Efficacy of a Bottom Screen Device, Apistan™, and Apilife VAR™, in Controlling Varroa destructor

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Abstract

This study tested the efficacy of a hive bottom screen device in controlling varroa mites, when used alone or in conjunction with the miticides Apistam™ and Apilife VAR™. Thirty-six colonies were randomized and each assigned to one of six treatments: (1) no treatment, (2) bottom screen, (3) Apistan, (4) Apistan + screen, (5) Apilife, and (6) Apilife + screen. Adult bee populations were not affected by treatment, but the number of brood cells was significantly reduced in colonies treated exclusively with Apilife compared to that of colonies treated with Apistam or exclusively with a bottom screen. Brood production was numerically highest in colonies treated exclusively with a bottom screen. Varroa populations were significantly reduced in colonies receiving acaricide compared to non-treated colonies. Varroa populations in colonies treated exclusively with a bottom screen were 14.9% lower than that of non-treated colonies, but this difference was not significant. The bottom screen did not affect the percentage of varroa mite population phoretic on adult bees. Apistan provided 100% mite control in South Carolina, whereas in Georgia it provided 8% control in colonies treated exclusively with Apistam. With the addition of a bottom screen, Apistan-treated colonies in Georgia experienced an average mite control of 44.3%. This suggests that fluvalinate resistance exists in Georgia varroa mites. It also indicates that a bottom screen may help compensate for reduced acaricide efficacy. Average efficacy of Apilife ranged from 66.2 - 97.1%

Keywords: Apis mellifera / Varroa destructor / integrated pest management / chemical resistance management

There is growing interest in the use of screened bottom boards as a tool for managing the varroa mite (Varroa destructor Anderson & Trueman). Specific designs vary, but most feature a floor comprised of #8 hardware screen (3 mesh per cm). The device can be either a standard bottom board whose solid floor has been replaced with screen, or a rim with screen made to fit between a Langstroth hive body and standard bottom board (Fig. 1). A screened bottom board has been used in conjunction with paper collecting sheets as a method for monitoring varroa levels (Szabo 1998, 1999). But the chief merit of the device is its presumed ability to hinder or prevent mites from re-mounting their hosts once the mites fall off the bees and through the screen. Even without miticide, it is not uncommon for mites to drop off their hosts, and it is possible for up to 51% of these individuals to be alive (Webster et al. 2000). Thus, any technology that prevents these mites from returning to the brood nest would be an important part of an integrated program for mite control.

In spite of the interest in bottom screens, they have received relatively little quantitative examination. In Russia, Rodionov & Shubarashov (1986) claimed that mite populations in the presence of bottom screens "may be considerably reduced." In the United States, the number of mites retrieved on sticky sheets was consistently lower in hives with screened bottoms compared to that in non-modified hives (Petit & Shimanuki 1999, Ostiguy et al. 2000), although a statistically significant benefit was realized only by Ostiguy et al. The observation by Petit & Shimanuki that bottom screens significantly increase brood production further justifies continued research on the technology.

We were interested in building upon the work of previous investigators by examining the efficacy of the bottom screen device when used alone or in conjunction with two acaricides, Apistan™ (fluvalinate) and Apilife VAR™ (76% thymol, 16.4% eucalyptol, 3.8% menthol, and 3.8% camphor).

MATERIALS AND METHODS

General

On 7-10 June 1999 the experiment was set up with 36 colonies, 18 in one apiary near Athens, GA and 18 in another apiary near Clemson, SC, USA. Bees, brood, and queens were collected within each state from a variety of sources. Bees were collected into pre-weighted cages, each of which was sampled in order to determine average weight (mg) per bee and average number of phoretic varroa mites per bee. Frames of brood were used if each con-

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Figure 1. This bottom screen is designed to fit between a Langstroth-style hive body and standard bottom board.
Figure 2. Apilife VAR™ waferS were enclosed in #8 mesh screen to prevent bees from removing the material from the hive.

Table 1. Treatments administered to Varroa mite-positive honey bee colonies included (1) no treatment, (2) bottom screen, (3) Apistan, (4) Apistan + screen, (5) Apilife, and (6) Apilife + screen. Values are mean ± standard error; + = 6 except for % varroa phoretic for which n is given in parentheses. Row means followed by the same letter are not different at the α = 0.05 level.

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>Screen</th>
<th>No Screen</th>
<th>Screen</th>
<th>No Screen</th>
<th>Screen</th>
<th>No Screen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brood mite contamination</td>
<td>74.3% ± 6.1%</td>
<td>95.9% ± 0.9%</td>
<td>48.3% ± 1.3%</td>
<td>63.8% ± 0.5%</td>
<td>50.3% ± 1.3%</td>
<td>73.4% ± 0.9%</td>
</tr>
<tr>
<td>Brood mite</td>
<td>96.2% ± 1.4%</td>
<td>99.5% ± 0.5%</td>
<td>96.9% ± 0.5%</td>
<td>98.3% ± 0.2%</td>
<td>95.3% ± 2.7%</td>
<td>90.7% ± 1.4%</td>
</tr>
<tr>
<td>Survival</td>
<td>0% ± 0%</td>
<td>0% ± 0%</td>
<td>0% ± 0%</td>
<td>0% ± 0%</td>
<td>0% ± 0%</td>
<td>0% ± 0%</td>
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<tr>
<td>Population</td>
<td>2200 ± 200</td>
<td>2210 ± 200</td>
<td>2080 ± 200</td>
<td>2200 ± 200</td>
<td>2190 ± 200</td>
<td>2050 ± 200</td>
</tr>
<tr>
<td>Varroa phoretic</td>
<td>95% ± 5%</td>
<td>97% ± 5%</td>
<td>95% ± 3%</td>
<td>98% ± 2%</td>
<td>95% ± 3%</td>
<td>90% ± 5%</td>
</tr>
</tbody>
</table>

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uncovered over concern that the bees were propolizing the packets. We returned the protective packets, however, because we noticed that bees were removing wafer particles from the colonies. Apistan-treated colonies each received two new strips, according to manufacturer's instructions, which remained in the colonies for the duration of the experiment. Bottom screens were each positioned between the hive body and conventional bottom board (Pettis & Shimanski 1999).

