, the serious decline of honeybee populations in Europe and the USA, commonly referred to as colony collapse disorder (CCD), which is mostly associated

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with honeybee diseases and pests, seriously affects the production, quality, safety and marketing of honeybee produces. In 2010, the United State Department of Agriculture (USDA) reported that data on overall honeybee losses for the year indicated that 34% of losses occurred. This is a threat and an alarm for governments, conservationists and the private sector engaged in the subsector in different parts of the world, with similar decline in Africa. The honeybee diseases, pests, predators and indiscriminate use of agrochemicals are among the major hindrance to the development of Ethiopia's beekeeping industry. However, not all of these issues may affect everyone equally and they may vary from location to location [19]. This is because the agro-ecologies of Ethiopia are not only favourable to honeybees but also to different kinds of honeybee diseases, pests, and predators that are interacting with the lives of honeybees [7]. Like honeybee in the world, honeybee diseases, pests and predators are considered driving forces that challenge local honeybees as well as the beekeeping industry of the country. The most commonly known honeybee diseases reported to exist in Ethiopia are varroosis, nosemosis, amoeba, and chalkbrood [1, 4]. Small hive beetle (SHB), different ants, and bee lice are major types of honeybee pests and predators that affect honeybees in the country [4]. However, the evidence on the distribution and magnitude of diseases and pests is still insufficient. It is true that the seriousness of honeybee disease and pests differs in and/or among colonies, apiaries, areas, and weather conditions. The West Hararghe Zone is among the potential zones for beekeeping in Oromia Regional State. The zone has favourable conditions that support considerable number of honeybee colony populations with a wealth of traditional beekeeping practices. However, a number of limitations hinder the use of better beekeeping practices. This is because honeybee diseases, pests, and predators are the most common challenges to the beekeeping subsector of the zone. As for the nation, the evidence on the distribution and magnitude of diseases and pests is still insufficient in the zone, which needs an urgent investigation to generate as well as document the current status of the prevailing diseases and pests, as well as the occurrence of unreported ones, in order to address these issues and ensure the sustainable development of beekeeping. Therefore, the objectives of this study are to determine the occurrence and prevalence of honeybee diseases pests and predators in the West Hararghe Zone, as well as their effects on honeybee colonies and their products.

2. Materials and Methods

2.1. Study Area Descriptions

The study was conducted in potential beekeeping areas of West Hararge. From the zone, three representative districts, like Gemechis (highland), Ciro (midland) and Daro Labu (lowland) were selected based on their potential for beekeeping. From each district, three representative kebeles were selected; and two to three bee colonies were randomly inspected both externally and internally for the occurrence and infestation of honeybee diseases and pests.

