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Investigating the Effect and Control of Small Hive Beetle, *aethina tumida* (Murray) on Honeybee Colonies in Ethiopia

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Abstract: *Small hive beetle 'SHB', Aethina tumida (Murray) is a pest and scavenger of honeybees and bee products. The study was conducted to investigate the effects of small hive beetle on honeybees and evaluating the effectiveness of different control methods at Bakko apiary site, western Ethiopia. A total of 32 honeybee colonies (Apis mellifera) were established and assigned into four treatment groups: seasonal colony management, hive entrance modification, trapping of small hive beetle larvae and control groups. Data on bee population, brood areas measure, infested comb and pollen and nectar store areas were recorded using Liebefeld method (frame unit area, 10 x10 cm^2) at every 21 days. Also, records on small hive beetle infestation rate, average honey yield and absconded tendency of bee colonies were taken. The result indicates that there is statistically significant difference ($P<0.05$) between treated and untreated colonies with high infestation rate and absconding tendency of the untreated colonies reaching about 80% and 7.33±2.6, respectively. Highest mean honey yield (23.5kg/hive) was recorded in seasonal colony management and the lowest (6.3kg/hive) was recorded in untreated groups. Significantly greatest bee population, brood area measure, pollen and nectar stores were also registered in seasonal colony management groups followed by hive entrance modification. Hence, providing bee colonies with proper seasonal management strategies is revealed to be the best option for the minimization and control of small hive beetles effect on honeybees and their products.*

Keywords: *absconding, control, honeybees, infestation, small hive beetle*

1. Introduction

Beekeeping is one of the major incomes generating agricultural activity for rural households and other smallholder communities in Ethiopia. It provides substantial benefits to address household's food security and poverty alleviation through income diversification for beekeepers in potential areas (FAO, 2009). However, the current bee colonies decline and subsequent reduction of honeybee products due to some of identified and unidentified pests and diseases are reported from different corners of the world (Potts et al., 2010; Neumann, P. and N. Carreck, 2010; Higes, et al., 2008 and Martin, S. 2001).

Small hive beetle 'SHB', *Aethina tumida* (Murray) is known as a major pest and scavenger of honeybees and other bee species (Neumann and Ellis, 2008; Neumann and Elzen, 2004; Hepburn and Radloff, 1998). It is becoming a serious threat to the long-term sustainability and economic prosperity of beekeeping and as a consequence, to agriculture and the environment through disruption of pollination services. The beetle is indigenous to Africa, where it was previously considered as a minor pest for colonies of African honeybees (*Apis mellifera*) (Lundie, 1940), and was thought to be restricted to the continent. However, in 1998 it was first detected in Florida, USA and then spread in different states (Elzen et al., 1999; Arbogast et al. 2009). Currently, the beetle is widespread in different states of the world, including Europe (Cuthbertson et al., 2013; Doug, 2003; Elzen et al., 2002; Elzen et al., 2001). In Ethiopia, the beetle was lately detected in southern and south eastern parts of the country including; Teltele, Konso, Moyale, Segen, Moga and KeyAfer districts in 2000 (Desalegn & Amssalu, 2001). Eight years later the pest was detected with highest distribution and prevalence rates in most beekeeping potential areas of the country (Amssaluet al., 2012).

Both larvae and adults of the beetle live in honey bee colonies, where they feed on pollen, brood, and honey, but the larvae inflict the most damage (Elzen et al., 1999). Adults invade honey bee colonies, where they lay eggs in crevices and on the combs. Eggs hatch in about 48 hours and the larvae feed on honey, pollen and bee broods until the pupation period. For pupation, the larvae crawl out of the hive and burrow into the surrounding soil where the moisture level is suitable for pupation (Zawislak, 2010). Upon eclosion from the ground, adult beetles search for honey bee colonies, probably identifying the host colony by a suite of olfactory cues (Zawislak, J. 2010; Elzen et al. 1999). Studies have shown that beetles fly before or just after dusk and attracted to odor from various hive products (honey, pollen) and particular pheromone from adult bees (isoamyl acetate) (Schmolke 1974; Elzen et al. 2000). They are strong fliers from hive to hive, and between apiaries in search of suitable places to get food and to reproduce. In severe infestations, the bees are generally forced to leave their hive and depressingly affect the beekeeping industry (Suazo et al., 2003; Sanford, 1998; Morse and Calderone, 2000 and Elzen et al., 1999).

