

Honey Bee Diseases, Pest and Their Economic Importance in Ethiopia

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ABSTRACT: The Honey bee (*Aphis mellonifera* L.) is prone to infected with fungal, bacterial and protozoan pathogenic organisms. Honey bee diseases in Ethiopia include Chalkbrood diseases caused by pathogenic fungi, *Ascosphaera aphisa*, Nosematosis caused by *Nosema apis* and amoeba caused by a single protozoa *malpighamoeba mellificae*. A numbers of invertebrate pests belong to insects themselves such as ants, beetle, moths, lice, termites, mites, and large vertebrate animals such as amphibians, reptile, lizards, birds, mammals like honey badgers and mice were recognized in the Ethiopian honey bees. Honey bee diseases, predators and pests are problems for bee keeping practice in Ethiopian. The success of apiculture influenced by these diseases causing pathogenic organisms and various pest animals. Infections of the disease ranging from chronic to highly virulent can result loss of honey bees' population and loss of honey bee products such as honey, wax and also caused honey bees to abscond and death. The economic loss associated with the presence of honey bee diseases and pest was estimated in some works and significant loss was reported. In the present review an attempt has been made to briefly the major honey bee diseases, pests and predators and their rate distribution in the country so as to help the researchers to develop efficient methods for prevention, control and management to improve productivity and the health welfare of bee population.

Key words: Honey bee, *Ascosphaera aphisa*, Nosematosis, pests, Chalkbrood diseases

Introduction

Bees are of commercial value today as pollinators of forests, horticultural and agricultural crops and for their marketable products such as honey and wax. The most important species for bee keeping in East Africa and the wider sub Saharan Africa is the *Apis mellifera scutellata* [1.]. Over the past 5-10 years, honey bees have been faced with many threats including pests and diseases [2]. Bees are found to infect with different pathogenic organisms such as fungi, virus, bacteria and protozoan organisms. In Ethiopia, the land is not only favorable to bees, but also for different kinds of honeybee pest and predators [3]. Pests and predators result in a great damage on honey bee colonies with in short period of time. In Ethiopia several surveys have been made on the existence of honey bee diseases such as Chalkbrood diseases, American foul diseases, European foulbrood, and sac brood, stone brood diseases and several pests and predators of bees and found that many of honey bee diseases and pests were reported in the country [4]. For example in Tigray regional state in Atsbi-Womberta honey bee diseases, pests and pathogens identified as major problem for the adoption of improved honey bee keeping [5]. Honey bees diseases, pests and predators are causing a significance economic loss in honey bees and their products. Historical evidences from various countries suggest that there is a significant relationship between the success of apiculture industry and the control of honey bee disease and pests.

The present paper briefly reviews major reported honey bee disease, pests and predator species in the wide geographical bee keeping areas of Ethiopia. An attempt has made in this article to present the geographical distribution of these various honey bee diseases, pests, predators and assessment made on the economic loss associated with their presence on life of honey bees.

Major honey bee diseases in Ethiopia

Chalk brood diseases

Chalkbrood 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 [6]. In Ethiopia the survey on chalkbrood diseases was started in the year of 2000, and the existence of the diseases was reported in 2001 around the Holeta research areas [3]. Survey on chalkbrood disease in Shoa and Arsi zones, reported an overall prevalence of 56.49%, with higher in west Shoa (24.5%) followed by Arsi (13.74) and lowest in East Shoa (7.63%) and North Shoa (9.92%). No comparative study in infestation rate of chalk brood diseases among colony in same apiary or among bee colonies at different apiaries is studied. However [7] reported highest infestation rate in two apiaries owned by private beekeepers around Holeta bee research center. The study reported variable infestation level of the diseases from different apiary sites with prevalence rate of range from 0- 100% with overall infestation level of 17.4%. Study in apiaries sites at Addis Abeba [8] also reported the diseases in 43% of the colony of bees. Observation and reports from bee keepers and experts confirmed the most affected broods were drones broods in month of October. [7] also reported the occurrence of the diseases during the brood season in October when the ambient temperature sometimes goes below zero degree in individual bee keeper farmers around Holeta and at Gedo demonstration site.