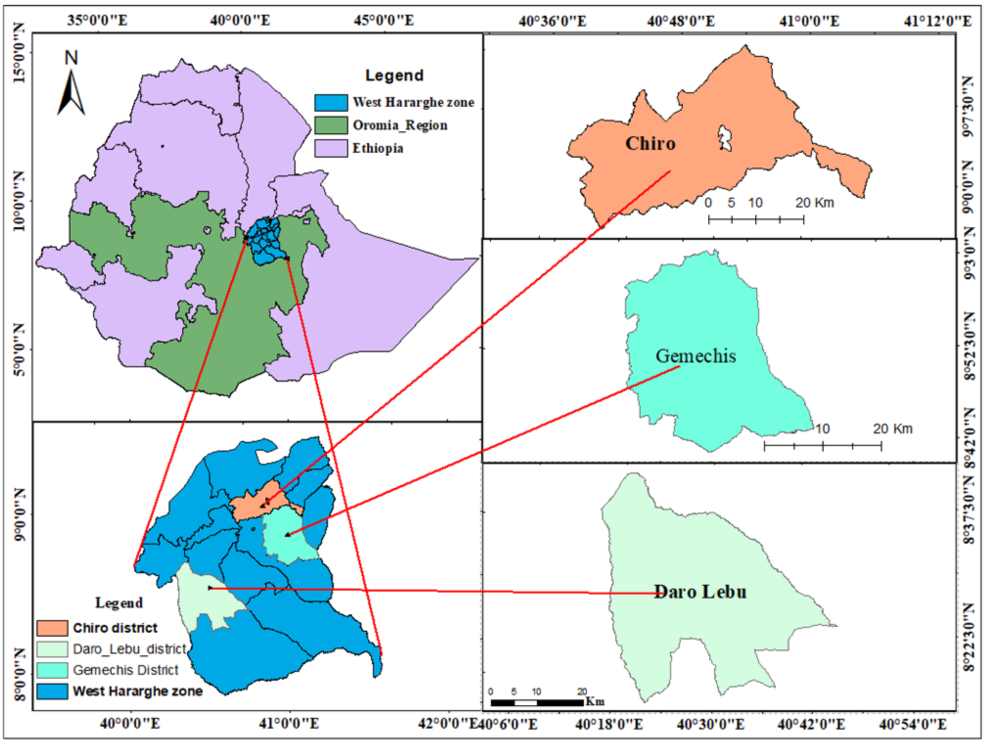

Figure 1. Map of the study areas.

2.2. Study Design

A cross-sectional study was conducted on honeybee colonies managed using traditional and modern beekeeping methods in the three districts of West Hararghe Zone. The prevalence of major honeybee diseases and pests, which are causes of significant economic loss in honeybees was assessed by collecting samples from the colonies. Then, the identification of honeybee diseases causing pathogens were conducted. The presence or absence of the diseases or pests was confirmed by employing both clinical and parasitological methods. Honeybee colonies were inspected internally and externally to collect data on their health status, and samples of adult honeybees were collected for further laboratory diagnosis. Records on the history and status of the colony and clinical symptoms of diseases and pests were taken. In order to examine the prevalence/distribution and infection/infestation rates of the onset of diseases and pests according to the activity periods of honeybees, samples were collected. Finally, prevalence at the apiary level and infestation or infection at the colony level were calculated using [19].

$$\text{Prevalence} = \frac{\text{Number of positive cases x 100}}{\text{Total number of sampled population}}$$

2.3. Sampling Techniques and Sample Size Determination

A multistage sampling technique was employed to select districts, beekeepers and honeybee colonies. In the first stage, three districts were selected purposively based on their relative beekeeping potential and representativeness to highland, midland and lowland agro-ecologies. In the second stage, three representative peasant associations (kebeles) were selected from each district proportional to the agro-ecological variation using purposive sampling techniques based on the beekeeping potential and transport accessibility of the kebeles. In the fourth thrid stage, honeybee colonies and beekeepers were sampled from all rural kebeles using a simple random sampling technique. The sample size required for the study was determined based on sample size determination in a random sampling method using 50% expected prevalence with a 95% confidence interval at 5% absolute precision, using [17] as follows:

$$n = \frac{1.962 * \text{Pexp} * (1-\text{Pexp})}{d^2}$$

Where: n=required sample size, Pexp = Expected prevalence (50%), d= desired absolute precision (5%).

Both adult bees and brood samples were randomly collected from each bee colony and examined in the laboratory following the standard methods for Varroa mite used by [5]. A survey questionnaire were developed and used to generate relevant information related to honeybee diseases and pests and their economic importance in different districts and Kebeles levels. In the case of kebeles, experienced beekeepers were purposively selected and interviewed. The major points included in the questionnaire was to state the major honeybee pests and predators, any clinical symptoms of honeybee diseases and pests, the level of their economic importance, etc.

2.4. Sampling Procedure

From each sampling locality, adult honeybees and sealed brood samples were taken from sampled honeybee colonies. In the absence of sealed brood, empty old brood combs were taken to see the remnant symptoms of disease attacks. Moreover, field observations were carried out on the presence of pests and the necessary records were kept. In addition to this, beekeepers were asked if there had been any occurrences of some diseases in the past (like chalk brood) that were not now observed and their reports were recorded.