Small hive beetle didn't get attention in general in Africa and considered as a minor pest for a long period of time. As a result, little progress has been done to determine its effect on beekeeping industry in most places where it is widely exists. This condition gave the pest sufficient time to widely spread in the continent and cause undetermined reduction of beekeeping production. To this fact, the realistic effect of small hive beetle on Ethiopian honeybee colonies and bee products has not been yet investigated, despite its long period distributed in different parts of the country. Moreover, no any attempt has made for the management against this pest to minimize its effect on beekeeping industry in the country. Therefore, this study is aimed at the investigation of the effect of small hive beetle on honeybee colonies and bee products and hence to develop a pragmatic prevention and/or control measure at the country situation.

2. Material and Method

The study was conducted at Bakko apiary site (Western Showa, Ethiopia) to determining the effect of small hive beetle on honeybee populations and bee products and to generate effective control/preventive method. A total of 32 honeybee colonies having the same population & free of small hive beetle were randomly assigned in to four groups (each with eight bee colonies): Seasonal colony management, Trapping small hive beetle larvae, Regular entrance modification and Control groups. The effectiveness of each treatment to prevent the SHB infestation was evaluated under uniform environmental conditions and compared with the control group (colonies left untreated). Data on bee population estimate, measurements on brood areas, infested combs and, pollen and nectar store areas were recorded using Liebefeld method (frame unit area, 10 x10 cm^2) at every 21 days. Data on average honey yield per harvest/colony and colony absconding tendency was also recorded for each treatment during the study period.

2.1. Seasonal Colony Management (T1)

Seasonal colony management was manipulated to strengthen the colonies via supplementary feeding, timely suppering and suppers reducing, removing the unoccupied frames, regular hive cleaning to remove comb debris. Each colony was given a 1.57 volume of sugar solution (1sugar: 1 H2O) once every 7-10 days of the dearth period, followed by regular colony inspection and follow up. Moreover, extra suppers’ reducing (when the colonies became dwindled), regular hive cleaning, removing and changing old combs and removing unoccupied frames were performed to maintain bee colonies healthy and strong.

2.2. Small Hive Beetle Larvae Trapping (T2)

This treatment was applied to trap the wandering and crawling of SHB larvae intended to fall in the soil for the pupation process. Eight strong and uniform colonies were selected for this treatment and dead brood traps were fitted at the entrance of each hive under the landing boards. Each trap was made from wooden boxes with upper side fitted by mesh wire to let bees fly and perform regular activities without any hindrances. Wandering beetle larvae were expected to fall into the trap as they attempt to exit the hive to pupate. This was designed to cease the life cycle of small hive beetle by hindering the larvae from pupation stage and inhibit the developmental process of small hive beetle. Every 21 days, accumulated larvae of SHB (dead and alive) in the trap were collected and removed including other debris.

2.3. Modifying the Regular Hive Entrance (T3)

Also, 8 SHB free honeybee colonies, consisting of single deep hive bodies was set up for this experiment. After colony set-up, the regular entrance of hives were blocked and sealed tightly with a piece of woods and new entrances consisting of ¾ inch (2-cm, ID) bamboo pipe were installed 3-4 inches (7.6 -10.2cm) above the bottom board. All cracks or holes in the hives were sealed to hinder the entrance of small hive beetle from these cracks. Every 21 days, number of adult beetles were counted and removed from the hive.

