Controlling Small Hive Beetles (*Aethina tumida* Murray) in Honey Bee (*Apis mellifera*) Colonies Using a Modified Hive Entrance

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Revised manuscript received for publication Jan. 9, 2002

ABSTRACT

This study was designed to test whether colony invasion by adult small hive beetles can be reduced by replacing the regular entrance of a hive with a ¾-inch (2-cm) PVC pipe located 3-4 inches (7.6-10.2 cm) above the bottom board. Colonies with pipe entrances had significantly fewer adult beetles (46.9 beetles / colony) than open colonies (107.7 beetles / colony). Pipe entrances did not significantly affect the amount of sealed brood in a colony nor the temperature inside colonies. However, brood significantly affected temperature inside colonies and there was a tendency for reduced brood in colonies with pipes; temperature increased as the amount of brood in a colony increased. Brood did not affect the number of adult beetles present in colonies. This experiment shows that modifying a colony's entrance may help control small hive beetles, but more work is needed to offset unwanted effects of reduced colony entrances.

integrated pest management (IPM) / *Aethina tumida* / *Apis mellifera* / small hive beetles

INTRODUCTION

Since their discovery in Florida in 1998, small hive beetles (*Aethina tumida* Murray) have been responsible for millions of dollars of loss to beekeepers in the southeastern United States. Small hive beetle (SHB) adults and larvae are found in honey bee (*Apis mellifera* L.) hives where they damage colonies by preferentially consuming bee brood (Elzen *et. al.*, 1999) in addition to honey and pollen. SHB are native to sub-Saharan Africa (Hepburn and Radloff, 1998) where they are considered only minor pests of beekeeping (Lundie, 1940; Schmolke, 1974). Both Lundie and Schmolke noted that only weak colonies tend to succumb to high SHB infestations whereas stronger colonies can support large populations of the pest without sustaining significant damage.

Coumaphos is the only chemical treatment registered in the United States for use against small hive beetles inside bee hives. Treating the ground around colonies with soil insecticides can control beetle larvae exiting hives. Non-chemical control measures are more poorly developed. Mr. J.M. Sikes of Richmond Hills, Georgia suggested that colony invasion by adult beetles may be reduced by sealing and replacing the regular hive entrance with a ¾-inch section of PVC pipe located 3-4 inches above the bottom board (Fig. 1). This study was designed to test that hypothesis.

MATERIALS AND METHODS

Twenty Langstroth style honey bee colonies, consisting of single deep hive bodies, were set up in Warren County, Georgia where there have been no reports of SHB. Each colony received 4 frames of drawn comb, 5 frames of foundation, and 1 division board feeder. One queen and an average of 1.14 kg of bees (range of 1.12-1.15 kg) were introduced into all colonies. Colonies were fed 1:1 sugar / water every 2-7 days for 5 weeks prior to the start of the experiment. One week after colony set-up, the regular entrances of 10 hives were blocked and sealed tightly with a piece of wood, and new entrances consisting of ¾-inch (2-cm, ID) polyvinyl chloride (PVC) pipe were installed 3-4 inches (7.6-10.2 cm) above the bottom board (Fig. 1).

Five weeks later, all colonies were moved to an apiary in Richmond Hills, Georgia where there were established SHB populations (>50 beetles per colony, based on visual estimates). All cracks or holes in the colonies were caulked and the lids taped to the hive bodies. The experimental colonies were left in the apiary, unmanaged, unopened, and available to invading beetles until the experiment was dismantled.

The experiment was dismantled on days 58-59. Colonies were removed from the experiment if they had died. For each colony the temperature of the interior brood nest and ambient temperature outside the colony were determined with a hand-held digital thermometer. Colonies were then taken to an area of the apiary where bees were shaken from the frames and adult beetles collected for counting, the area of sealed brood (cm^2) measured, and colony debris on the bottom board collected for weighing.

The effects of pipe entrance on adult beetle numbers, amount of sealed brood, temperature inside colony, and temperature deviation from ambient were analyzed with a randomized design analysis of variance (PROC GLM, SAS 1992) recognizing residual error as the test error term. Because we noted considerable variation in the amount of sealed brood among colonies, we tested brood as a covariate for all variables of interest and retained it for one for which it significantly contributed to the model (temperature inside colony). Additionally, the effects of brood on inside colony temperature were tested with linear regression analysis (PROC REG, SAS 1992).

RESULTS AND DISCUSSION

General

There were treatment effects for number of adult beetles (P =

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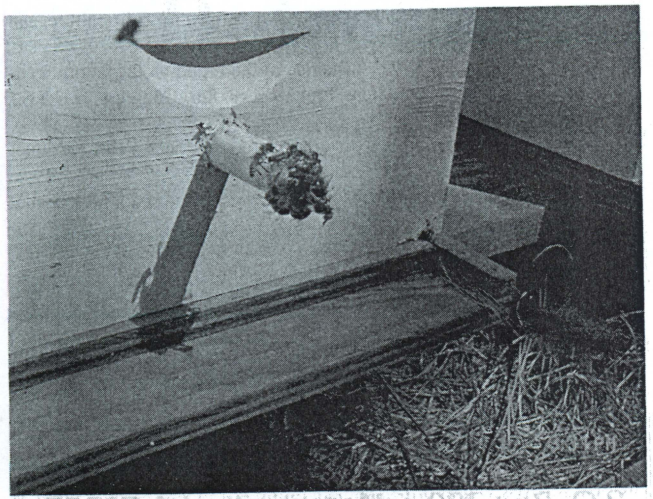

Figure 1. A colony with a ¾-inch PVC pipe entrance placed 3-4 inches above the bottom board of a Langstroth-style hive body. The regular entrance is blocked, and all superfluous gaps or holes in the hive are sealed. Colonies with pipe entrances had significantly fewer adult small hive beetles; however there appear to be associated problems with reduced brood production, impaired thermoregulation, excess floor debris, and poor water drainage.