2.5. Field Colony Inspections

Colony inspections were carried out for pest and disease. Diagnosis was conducted through colony inspections for major honeybee diseases, including nosema, amoeba, chalk brood, American foul brood, European foul brood (where there are suspected clinical symptoms). Besides field observations, laboratory testing for each type of disease was conducted following the standard procedures for each honeybee disease.

2.6. Laboratory Tests

2.6.1. Bacterial Diseases (*Nosema apis* and Amoeba)

For suspected colonies, the abdomens of 10-20 adult bees were removed and placed in a mortar dish with 1.0 ml of distilled water. The abdomens were ground with a pestle or the rounded end of a clean test tube to a paste. A cleaner preparation can be obtained by grinding the digestive tracts removed from the abdomens. A wet mount was prepared from the resulting suspension on microscopic slide with cover slips and examined under a light microscope for the presence of the spores with a magnification power of 40X. The presence of slippery and rod-shaped spores indicates the detection of *N. apis*, and the presence of round cysts and spore balls indicates the infection of adult honeybees with amoeba.

2.6.2. Fungal Diseases (Chalk Brood)

Both external and internal inspections were conducted for the presence of chalk brood clinical symptoms. Dry scales with white to dark coloured moulds and chalk brood mummies were carefully observed in the comb cells and on the ground under the hive entrances and bottom boards of the hives. Then, samples of mummies were taken from positive colonies and microscopic examination was undertaken in the laboratory for the presence of *Ascosphoraera apis* spores using a Zeiss AxioVert A.1 light microscope under a magnification power of 40X.

2.6.3. Examination for Varroa Mite

To examine the presence and infestation level of varroa mite in honeybees, the standard washing by soap method was followed [5]. Samples of 250-300 adult bees were collected from randomly selected colonies and brushed off directly into a wide mouth jar with a mesh lid. Furthermore, brood examinations were done by cutting off 5 x 5 cm brood comb areas from drone and/or worker pupae. About 100 pupae were removed from their cells using forceps and checked for the presence of varroa mites. Lastly, a number of Varroa mites per checked sample were recorded, and the infestation level per cell and per colony was determined.

2.6.4. Diagnosis for Major Honeybee Pests

The occurrence and economic importance of major honeybee pests, including wax moth, small hive beetle, ants, spiders, bee-eater birds, honey badger, bee lice, lizards and dead hawk moth, in the study areas were determined through beekeeper interviews, using semi-structured questionnaires and internal and external hive inspections. Moreover, clinical symptoms and infested combs, adult and larvae of small hive beetles and wax moths, and other decayed materials were observed in the hive through inspection of the beehives described by [12]. The presence of a small hive beetle infestation (*Aethina tumida)* was identified through its adult or larval and colony examination methods as larvae of SHB have pairs of prominent brownish dorsal spines on each segments with three pairs of anterior prologs only. The larvae of the wax moth have no spines but a number of setae (hairs) on each segment with 8 pairs of prologs (3 pairs, 4 pairs and 1 pair on the anterior, abdominal and last segments, respectively) [6]. Unlike small hive beetles, it produces silken galleries.

2.7. Data Analysis

All data was entered into Microsoft Excel spread sheets after the completion of the data collection work in the study areas. Then, the collected data were analyzed by descriptive statistics using SPSS software version 20 and the chi-square test. [20] rank index calculation was also employed to determine the order of importance of pests and predators, which challenges honey production in the study area.

3. Results and Discussions

3.1. Socio-Economic Characteristics of the Respondents

3.1.1. Sex of the Respondents

Out of the total number of beekeepers interviewed, 82.7% were male and the rest, 17.3%, were female in the study areas. The number of females engaged in beekeeping activities was very low. The reason may be the challenging nature of traditional beekeeping activities, especially forest beekeeping. This was in line with the reports of [18], who noted that the conventional placement of the hives in forest areas makes it impossible for women to operate them, thus reducing women's participation.