Table 1. Distribution rate (%) of honeybee chalkbrood disease in study Regional States of Ethiopia

Region	Zone	HCBD distribution percentage
Amhara	N. Gonder	80%
	W. Gojam	100%
	S. Wollo	75%
Oromiya	Jimma	95.24%
	Ilubabor	64.7%
	E. Wollega	25.5%
	W. Shoa	40%
	Arsi	45.45%
Beneshangul- Gumuz	Assosa	33.33%

In Ethiopia the geographical distribution of chalkbrood diseases in honey bee were recorded [9]. 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 Beshangul- gumuz. In the study a number of bioclimatic variables such as mean annual temperature, annual rainfall, annual range in temperature and precipitation were used to establish the ecology of the diseases. The finding shows that moist dega, moist weina-dega and wet -weynadega were identified as suitable ecological zones. However, the dry alpine, dry bereha and moist bereha areas are not suitable for the diseases at all [9].

In Ethiopia the infestation and distribution rate of the chalkbrood diseases is unequal. [9] reported distribution rate of (100%) of in West Gojam and 95.42% in Jimma out of 33 Woredas sampled for the study of the diseases (Table1). Distribution of the diseases is associated with delivery of contaminated apiary equipment's such as wax foundation sheets contaminated with *Ascosphaera apis* [10]. The highest distribution rate of in West Gojam and Jimma zone is the results of the introduction of contaminated bee equipment's through the extension service in these areas [9].The disease causes loss of colony of bees and reduction in the productively in infected colonies. [9] reported the mean yield of honey in colony infected with chalkbrood diseases (45kg) is lower than the mean yield (80kg) in uninfected bee colony.

Nosematosis

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 [4]. Diagnosis made on 152 colony bees in field and laboratory at Addis Abeba reported prevalence rate of 53.3% [8]. 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[11]. Similar survey conducted in 58 districts of Oromia, Amhara, Southern Nations and Nationality and Peoples (SNNP), Tigray, Gambella, Benishangul –gumuz, Somale regional state of Ethiopia, *Nosema apis* were identified the species causes nosematosis with 37.3% of infection rate [12]. In the central highlands of Ethiopia, highest infestation level of *Nosema apis* and spore number per individual honey bees was reported in the month of

August and September [13]. The study also found positive correlation between Nosema infestation rate, number of Nosema spore per individual honey bee and humidity.

Amoeba

Amoeba is diseases of honey bee caused by a single celled parasite called *malpighamoeba mellifica*. The parasite affects malpighian tubules of honey bees and shortens the life cycle of bees. The diseases were reported in Ethiopia with low infestation level in the survey made in the country initiated by FAO [4]. Survey conducted in the year of 2000, Amoeba was reported in South and South parts of the country [14]. [8] Diagnosis made on honey bees in field and laboratory at Addis Abeba reported a prevalence rate of 73% of amoeba infestation. 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 [11]. Study on annual cycle and seasonal dynamics of amoeba from the Holeta research center apiary [13] reported, amoeba cysts were reported throughout the year regardless of hive type. The study also reported that highest cyst number (disease intensity) in the months of April and August and lowest intensity in the month of January [13]. This study helps to understanding the seasonal dynamics of the diseases in the area and to undertake seasonal management of colony honey bees.

Honey Bees Pests and Predators

The honey bee colony is not immune from predation and it can take a variety of forms, from destruction of a comb by wax moth to physical dismembering of a colony by a hungry black bear. The most damaging group of pests are arthropods, relatives of the bees themselves and different vertebrate pest animals.

Small Hive Beetle, *Aethina tumida*

Small hive beetle (SHB) is indigenous to Africa, where it is considered a minor pest of honey bees. Both adults and larvae can be serious pests of weakened honey bee colonies or honey supers. The beetles multiply to huge numbers, their larvae tunnel through comb to eat brood, ruin 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. The SHB is a nest parasite of honey bees (*Aphis mellifera* L.) colonies native to Sub-Saharan Africa. The pest was reported from many African country such as South Africa [15], Kenya, Namibia and Eritrea [16].

In Ethiopia the small hive beetle was recognized as local honey bee parasite in two honey flow seasons in the south and south-west parts, in 37.5 % of colony bee with prevalence rate of 10 % [14]. The small hive beetle was reported in the maize and coffee growing regions of Oromia regional state; Jimma, Illu Abbabora, Horo Guduru, Wollega, East Wollega and Western Showa. [17] reported highest infestation and distribution of Small hive beetle in Jimma (60% and 83.9% and 5.3% and 1.1% in Horo Guduru. Similarly the small Hive beetle was reported in six districts; Mega, Moyale, Teltele, Konso, Key-Afer and Segen in the South and Southern parts of Ethiopia with prevalence rate infection ranges from 21% in Konso to 66% in Teltele [18].The study speculates the locality of the pest in region might be that the pest entered to the country from this direction.

