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The prevalence of wax moth and associated risk factors in selected districts of Arsi Zone

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Abstract
The beekeeping sector is constrained different honey bee disease and pests'. The most commonly known honey bee diseases and pests so far reported in Ethiopia are chock brood, nosema, ameba, ants, varoa mites, spider, lizard and wax moth. Wax moth is one of the most economically important and prevalent pest found in Ethiopian. A cross-sectional study was carried out from May 10, 2016 to September 15 2017 in the two districts of Arsi Zone to identify cause of colony, dwindle, absconding and the prevalence of wax moth. A total of 320 bee hives with and without bee colonies were inspected internally and externally during the study period. During external hive inspection, any abnormalities, like stained hive entrance, pests, disease symptoms, death of bees, and paralysis of adult bees were recorded in the record book. Presence of colony mass death, presence of adult and larval stages of wax moth, varoa mite, bee lice and hive beetles were also investigated during internal inspection. Spider net, ants and, wax moth were frequently observed pests ranked as 1st, 2nd and 3rd regardless of hive type. In addition dormant and active larval stages with its cocoons, webs and debris together with adult wax moth flies were identified. The overall prevalence of wax moth in bee hive was found to be (22%). The majority of the colonies infested with wax moth were from box hive (33.3%) followed by traditional (11.5%). Prevalence was significantly higher $X^2 = 31$; P=0.001 in box hive than transitional and traditional one. The prevalence was statistically significant $X^2 = 50$; P=0.001 in weak honey bee colonies than strong and moderate ones. Wax moth larval infestation and severity was higher in absconded and week colonies managed in box hive which, wax moth is considered as the major cause of colony dwindle and absconding in the study areas. Lack of proper management of the colony is one of the major problems for wax moth and other pest infestation, so to combat the problem; awareness creation should be done on proper colony management in the study areas.

Keywords: Wax moth, prevalence, honey bees, ranking, Arsi

Introduction
Beekeeping is an important component of agriculture and rural development program in many countries [1]. It plays a role in providing nutritional, economic, and ecological security. In addition to honey and bees wax production, honey bees are potential pollinators of different plant species and the economic values of pollination is higher than honey and beeswax harvest in Africa, even though the importance of pollination is still not know by the people in general and agricultural experts in particular. Based on FAO [1] report the value of pollination can be 100 times more important than honey harvest in Africa. On the other hand, the sector is affected by different problems of colony collapse disorder, colony mass death, and colony decline, colony dwindle and absconding which are commonly reported in the world caused by different honey bee diseases, enemies, predators, indiscriminate application of agrochemicals and honey bee pests and pathogens [2, 11].

Similarly in Ethiopia, the majority of the beekeepers complained about mass death of honey bees', colony dwindle and absconding in different parts of the country in 2015. Based on survey and prevalence studies conducted in different parts of the country, diseases of honey bees, pests, enemies, predators and in discriminate application of agrochemicals were reported as the major problems of beekeeping. Of those, wax moth [12, 13], *Nosema apis* and *Melpighamoeba mellificae* [14], Chalk brood [15], Small hive beetle [14] Ants [16] and bee lice [17, 18], varroa mite [19] were the most commonly reported honey bee diseases and pests in different parts of the country.

Honey bee pests particularly wax moth is known to cause economic loss with widely distribution in Ethiopia and it is potentially very troublesome to bee keepers with the transmission of viral pathogens [20].

It is a serious destructive pest which causes considerable damage to both normal and abandoned combs of bees and brings considerable loss to beekeeping industry [21, 22]. Wax moth alone can cause about 60-70% lose by damaging honey combs, colony dwindle and absconding [23].The larval stages of the moth can emerge as adults in the hive and the female may live a few days or a few weeks and she flies out to a tree and mates, she then re-enters to hive and lays about 500 eggs. The newly hatched larvae can run very fast and thus distribute themselves around the hive, they then burrow in to comb, damaging it in a characteristics way by constructing a feeding tunnel of silk through it [24]. The actively moving larva of the moth is responsible for damaging the honey combs and feeds completely, and cause for the colony to be absconding [25].