3.1.2. Educational Level of the Respondents

About 23.6% of the beekeeper were illiterate (did not received any formal or informal education), while the rest 33.3%, 16%, 16% and 7.2% can read and write, primary education, junior education and secondary education, respectively (Table 1). This reveals that beekeeping is practiced by both groups (literate and illiterate). The study result is in line with the findings of [16], that traditional beekeeping can practiced both by non-educated and educated groups. Empowering beekeepers with knowledge and skills ensures proper beekee management in which they can care for the health of theirs bee colonies [10]. Moreover, education is a key to increase the access to information thereby increase knowledge and skills of beekeepers, as well as how to keep healthy bees [18, 9].

Table 1. *Sex, educational level, age and family size of respondents.*

Socioeconomic Variables	Category	N (Frequency)	Percentage (%)
Sex	Male	67	82.7
	Female	14	17.3
Age	18-30	11	13.6
	31-45	52	64.2
	Above 45	18	22.2
Educational level	Illitraterate	19	23.5

Socioeconomic Variables	Category	N (Frequency)	Percentage (%)
	Can read and write	13	16.0
	Primary education	27	33.3
	Junior education	13	16.0
	Secondary education	6	7.4
marital status of the respondent	Single	5	6.2
	Married	76	93.8
Number of family members	below 5	38	46.9
	6-12	41	50.6
	above 12	2	2.5

3.1.3. Trends of Honeybee Colonies and Hive Products in the Study Areas

Out of the total respondents, 58% and 77.4% replied that honeybee colonies and honey yield were decreasing from time to time, respectively. Contrary to this, the respondents stated that their colony number and honey yield were increasing by 23.5% and 12.9%, respectively. Whereas, 18.5% and 9.7% of beekeepers stated that no change occurred in their colony number or honey yield, respectively (Table 2). The major causes of the decrease in the number of honeybee colonies and productivity of honeybees were disease, pests and predators, unwise use of agro-chemicals, and a lack of bee forage in the area. A decrease in honeybee colony numbers for similar reasons has also been reported in northern Ethiopia [8, 16, 21].

Table 2. *Trend of bee colonies number and honey yield in study area.*

Trend		Frequency	Percent
Trend of bee colonies number	decrease	47	58.0
	increase	19	23.5
	no change	15	18.5
Trend honey yield	decrease	48	77.4
	increase	8	12.9
	no change	6	9.7

3.1.4. Constraints of Beekeeping in the Study Areas

The respondents reasoned out that many factors were responsible for the decline in honeybee production. Lack of bee forages, diseases, pests and predators, extended dearth period, absconding of colonies and unwise use of agro-chemicals were among the causes mentioned (Table 3). This result agrees with the previous reports in the country [14, 15].

Table 3. *Causes of the decreasing number of colonies and honey yield over the years.*

Bee colony and honey yield reducing factors	Frequency	Percent
Disease	13	23.6
Pest and predator	12	21.8
Length of dearth period	10	18.2
Lack of bee forages	14	25.5
Pesticide	2	3.6
Absconding	4	7.2
Total	55	100.0

3.2. Behaviors of Honeybee Colonies Infested by Pests and Predators

According to the responses of sample respondents, honeybees' behaviors in the study areas were changed before and after infestation by pests and predators. The result indicated that the cleaning and foraging activity of honey bees changed after being attacked by pests and predators, which means that they were categorized as very good, good and poor (Figure 1).

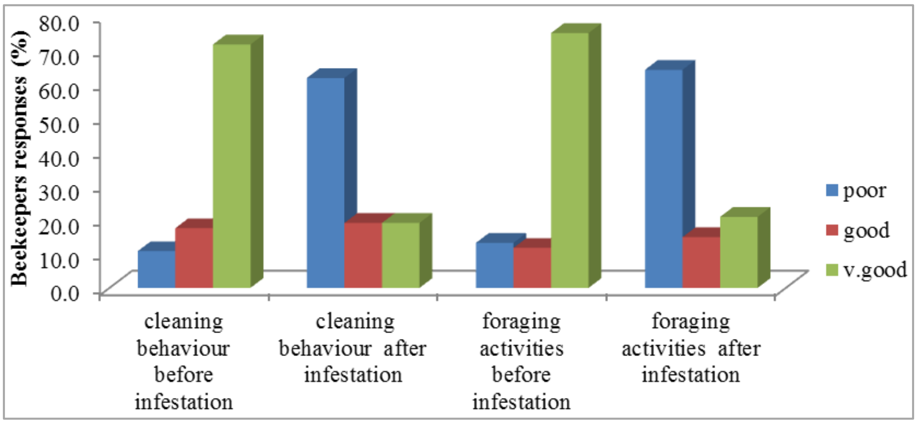

Figure 2. Colony behaviour before and after being infested by disease causing pathogens, pests and predators.