Bee lice

Lice are known to infect honey bees in hive. Bee louse are wingless ectoparasite fly which causes significant damage in colony bees. Bee lice larvae feed on honey and pollen by tunneling under the cell capping [19]. The adult lice feed on nectar directly from the mouth of honey bees, this reduce food availability of queen and reduce egg-lying capacity [20]. Bee louse are widely distributed in Africa, Asia, and North America and southern of Africa. In Ethiopian 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 [21]. In the study the prevalence in infestation rate of bee lice was significantly associated with hive type and management type (Table 1).

Table 1. Prevalence of bee louse with its associated risk factors around Holeta research center of Oromia regional state.

Risk factors	No hives examined	% of lice infestation	p-value
Hive type			
Modern	165	76(46.1%)	0.001
Transitional	188	22(25%)	
Traditional	132	64(48.5%)	
Altitude			
Highlands	322	130(40.4)	0.125
Midlands	63	32(50.4%)	
Management type			
Backyard	256	97(37.9%)	0.019
Apiary	129	65(50.4%)	
Colony type			
Weak	83	34(40.9%)	0.956
Medium	160	67(41.9%)	
Strong	142	61(43%)	

Similar study conducted in Tigray regional state reported an overall prevalence louse infestation 4% and 5.5% in brood and adult bees in three peasant associations of Genfel, Adikisandid and Aynalem in Wukro districts [22]. The study reported the main lice species affecting honey bees in the area is *Braula coeval*. Similarly bee louse was also identified as major constraints of bee keeping in Addis Abeba [8], in Illu Ababora and Arsi Zone [9] and in Burie District of Amhara [23].

Ants (*Dorylus fulvus*)

Ants are most troublesome to honey bees and bee keeping sector. Ant eats or carries off any comb contents honey, pollen and brood [24]. Ant (*Dorylus fulvus*) was one of important honey bees' enemies and causing a serious problem [3]. In Ethiopia ants in colony of honey bees were reported from different regions such as Addis Abeba [8], Keffa, Shako and Bench-Maji zone [25], Kombelcha [26], Highlands of Southeast Ethiopia [27]. In Atsbi-Womberta, Ahferom and Wukro districts of Tigray regional state ants was reported as series problem in bee keeping [28] and the problem ants is major problems for the adoption of improved honey bee keeping [5]. In Tigray, Amhara and SNNP regional states and Gomma district Jimma zone bee keepers ranked ants as first problematic pest insect in honey bees [29].

Ants causes severe economic loss in honey production by killing bees, rob their products [30], initiate aggressiveness in bees, lead to absconding and destroying the entire colony of honey bees [31]. Bees are the first and most victim of the attack with ants followed by honey [32]. Ants were also reported to feed on honey, brood, and bees' wax and pollen after all honey and the broods are depleted.

Table 2. Percentage of respondents to Ant (*Dorylus fulvus*) attack on honey bee colonies

District infected	No colony owned	No colony attacked by ants	% of colony infected
Ameya	547	157	29%
Tikur-Inchini	134	22	16%
Ambo	179	95	53%
Dano	270	208	77%
Adeaberga	414	163	39%
Cheliya	298	185	62%
Welmera	155	56	36%
Total	1997	884	44%

Study in seven districts of West Shoa Zone (Table 2), shows that 44 % of the colony bees were attacked by Ants result in 24% of absconding and 4.2% death and 29% of honey production was loss to due to Ants attack [32]. The total economic loss caused due ants attack was estimated to be 3,839.810 Ethiopian birr [32]. Comparing the monetary loss in terms of products the loss through bee products (honey and wax) overweight the loss produced through the bee colonies themselves.

Wax Moth

A number of moth species are known to infest honey bees. Wax moths causes significance damage in colony of honey bees in several countries such as: Algeria, Egypt, Kenya, Tanzania, Uganda, Sudan, Ghana, Nigeria and Senegal [33]. Wax moths are serious pests causing damage on wax production of honey. 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. However, strong colony of bees keeps wax moths under control. The wax moth (smaller and larger) in honey bees was reported in the South and South West of parts of Ethiopia in the year of 2000 [14]. Similarly wax moths (*Galleria mellonella*) and the night flying sort of wax moth (*Aphomia sociella*) was reported in honey bees in the study carried in Tigray regional state in three district of Atsewonberta, Aheferom and Wukro [28]. In the five regional states of Ethiopia wax moths ranked among the disastrous pests of honey bees by bee keepers [29].