0.0004) and temperature deviation from ambient ($P = 0.05$). There were no treatment effects for cm^2 sealed brood nor temperature inside colonies. The covariate brood significantly affected the temperature inside colonies ($P = 0.0112$), but not the number of adult beetles nor temperature deviation from ambient. Treatment means are presented in Table I.

Treatment effects on number of adult beetles and temperature deviation from ambient

There were treatment effects on the number of adult beetles found within colonies ($F = 19.7$; df =1,17; $P = 0.0004$). Colonies with pipe entrances had significantly fewer beetles (46.9 beetles / colony) than colonies with conventional entrances (107.7 beetles / colony). The effect of brood on the number of adult beetles within colonies was not significant ($P > 0.05$). Therefore, differences between entrances account for the differences found in adult beetle populations. It is possible that adult beetles have difficulty entering colonies with PVC pipe entrances due to problems maintaining footing on plastic pipes. Alternatively, and perhaps more likely, the bees are able to guard smaller entrances better, thus protecting the colony from potential beetle invaders.

Treatment did not significantly affect cm^2 sealed brood ($P = 0.094$), although there is a pronounced numeric difference (Table I). Colonies with open entrances had almost 2.5 times as much brood (358.2 cm^2) as colonies with pipe entrances (142.0 cm^2). Even though this difference was not significant, it suggests a liability associated with beetle control measures that involve reduced colony entrances. Insofar as the problem is associated with reduced airflow, it may be possible to ventilate hives or hive floors with screen. Finding the appropriate screen material, however, may be a problem as small hive beetles are capable of moving through screen as small as 10-mesh (10 meshes per inch) (Baxter *et al.* 1999), and smaller screens such as window screen tend to be heavily propolized by bees.

Treatment significantly affected colony nest temperature deviation from ambient ($F = 4.34$; df = 1,17; $P = 0.05$). The deviation was smaller (ie., more similar to ambient) for colonies with pipe entrances (Table I), suggesting that these colonies have greater difficulty regulating their temperatures independently of ambient

Entrance	sealed brood (cm^2)	no. adult beetles	Temp (°C) inside colony	temp deviation (°C) from ambient
Open	358.2 ± 119.0 (9)a	107.7 ± 11.9 (9)a	29.7 ± 1.2 (9)a	5.7 ± 0.8 (9)a
Pipe	142.0 ± 44.2 (10)a	46.9 ± 7.3 (10)b	28.1 ± 0.8 (10)a	2.9 ± 1.1 (10)b

Table I. Treatments administered to honey bee colonies placed in an SHB-infested apiary included conventional, open entrances or entrances reduced to a single PVC pipe. Values are mean ± standard error; *n* is given in parentheses. Column means followed by the same letter are not different at the a $\alpha \leq 0.05$ level.

conditions. This could pose a problem when outside temperatures are extreme.

Brood effects on temperature inside colonies

The covariate brood was found to significantly affect the temperature inside colonies ($F = 8.22$; df=1,16; P=0.0112), and the relationship was explained by the positive linear model $y=0.007x + 27.2$ where y=nest temperature (°C) and x=cm^2 brood, r=0.59. The more brood in a colony, the higher the nest temperature. A positive relationship between nest temperature and brood has been reported by others (Ritter & Koeniger, 1977; Kronenberg, 1979; Delaplane & Harbo, 1987).

Colony debris

On average, 7.2 ± 2.7 grams of debris were found in colonies with pipe entrances. No measurable debris was found in open, conventional entrances. This suggests that bees living in hives with reduced entrances have greater difficulty maintaining general hive sanitation. Five of the 10 pipe colonies had debris. Additionally, four pipe colonies had flooded bottom boards, indicating poor water drainage. These problems are further justification for incorporating some type of screened floor in hives with reduced pipe entrances.

CONCLUSIONS

Using hives whose entrances are modified to a single PVC pipe can reduce colony invasion by adult small hive beetles. The efficacy of the practice depends presumably on honey bees' ability to better guard a reduced entrance. For the practice to work optimally, it is necessary to close superfluous gaps or holes in bee hives. In spite of its benefit, there remain some problems with the technology. Colonies with pipe entrances seem to have associated problems with reduced brood production, impaired thermoregulation, excess floor debris, and poor water drainage. It may be possible to mitigate these problems by incorporating screen ventilation in hives or hive floors. However, it will be necessary to design screens that exclude beetles, while at the same time preventing excess buildup of propolis. In spite of these challenges, we believe that non-chemical controls, such as the one indicated in this study, are an important step toward a more environmentally sound management program for *Aethina tumida.*

ACKNOWLEDGMENTS

This research was funded by the United States Department of Agriculture. Technical assistance was provided by Amanda Morgan and Jennifer Berry of The University of Georgia. Gilbert and Grace Smith provided the Warren County, Georgia site. J.M. Sikes provided the Richmond Hills apiary site.

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