3.3. Major Honeybee Pests and Predators in the West Hararghe Zone

Sampled respondents reported the presence of pests and predators in the study areas. The major honeybee pests and predators mentioned were honey badgers (*Mellivora capensis*), spiders (Arachnids), ants (Dorylus fulvus), wax moths (*Achroia grisella*), bee-eater birds (Meropidae), small hive beetles (*Aethina tumida*), lizards, snakes, wasps and bee lice. According to the ranking index of the respondents, the wax moth was ranked first (Table 4) based on its economic importance, followed by birds.

Table 4. The major pests and predators of honeybees in the study areas.

Pests	Index	Rank
Ants	0.092079	5
Wax moth	0.327723	1
Birds	0.244554	2
Spider	0.159406	3
honey badgers	0.128713	4
Beetles	0.016832	6
Lizard	0.012871	7
Snake	0.00297	10
Wasps	0.00396	9
Bee lice	0.010891	8

3.4. Season of Occurrence for Pests and Predators

The pressure of pests and predators to honey bees varied from season to season in the study area. Wax moth, honey badger, hive beetles, spider and lizard were more commonly occur all the year around. Birds were highly occurring in rainy season. This is may be because of the less available foods of other sources for birds. Most ant attacks were also occurred at the beginning and end of rainy season (Figure 3).

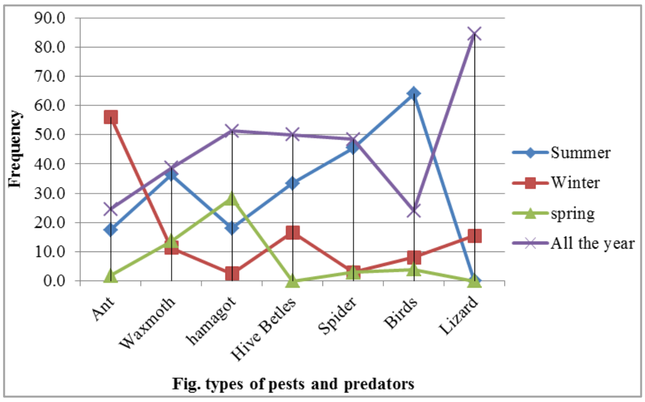

Figure 3. Types of pests and predators

3.5. Perception of Beekeepers Towards Honeybee Diseases

According to this study, about 65% of the respondents had information on disease transmission from infected colonies to healthy ones, while the rest, 35%, did not know if the disease was transmitted from infected to healthy colonies. The respondents had an idea on honeybee disease transmission mechanisms, such as equipment (47%) and bulk feeding (29%) (Table 5). The majority of the beekeepers responded (43%), saying that weak colonies were more affected by disease and pests than colonies with better strength (40%). Concerning the defensive behavior of honeybee colonies against disease and pest attacks, behaviorally highly aggressive honeybee colonies confer more defensive capability (53%) to disease and pest attacks compared to colonies with aggressive behavior (25%) and less aggressive colonies (22%). This indicated that honeybee colonies with very aggressive behavior had better defensive behavior against diseases and pest attacks.

Table 5. Frequency of responses on honeybee disease transmissions mechanisms and the level of colony defenses against diseases.