The prevalence of wax moth in Oromia Region specifically in South West Shoa and West and East Shoa Zones ranges from 22.85% -26.66%.Other study also, indicated that about 56%-75% prevalence of wax moth infected honeybee colonies absconded and the remaining dwindled. However, the evidence on the magnitude and distribution of disease and pests particularly wax moth is till insufficient in Ethiopia as mentioned by Desalegn Begna, [26].In addition Etsay *et al* [13] reported (27.4%) wax moth prevalence in the northern parts of the country. The prevalence of wax moth is not studied in Arsi Zone even though the problem is there till the report and complaining comes from the beekeeper farmers. They complain about colony absconding, colony dwindle and wax moth locally called (sumbeltl) problems in different districts of Arsi Zone initiates us to investigate the cause of absconding and colony dwindle in the study areas. Thus, this study was proposed to investigating the prevalence of wax moth and the associated causes of colony dwindle and absconding in Tiyo and huruta district of Arsi Zone, Oromia Region.

Materials and Methods

Study areas

The study was conducted in selected districts of Arsi Zone which is located at south-Eastern part of Oromia Region. The Zone is one of the 22 beekeeping production potential Zones, located at a distance of 175 kilometers far from the capital city Addis Ababa. It is also situated between 6˚45'N to 8˚58'N latitude and 38˚32'E to 40˚50'E longitude with average elevation 2436 m.a.s.l. The mean annual minimum and maximum temperature of the Zone is 15 ˚C and 18 ˚C respectively. The two study districts (huruta and Tiyo) are located in the central mid and highlands of the Zone.

Study design

Cross-sectional study design was employed from May 10, 2016 to September 15 2017.External and internal inspections with questionnaire survey were used to investigate the root cause of colony dwindle, absconding and wax moth prevalence. Apiary sites were visited and bee hives were inspected externally and internally. Data on the hive types and colony strength were collected based on Etsay *et al* [13] criteria. The colony strength were categorized as weak, moderate and strong by physical observation during external and internal inspection. Availability of adult bees, brood, pollen and honey in the hive were seen by internal inspection and the activities of adult bees like foraging and defensive behavior of the colonies were observed during external inspection. Types of the hive, strength of the colony and agro ecology were considered as the major risk factors for the occurrence of wax moth. The two study districts were categorized in to two based on the altitude as mid and high land. Beekeeping management in the study areas were categorized as backyard, in the house and hanged on the tree**.** Purposive sampling method was employed based on report of absconding, colony dwindle and mass death of adult bees. The study was conducted on bee colonies owned by farmers in Tiyo and Huruta districts in Arsi Zone which are kept in traditional (104,colonies), transitional (48 colonies), and modern (168 colonies) with a total of 320 colonies.

Inspection procedure and data collection

In the apiary site hives with problems reported by the beekeeper farmer were selected and physical observation and internal inspection for identification of the cause of the colony dwindle, absconding and adult bee death was performed. Health related problems, death of bees' paralysis (adult bees crawling near, around and under the hive stand which are unable to fly, dead brood, pests and enemies around and inside the hive were recorded.

Data management and Analysis

All data was entered in to M**S** Excel spread sheets after completion of data collection work from the study areas. SPSS version 16 was used to analyze the data. Descriptive statistics and ranking of the honey bee diseases and pests were used.in addition Chi-square test and multivariate logistic regression analysis was conducted to see the association and strength of association between the different explanatory and dependent variables. The result was considered significantly varied at (p<0.05).

Results and Discussion

Potential causes colony dwindle and absconding

From the 320 inspected hives with and without honey bees 68% were attacked by different diseases, enemies and pests. The common diseases symptoms, enemies and pest so far identified during inspection in order of importance were, spider and spider net, ants, wax moth, paralysis of adult bees, stained frame (diarrhea) ameba, lizards, dead bees, hive beetles and, bee lice respectively. This study finding was similar with Askale *et al*. [27] and Gidey *et al*. [17]. The causes of colony dwindle and absconding previously reported by the beekeeper was due to different honey bee disease, enemies, predators and pests. Spiders and ants were the first and second prevalent enemies of bees (41%) and (30%) respectively. The symptoms of paralysis of bees, deformed wing, dead adult bees and diarrhea were some of the symptoms observed and recorded during inspection. Some dead adult bees were observed around and under the hive stand which is not considered as mass death except one colony mass death seen in one traditional bee hive which were infested with wax moth, ants and molds (figure 4). Honey bee disease and the major enemies and pests identified so far during inspection were described under (Table 1).