Poisonous plants

A number plant species are poisonous pest to honey bees. A recently emerged red color flower locally called Ababbo Diima [34] was reported to kill worker bees during their flowering stages. Plant species belongs to families of *Ranunculaceae*, *Solanaceae*, *Acanthaceae*, *Euphorbiaceae* and *Phytolacaceae* were reported to poisons to bees [35]. Similarly the nectar or pollen of poisonous plants such as *Cassia siamea*, *Croton macrostachyus*, *Aloe brahana*, *Zizyphus mucronata*, *Phytolacca dodecandra* and *Susbania* species was reported to be toxic to the bees themselves and those in which the honey produced from their nectar are toxic to humans [36]. Similarly honey from *Datura arborea* is reported irritates human beings when eating and *Euphorbia cottinifolia* is known to kill honeybees [25]. These studies indicated the emergence new enemies of honey bee pest plants, this needs a scientific study on the real impact of these pest plants on health of honey bees their influence on the productivity to mobilize community in identification and eradication of the pest plants form the environment.

Vertebrate Pest and Predators of Honey Bees

Bee keeping in tropical climates frequently suffers from damage caused by different vertebrate pests. In Ethiopia honey bee predators were reported from all the classes of vertebrate animals. Reptiles, frogs, toads, birds, lizards, mammals like, monkey or apes, mice and honey badger were reported as predators of honey bees in several studies by bee keepers [14, 26]. According of the respondents these honeybee enemies are causing great losses (40.7%) of total honey production per annum. In Kombelsha area [26] reported honey badgers (*Mellivora capensis*) as a series predator causing considerable amount of honey lost and causing absconding. The predator also reported causing damage in colony of honey bees in month of November and April in Keffa, Sheka and Benchi Maji zone [25].

Bees are virtually defenseless against predation of by birds. The heavy traffic of bee flying in out of hive provides as source of food for different bird species. For example birds such as: bee-eaters (*Merops apiaster*, *Merops orientalis*), swifts (*Cypselus species*, *Apus species*), drongos (*Dicurus species*), Shrikes (*Lanius species*) and wood peckers (*Picus species*) are reported as predators of honey bees [37].

In Ethiopia bee eating birds are described as problem in colony of honey bees. In Illubabor zone locally birds known Hamaa were reported to eat bees by breaking the hives at night and other bird called Simbiroo predate bees by waiting around the hive [34]. These birds weaken the hive and reduce the quantity of honey harvested. [38] also reported bee keeping the most stable for most formers In Illubabor Zone is affecting by bee eating birds such Aardvark (*Orycteropus afer*).

Man

Perhaps the greatest predator/pest of honey bees is man. Bees can be vandalized, stolen and/or burned [39]. In the southern regions of the country hunting of wild honey bees is practiced. Peoples never keep bees, but harvest wild bees from caves, cracks using indicator birds and numbers of bees were burned through fires. Man is also reported as predators or pests and robbery of bee were reported in rural bee keeping areas of Ethiopia and developing countries. Some authorities speculate that bees came to Ethiopia from Egypt along the Nile Valley, and that the same bees were also taken to Somalia [40]. Somali bee-eater is one of the most serious pests of honeybee colonies in Somalia [40]. In addition, reduction of bee forage by large-scale agriculture and urbanization is deleterious to bee populations.

Traditional methods of controlling of honey bee diseases and pests

Beekeepers practice different prevention methods but are not totally efficient which requires developing suitable prevention methods. Some of the cultural practices are as follow: for ants destroying the ant nest and killing the queen of ant, putting ash around hive stand, tying "Teff" straw on the hive stands and using of another small ant *Cremato*

gasterchiarinii Emery (1881) as biological control [25]. For honey badger they use mechanical barriers putting like thorny woods around the tree; fixing smooth iron sheet on the trunks of a tree where hives are hanged; hanging hives on ficus trees which has very smooth bark which is not suitable for honey badgers to climb on it and tying of thorny branches [25]. Different types of pest and predators control methods are employed in different bee keeping areas of the countries (Table 2). These numbers of traditional control methods are either used individually or in combination with other methods in all types of bee keeping practice and in all hive types.