2.4. Control Group (T4)

For a comparison, 8 uniform colonies were exposed to small hive beetle infestation and used as control group. In this case the colonies were left unmanaged, unfed and exposed to invading beetles until end of the experiment. This group was used to compare the results of other treatments with regard to small hive beetle infestation, colony absconding tendency and average honey yield. Every 21 days after colony set up, data was collected to determine the magnitude of SHB effect on bees and bee products.

For all treatments, pieces of corrugated cardboard (45 cm × 45 cm), with one surface peeled to expose the ridges were place on the bottom board of each bee hive with the ridged side down. Underneath of the frames on the bottom board were covered with mesh wires which allow SHB to enter and hide in the corrugations, but exclude honey bees to fit the bottom board. The inserts were removed and replaced every 21 days to examine small hive population measure.

All the collected data was organized by Microsoft excel and analyzed using descriptive statistical analysis of variance ANOVA of SAS version 9.0. Tukey's honest significant difference (HSD) at 5% level of significance was used for mean separation.

3. RESULT AND DISCUSSIONS

The result of the study indicated that there is statistically significant difference ($P<0.05$) between treated and untreated colonies with regard to small hive beetle infestation rate and hive product production. Significantly higher mean bee population, brood area, pollen and nectar stores 722±6.51, 136±7.4, 55.3±3.72 and 213±8.4, respectively were recorded in seasonal colony management groups (Table.1). However, the amount of brood area, pollen and nectar stores did not significantly differ ($P > 0.05$) between colonies treated by hive entrance modification and small hive beetle larvae trapping, but significantly higher than control groups (Table1).

The study indicates that, as the highest number of adult beetles found in the hive, less amount of bee brood, pollen and nectar stores were recorded indicating that SHB has caused substantial reduction in bee products (probably by feeding and ovipositing on brood, pollen and nectar) which in turn lead the queen to cease egg laying and eventually decrease bee population (Fletcher and Cook 2002, Fell, 1999). To this fact, the highest SHB population rate (79.67%±7.6) with greater comb damage (36.67±1.56) was recorded in colonies left untreated (T4) which most likely indicates the strong correlation between SHB population and infested combs (Table. 1). In contrast, less damaged combs were recorded in seasonally managed colonies, and not significantly differ when compared to small hive beetle larvae trapping and hive entrance modification. This agrees with the study of Zawislak, J. 2010 that showed that good beekeeping management practices both in the apiary and in the bee hives are sufficient to tackle the effect of small hive beetle.

Table1. *Mean ± SE of bee population and bee product area measures (with frame unit area, 10 x10 cm^2)*

Treatments	Honey bee Population	Brood area	Pollen area	Nectar area	Adult SHB beetles	Infested Combs
T1	722 ± 6.51^a	136.00 ± 7.4^a	55.33 ± 3.72^a	213 ± 8.41^a	14 ± 3.21^a	1.30 ± 0.33^a
T2	284 ± 7.00^b	98.67 ± 3.33^a	49.00 ± 7.37^b	122 ± 8.88^b	16.33 ± 2.6^a	2.33 ± 0.88^a
T3	350.6 ± 4.8^b	122.67 ± 17.6^a	40.33 ± 1.85^b	113 ± 9.86^b	16.0 ± 4.58^a	3.00 ± 0.57^a
T4	53.0 ± 22.6^c	17.67 ± 3.93^b	12.67 ± 0.88^c	28.33 ± 9.5^c	79.67 ± 6.7^b	36.67 ± 1.56^b

** Values are mean ± standard error. In columns total means followed by the same letters are not significantly different at p≤0.05 using Turkey's Standardized Test (HSD). T1: Seasonal colony management, T2: Small Hive beetle larvae trapping, T3: Modifying regular entrance, T4: control group.*