Table 1: Ranking of major diseases, enemies and pests of honey bees

No	Diseases, Pests and symptoms observed	Frequency	Percent	Rank
1	Ant	96	30	2nd
2	Wax moth	69	21.6	3rd
3	Lizard	7	2.2	6th
4	Paralysis of adult bees	26	8.1	4th
5	Dead bees	6	2	7th
6	Stained frame(diarrhea) ameba	8	2.5	5th
7	Small hive beetle	1	0.3	8th
8	Bee lice	1	0.3	8th
9	Spider and spider net	132	41.3	1st
10	No any abnormalities observed	103	32.0	

Wax moth prevalence

The prevalence of wax moth was seen in the apiary sites, different types of hives. The overall prevalence of wax moth at least one colony is infested with one of the devastating pest called wax moth was (28%) 9/32 apiary sites. From the total hives inspected (21.6%) 69/320 were infested with wax moth with confidence interval of 15-23%. Active and dormant stages of the moth larvae and adult flays were identified during internal hive inspection. The majority of the colonies infested with wax moth were from box hive 33.3% (56/168) followed by traditional 11.5%. From 320 inspected hives (36.25%) 116/320 were confirmed to be empty due to absconding caused by bee pests and enemies. From the above empty hives due to absconding 26.7% of the empty hives were infested with wax moth before and after absconding. During the study period it was observed that larval stage of wax moth was responsible for destroying both honey combs and frames. Wax moth is mainly responsible for damaging the combs and feeds completely, and cause for the colony to be absconding. Prevalence of wax moth significantly varied among hive types and colony strength. It is significant at $p<0.001$. The prevalence was high in colonies managed in frame hives than traditional and transitional. Wax moth prevalence was high in the weak colonies than strong and moderate colonies. The prevalence of wax moth in weak colonies was 44.6% followed by empty hives 31/116(26.7%). Empty hives in this research context is colonies were absconded due to different factors including the wax moth itself. High prevalence rate of wax moth in empty hives with abandoned honey comb with brood, honey and pollen indicated that, the cause of absconding in the study areas could be wax moth. The prevalence of wax moth was not statistically varied in agro ecology, hive size and types of beekeeping management. The association between the potential risk factors and independent variable is seen under table 2 below.

The results of multivariate analyses of wax moth prevalence with different risk factors was depicted under (Table 3) below. Weak honey bee colonies were 76 times more likely to be infested with wax moth than strong colonies and combs in empty hives were 46 times more likely infested with wax moth than strong colonies.

Table 2: Chi square test result between wax moth prevalence and different risk factors

Risk factors	No of hive inspected	No and % positive	X^2	p-value
Types of hive			31	0.001
Traditional	104	12(11.5%)		
Transitional	48	1(2.1%)		
Modern	168	56(33.3%)		
colony Status			50	0.001
Weak	74	33(44.6%)		
Moderate	58	4(6.9%)		
Strong	72	1(1.4%)		
Empty due to absconding	116	31(26.7%)		
Agro ecology			0.5	0.5
Highland	273	57(21%)		
Midland	47	12(25.5%)		
Types of beekeeping			3	0.3
Back yard	285	63(22.1%)		
In the house	32	8(25%)		
Hanged on the tree	5	0%)		
Box Hive size			0.4	0.9
Base +supper	50	11(22%)		
Brood chamber only	270	58(21.5%)		

Table 3: Multivariate logistic analysis of different risk factors and prevalence of wax moth in the study areas

Risk factors	No of hive inspected	No and % positive	Odds ratio 95%CI	p-value
Types of hive				0.001
Traditional	104	12(11.5%)		
Transitional	48	1(2.1%)		
Modern	168	56(33.3%)		
colony Status				0.001
Weak	74	33(44.6%)	76(10-59)	
Empty	116	31(26.7%)	46(6-358)	
Moderate	58	4(6.9%)	5(0.6-53)	
Strong	72	1(1.4%)	1	
Agro ecology				0.5
Highland	273	57(21%)		
Midland	47	12(25.5%)		
Typesof beekeeping				0.3
Back yard	285	63(22.1%)		
In the house	32	8(25%)		
Hanged on the tree	5	0%)		
Box hive size			0.8	0.9
Base +supper	50	11(22%)		
Brood chamber only	270	58(21.5%)		