Description	Response variables	Frequency	Percentage
Diseases transmission from infected colonies to healthy ones	Yes	52	65
	no	28	35
Diseases transmission mechanisms	Equipment	37	47
	Bulk feeding	23	29
	Beekeepers	8	10
	Robbing	10	13
Colony status infected by diseases and pests attack	Weak	30	43
	Moderate	28	40
	Strong	12	17
Defensive behavior of honeybee colony against diseases and pests attacks	Aggressive	16	25
	Very aggressive	34	53
	Less aggressive	14	22

3.6. Prevalence of Honeybee Diseases and Pests

The present study revealed that the overall prevalence of *Nosema apis* in the West Hararghe Zone was 42.3%. The highest prevalence of *Nosema apis* was observed in Daro Labu Werada (lowland agro-ecology), followed by Gemechis Werada (highland agro-ecology) and the least was observed in Ciro Werada (midland agro-ecology) (Table 6). The highest prevalence was observed in traditional beehives, followed by modern beehives. Even though a higher prevalence of *Nosema apis* was observed in traditional beehives and lowland agro-ecology, the association between prevalence and hive type, and between prevalence and agro-ecology had not shown significant differences (P>0.05) (Table 6).

Table 6. The prevalence of Nosema apis and its association with agro-ecology and hive types.

Variables	Category	Total colony examined	Prevalence (%)	χ2	P-value
Agro-ecology	Midland	26	9 (34.6)		
	Highland	25	11 (44)	5.96	0.42
	Lowland	17	9 (53)		
Hive types	Modern	32	13 (40.6)		
	Tradition	36	16 (44.4)	2.407	0.49
Overall prevalence		68	29 (42.3)		

The overall prevalence of amoeba (*Malpighamoeba mellificae*) was 78% (Table 7). The current result showed that highland agro-ecology had the highest prevalence (96%) of amoeba, followed by midland (34.6%) and lowland (58.8%) agro-ecologies. However, the association between amoeba prevalence and agro-ecology as well as hive type was not significant ($p > 0.05$). Although similar results have been reported that amoeba is more common in highland areas than lowland and midland agro–ecologies [13] as well as in traditional hives than modern hives [11], these works did not state whether there was an association between agro-ecologies as well as hive types or not. Moreover, amoeba was more prevalent in traditional hives than modern hives, which is similar with the previous in North Gondar.

***Table 7.** The prevalence of amoeba and its association with agro-ecology and hive type.*

Variables	Category	Total colony examined	Prevalence (%)	χ2	P-value
Agro-ecology	Midland	26	9(34.6)		
	Highland	25	24(96)	18.67	0.097
	Lowland	17	10(58.8)		
Hive types	Modern	32	24(75)		
	Traditional	36	29(80)	6.52	0.368
Overall prevalence		68	53(78)		

3.7. Prevalence of Honeybee Pests

Results indicated that the prevalence of bee lice was higher in modern beehives (31.3%) than tradition beehives (22.2%), as well as in midland than highland (Table 8), but the p-value of a *chi square* showed no significant association for both factors. The higher prevalence of the bee at lower altitudes is in agreement with the report in the Northern Gondar of the Amhara Region [11].

***Table 8.** The prevalence of bee lice and its association with agro-ecology and hive type.*

Variables	Category	Total colony examined	Prevalence (%)	χ2	P-value
Agro-ecology	Midland	26	10 (38.5)		
	Highland	25	3 (12)	3.2	0.202
	Lowland	17	5 (29.4)		
Hive types	Modern	32	10 (31.3)		
	Traditional	36	8 (22.2)	0.83	0.36
Overall prevalence		68	18 (26.5)		

The overall prevalence of small hive beetles was 11.7% in the study area (Table 9). However, the level of prevalence was not associated either with the agro-ecology or the hive type. This could be due to the wide distribution of the beetle in the maize and sorghum growing nature of the districts [3, 2].

***Table 9.** The prevalence of small hive beetles and its association with agro-ecology and hive type.*

Variables	Category	Total colony examined	Prevalence (%)	χ2	P-value
Agro-ecology	Midland	26	1 (3.8)		
	Highland	25	4 (16)	2.66	0.615
	Lowland	17	3 (17.6)		
Hive types	Modern	32	4 (12.5)	2.87	0.238

Variables	Category	Total colony examined	Prevalence (%)	χ2	P-value
	Traditional	36	4 (11.1)		
Overall prevalence		68	8 (11.7)		

The current *chi* square test results showed that the prevalence of wax moth was neither associated with agro-ecology nor hive type (Table 10). Earlies works indicated that wax moth has wide scale distribution across the country [3, 2].