To determine the effect of small hivebeetle on honey yield, honey was harvested from each treatment during active seasons and compared with control group. Acordingly, the highest mean honey yield was recorded in seasonal colony management with mean value 23.5 kg/hive, and the lowest yield was recorded in untreated colonies (6.3kg/hive) (Fig.1). Colonies exposed to the infestation of SHB clearly reduced the amount of honey stores by three folds and in turn decreased other hive products. This difference could be due to the feeding habits of both adult and larvae beetles on honey and nectar (Lundie, 1940; Schmolke, 1974). Moreover, colony stress conditions due to small hive beetles or other pest infections might also generally contribute for the honey yield reduction in untreated colonies. Colonies treated by trapping of SHB larvae and hive entrance modification showed almost similar amount of honey yield per hive/ harvest time (Fig. 1). This similarity might be due to the obstruct of SHB larvae from pupation in the soil which in turn blocks the life cycle of the pest.

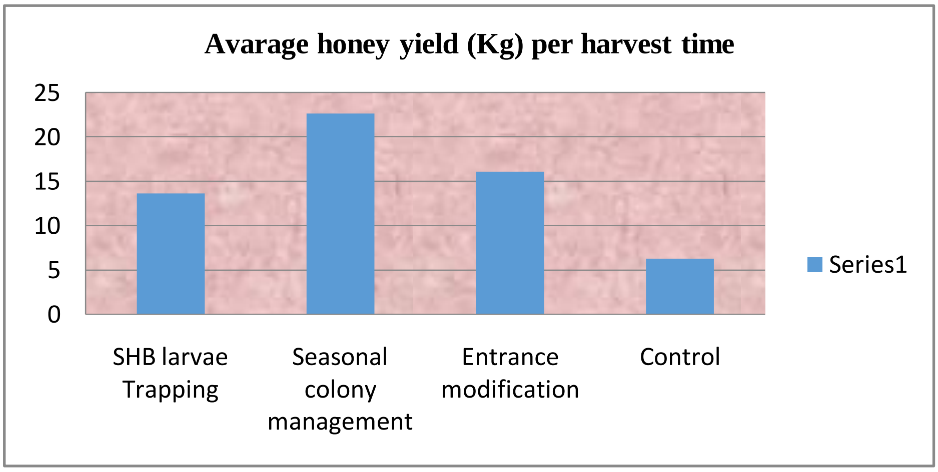

Figure1. *Comparision of honey yield between the treatments during honey harvest time*

In order to investigate the seasonal dynamicity of small hive beetle population and its infestation level, data on adult beetle population and comb infestation were taken every 21 days of the month during the study periods. Accordingly, higher SHB population and infected combs were recorded in months from July-August and February-April (Figure 2.) This suggests that honeybee colonies prominently affected by SHB following the dearth periods as bee colonies are weak during this period and less likely defend themselves against pests and diseases (Schmolke, 1974; Anderson et al., 1973). In line with this, higher bee population and brood area measure was recorded during the active periods, in months between September-November (Figure 1).