Degree of wax moth infestation

The degree of wax moth infestation in box hive were described as severe moderate and slightly affected based on the cocoons developed and damage the honey comb according to Burges, [28] criteria. Based on Burges criteria, (26.8%) 15/56 of modern hives were severely affected. Empty honey combs and weak colonies were severely affected by wax moth larva. It could be because of colonies that have low numbers of adult bees resulting from different factors like starvation, queenllessness, excessive swarming, disease and pesticide poisoning which cannot effectively guard their hive against wax moth infestation. Similar research result was reported by crane, [29]), charless *et al*. [2], Etsey *et al*. [13] and James *et al*. [21]. Hanumanthaswam and Rajagopal [23] reported the cause of heavy economic loss (60-70%) to beekeepers all over the world was caused by greater wax moth. In addition our result indicated that the moth larva can also damage the box hive frames in highly infested hives and can cause huge economic loss to beekeepers. Similarly Alemu *et al*. [30] reported the impact of wax moth larva on the frames of box hive was highly damaged significantly which was discouraging to beekeepers. Severity of the wax moth infestation can be seen in (figure 1) below. In addition the picture of adult wax moth flays a larval stage of wax moth, is given in figure, 2, and 3 below.

Conclusions and Recommendation

In conclusion colonies dwindle and absconding was caused by wax moth aggravated with other honey bee pests and diseases with poor seasonal management of the hive. From our observation during inspection honey combs in the hive which in part or fully not occupied by honey bees were vulnerable to wax moth infestation and severely affected. The fast moving larval stage of wax moth was responsible in destroying the honey comb, frames and its contents. It is must to keep colony of hive to be strong and healthy to avoid infestation of wax moth by providing proper seasonal colony management practice. Beekeepers and Researchers must be able to recognize and apply possible intervention option for the control of wax moth to minimize the economic loss.

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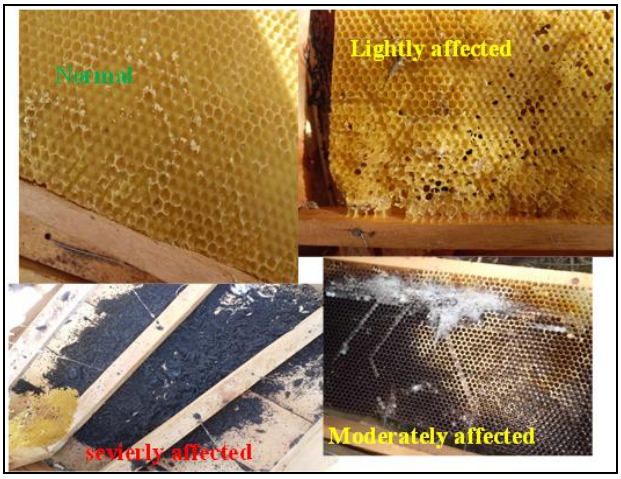
Competing Interest

No computing interest regarding this paper



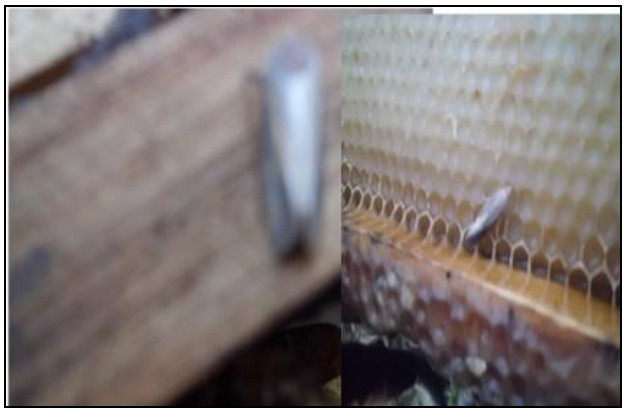


Fig 2: Adult wax moth fly

Fig 3: larval stage of wax moth

Mass death of honey bees in traditional hive

Dead bees around box hive stand

Fig 4: Death of honey bees observed during inspection

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