Table 3. Traditional methods used by bee keepers for control and management honey bee pests and predators in Ethiopia

Pests and predators	Methods of control
Ants	Applying ash under the hive stands, clean the underneath of the hives & keep their apiary neat, use of leaves of eucalyptus & aje (local naming) as deterrents when it appears, wrapping the hive stands with polytine bag, hunting and killing ant queens
Wax moth	Clean apiary, remove old comb, and strengthen the colony, fumigation with cotton cloth and sorghum bran, rubbing with recommended plant materials like, <i>Vernonia amygdalina</i> , spraying garlic juice.
Bee lice	Clean apiary, fumigate with <i>Olea Africana</i> and cigarette and sorghum bran and make the colony strong.
Beetles	Clean apiary, narrowing the hive entrance, hand picking and kill, cover r opening of hive.
Lizard	Clean apiary, use spin around and kill
Snake	Clean apiary, smoking with plant material and kill
Birds	Putting something (cloth, festal...) and spin around the hive and, Killing using stones e.t.c
Honey badger	barriers putting like thorny woods around the tree; fixing smooth iron sheet on trunks of a tree where hives are hanged, hanging hives on ficus trees which has very smooth bark which is not suitable for honey badgers to climb, fastening corrugated iron on the bark of the trees containing honey bee colonies

A number of preventive or control management practices to minimize the effect honey bee pests are practiced in the country. For example strengthening honey bee colonies via feeding, removing unoccupied suppers and combs, trapping adult wax moths were tested against wax moths and results in reduction of infestation level of wax moths by 82.3% and increasing honey bee [41]. Three different ant protection methods such as inner tube, smooth iron sheet and tin filled with used engine oils are tests for their effectiveness in preventing access of ants by exposing to massive raids of ants and the tin filled with used engine oil methods was found the best in totally protecting honey bee colonies [30].

The way forward: Recommendations for control of honey bee diseases and pests

The following methods either individually or in combination with other integrated methods of diseases and pest control were recommended to improve productivity honey bees and their health welfare.

Good Hive Management

The effect of different honey bee diseases and pests can be reduced by improved management techniques such as strengthening colony with bees or hatching brood and enlarging colony entrance to aid ventilation [41]. Good bee keeping practice such as avoiding use contaminated equipment, transfer of infected combs from infected hives were recommended to avoid horizontal and vertical transmission of different honey bee diseases from colony to other near colony. In general the following colony management tools with integrated other improved beekeeping practice are recommended

- ✚ Maintain a strong bee in each hive.
- ✚ Inspect every hive at least once a month.
- ✚ Move the hive to disrupt the life cycle of honey bee pests
- ✚ Maintain close mowing or bare ground around the hive to facilitate chemical controls and provide less shelter for beetle larvae leaving the hive to pupate population

Searching Veterinary Medicinal Plants

For centuries medicinal plants were used for treatment of different diseases in animal and humans in health welfare. Crude medicinal plant extracts such as *Allium sativum* Linn, *Eugenia caryophyllum* Bullock & Harrison, *Piper betel*, *Curcuma*

longa Linn, *Illicium verum* Hook, *Cinnamomum cassia*, *Rhinacanthus nasutus* Kurz, *Azadirachta siamensis*, *Acorus calamus* Linn., and *Stemona tuberosa* Lour) shows anti fungal activity for treatment of chalk brood disease[42]. In order to prevent and control honey bees diseases, it is recommended to search and investigate veterinary medicinal products which value for treating honey bee diseases.

Breeding Resistance Variety Bees

Some hives appear to be more resistant to different honey bee diseases than others due their hygienic behavior [43]. These colony have an ability of their adult bees to uncap and remove affected brood which reduce the spread of infection to whole colony. This hygienic behavior was explained as being controlled by two recessive genes, one for uncapping and one for removal of larva [44]. So it is recommended to selective breeding of varieties of honey bees colony by evaluating the hygienic behavior in different honey bee species found in the country. Breeding resistant variety of colonies should be practiced through selective rearing of queen from the resistant colony of bees.

Providing Education to Bee Keepers

Controlling of honey bee disease and pests require intensive knowledge of recognizing and detection of these different diseases causing organisms and pests in colony of honey bees. It is recommended to provide educational delivery through extension service to bee keepers on management of honey bees, detection of diseases in brood and how to manage the problems.

Quarantine measures

The spread and entrance of some honey bee diseases is associated with delivery of contaminated apiary equipment's such as wax foundation sheets [10]. Establishing quarantine measures through legal regulation and enforcement on introduction of honey bees and equipments can be reduce introduction of diseases from infested areas. During introduction of colony bee to a given locality of providing health of stock of bee and educating bee keepers the risk of buying infected colony of is recommended. In general the following measures are recommended when buying, selling of stock honey bees

- ✓ Before introducing new species or race of honey bee, it is important to study its potential (diseases and pest resistance) quality, foraging behavior and availability of forage
- ✓ In terms of introducing and buying of stock of bee from market/ regions to locality areas well quarantine and inspection is essential
- ✓ During introduction of honey bee equipment from abroad to country proper inspection of instruments is recommended

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