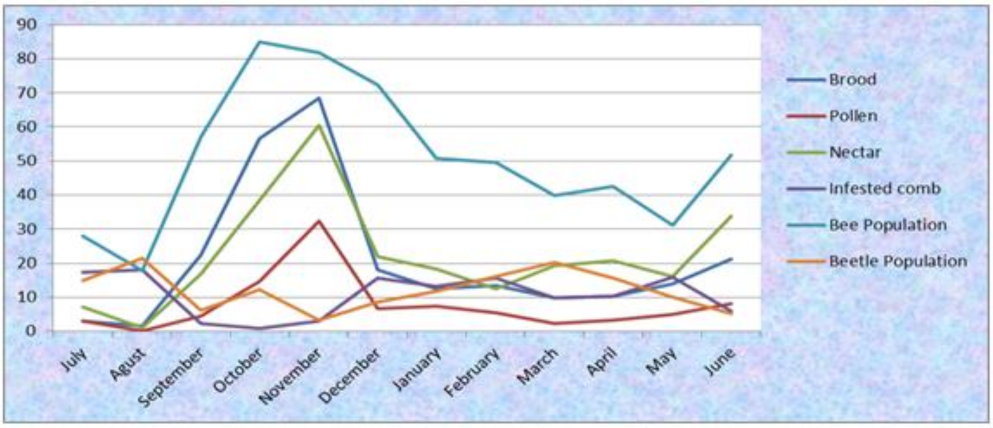

Figure2. *Seasonal effect of SHB on honeybees and bee products*

In addition, absconding tendency of bee colonies was evaluated by the ratio of colonies evacuated to the number of colonies used for each treatment under uniform environmental condition. In this case a fewer number of bee colonies were absconded in seasonal colony management (20%, Or 1.67±1.3), while the highest percentage of colonies were absconded in the untreated groups (92%, Or 7.33±2.6 %) at the end of the study period (Fig. 3). This suggests that, colonies exposed to infestation of pests, including small hive beetle are forced to leave their nest and abscond. This is of particular interest because most

African honey bee subspecies readily abscond in response to nest predation (Hepburn and Radloff, 1998). However, other factors (colony disturbance, nectar dearth, etc.) might be also causes honeybee colonies to abscond and not merely the presence of large numbers of adult beetles.

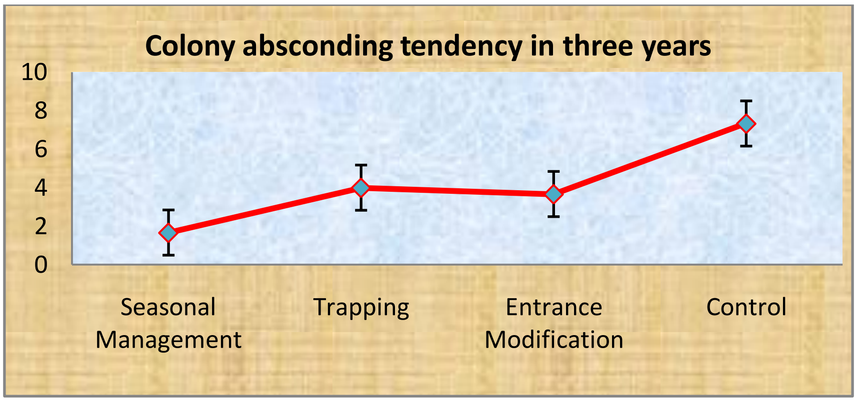

Figure3. *Comparison of colony absconding tendency due to SHB under treatments*

**Absconding tendency was evaluated by the ratio of colonies evacuated to the number of colonies used for the experiment in three years.*

4. Conclusion

Even though small hive beetle (Aethina tumida, *Murray)* is thought to be a minor pest in Africa, our study reveals that the pest can potentially affect honeybees and bee products of colonies that lack proper management. Under poor beekeeping management, the beetle can cause significant damage to comb, pollen and nectar stores which in turn lead to higher reduction in the honey yield. The beetles can also promote structural collapse of the nest and colonies to abscond under sever infestation. Our data shows that the extent of beetle-associated damage most likely depends on the type of colony management practices, among other factors. Colonies with poor management in general are more vulnerable to small hive beetle infestation than colonies provided with regular treatments. As a result, higher infestation of small hive beetle appears more successful in weak and stressed colonies which adversely affect all aspects of beekeeping, including honey production and pollination services. This mainly occurred in months from July-August and February-April following the dearth period, so that honeybees less likely defend themselves against pests and diseases during this season.

Therefore, the result of this study indicates that maintaining colonies healthy and strong via proper seasonal colony management is the most effective way to minimize the threat of SHB. In addition to this, trapping the beetles' larvae by dead brood trap might also slow down beetle population, as this can cease the pupation of larvae in the soil and then obsolete its life cycle. Hive entrance modification by sealing and replacing the regular hive entrance with bamboo pipe can also reduce colony invasion by adult beetles. Future research should look in to investigation of botanical pesticides and biological controls (such as; soil-dwelling entomopathogenic nematodes) against SHB control.

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