Table 10. *The prevalence of wax moth and its association with agro-ecology and hive type.*

Variables	Category	Total colony examined	Prevalence (%)	χ2	P-value
Agro-ecology	Midland	26	12 (46.2)	11.7	0.164
	Highland	25	9 (36)		
	Lowland	17	12 (70.5)		
Hive types	Modern	32	20 (62.2)		
	Traditional	36	13 (36.1)	5.98	0.2
Overall prevalence		68	33 (48.5)		

3.8. Prevalence of *varroa* Mites on Adult Bee

The study result showed that the prevalence of *varroa* mite was 94% in Daro Labu, 88.5% in Ciro Werada and 64% in Gemechis werada. This indicated that the hot environment of Gemechis werada is conducive to the spread of the mite. The result of varroa prevalence is relatively higher than the earlier report in the Tigray Region [4]. Regarding the association between prevalence and agro-ecology or hive type, the prevalence was not significantly related to both factors (Table 11). The observed figurative variation in prevalence between hive types could be attributed to the exchange of bee equipment during hive management in modern hives [21].

Table 11. *The prevalence of varoa mite on adult bees and its association with agro-ecology and hive.*

Variables	Category	Total colony examined	Prevalence (%)	χ2	P-value
Agro-ecology	Midland	26	23 (88.5)	13.6	0.322
	Highland	25	16 (64)		
	Lowland	17	16 (94)		
Hive types	Modern	32	28 (87.5)		
	Traditional	36	27 (75)	7.19	0.303
Overall prevalence		68	55 (80.8)		

3.9. Prevalence of *varroa* Mite on Sealed Pupae

The current results showed that the highest prevalence of varoa mite on brood was 57.6% at midland, followed by 41.2% at lowland and 24% at highland (Table 12). The present finding showed varroa mite was found in all agro-ecologies, but there no significant association between prevalence and agro-ecology. This indicates that the mite prevalence may be associated with other factors than agro-ecology or hive type that need further work.

Table 12. *Prevalence of varoa mite on sealed pupa areas across agro-ecologies and hive types.*

Variables	Category	Total colony examined	Prevalence (%)	χ2	P-value
Agro-ecology	Midland	26	15 (57.6)	3.6	0.89
	Highland	25	6 (24)		
	lowland	17	7 (41.2)		
Hive types	Modern	32	17 (53.1)	2.18	0.702
	Traditional	36	11 (30.6)		
Overall prevalence		68	28 (41.2)		

4. Conclusion and Recommendations

Beekeeping is important for securing food, poverty reduction, health, environmental protection and plant pollination. However, because of honeybee diseases, pests and predators, a shortage of bee forage and poor management practices in the study areas in general and at the beekeeping household level in particular, the beekeepers of the zone have not been sufficiently benefited from the sub-sector. The present study identified honeybee diseases, pests and predators as well as a shortage of bee forage, are among the major challenges the beekeepers of the study areas are facing. Nosema and amoeba are the common honeybee diseases identified and prevalent across the three agro-ecologies and in modern and traditional hives as well. The prevalence of honeybee pests, such as varroa mite, bee lice, wax moth, and small hive beetle, is also confirmed across the three agro-ecologies and in both hive types. However, the prevalence of the diseases and pests was not associated with either agro-ecology or hive type. Therefore, further in-depth study is needed to sort out factors associated with the prevalence of these important diseases and pests to proceed to further studies that minimize the effect of diseases and pests on the bee as well as on their products.

Abbreviations

CCD: Colony Collapse Disorder
USDA: United State Department of Agriculture
SHB: Small Hive Beetle
FAO: Food and Agriculture Organization

Conflicts of Interest

The authors declare no conflict of interest.

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