Breed survivorship
Percentage brood survivorship was assessed during weeks 5 and 6. Each week, one comb containing open larvae was labeled per colony, a sheet of transparent acetate placed on one side the comb, and the position of two groups of ten cells (20 cells) each containing a live larva was indicated on the acetate with a permanent marker. Three days later the acetate was returned to the corresponding side of a comb and the number of remaining live brood cells counted. If the larvae had become capped, the cells were opened to confirm that the pre-pupa/pupa were still alive. Forty brood cells were appraised per colony (2 groups per comb x 10 cells x 2 samplings).

Dismantling
The experiment was dismantled on days 50-51 and the number of brood cells, bee populations, colony varroa mite populations, and number of mites retrieved on bottom board adhesive sheets appraised. The methods for making these determinations are explained in detail elsewhere (Delaplane & Hood 1997, 1999). Our data also permitted us to calculate percentage varroa mite control, according to 100 - (ending mite population - beginning mite population) x 100, and percentage of varroa mite population phoretic on adult bees.

Analyses
The effects of treatment on number of brood cells, percentage brood survivorship, bee populations, colony varroa mite populations, percentage varroa mite control, percentage of varroa mites...
Table II. Percentage varroa mite control in colonies treated as explained in Table I and calculated according to 100-((ending mite population + beginning mite population) × 100). There was a treatment × state interaction for this variable, so analyses were run separately by state. Values are mean ± standard error, n = 3. Row means followed by the same letter are not different at the α ≤ 0.05 level.

RESULTS AND DISCUSSION

General

There were treatment effects for number of brood cells, colony varroa mite populations, percentage varroa mite control, and number of varroa mites retrieved on adhesive sheets (P ≤ 0.046). There were state effects (P = 0.0001) as well as a state × treatment interaction (P = 0.0026) for percentage varroa mite control. There were no treatment effects for percentage brood survivorship, bee population, and percentage varroa mites phoretic. The covariate beginning varroa mite population significantly affected percentage varroa mite control (P = 0.0015). Treatment means and mean separation tests are presented in Tables I and II.

Treatment effects on adult bees and brood

Adult bee populations were not affected by treatment, but the number of brood cells was significantly reduced in colonies treated exclusively with Apilife compared to that of colonies treated with Apistan or exclusively with a bottom screen. It is also noteworthy that brood survivorship was numerically smallest in Apilife-treated colonies (Table I). Although the brood survivorship means were not statistically different, the total data set suggests that the effects of Apilife on brood are not innocuous. Published data are not congruent on the toxic effects on bees of thymol-based acaricides. Chiessa (1991) found evidence for increased adult bee mortality in thymol-treated colonies, and Bunsen (1991) documented increased brood mortality in the presence of thyme. However, Mathia et al. (2000) failed to detect differences in brood mortality between non-treated colonies and colonies treated with the thymol-based acaricide Apiguard.

There is evidence that negative effects of thymol may be mitigated by management. In the present study the addition of a bottom screen elevated brood production in Apilife-treated colonies to a level comparable to that of other treatments (Table I). Brood production was numerically highest in colonies treated exclusively with a bottom screen (Table I), an observation noted before by Pettis & Shimamuki (1999). This is a noteworthy feature of the bottom screen and justifies further research to confirm if it is a general phenomenon and to determine its mode of action and implications for the nesting biology of honey bees.

Treatment effects on varroa mites

Compared to non-treated controls, ending colony varroa populations were significantly reduced in colonies receiving acaricide (Table I). Average ending varroa populations in acaricide-treated colonies ranged from 34-131, well below established economic thresholds for the region (Delaplane & Hood 1997, 1999); conversely, mite populations in non-treated colonies (2202 per colony) were approaching the threshold level of 3172 (Delaplane & Hood 1997, 1999). Ending varroa populations in colonies treated exclusively with a bottom screen (1874) were about 14.9 % lower than that of non-treated controls (2202). Although this difference was not statistically significant, it is congruent with the findings of Pettis & Shimamuki (1999) and Ostiguy et al. (2000) and suggests that the bottom screen does exert a negative influence on mite populations. The number of mites retrieved on adhesive sheets was about 44% lower in colonies treated exclusively with a bottom screen compared to non-treated controls, a difference outside the range of 14-28% reported by Pettis & Shimamuki (1999).

In Table II we report percentage varroa mite control which represents the percentage change in mite populations from the beginning to the end of the experiment. This allows us to compare treatments, while accounting for differences in beginning mite populations. There was a treatment × state interaction for this variable, so it was analyzed separately by state. The interaction is explained by a pronounced difference in the performance of Apistan in Georgia compared to South Carolina. Apistan provided 100% mite control in South Carolina whereas in Georgia it provided 0% control in colonies treated exclusively with Apistan. In the presence of a bottom screen Apistan-treated colonies in Georgia experienced an average mite control of 44.3%. This suggests that Apistan (flumetrinate) resistance exists in Georgia varroa mites, a phenomenon documented in Europe and other regions of the USA (Milani 1999). The present data also suggest that in cases of resistance a bottom screen may help compensate for reduced acaricide efficacy. The range of average efficacy for Apilife across both states was 65.2 - 97.1% (Table II) which is similar to the range of 63.9 - 99.5% reported for Apilife in Europe (Jandorf et al. 1999) and to the range of 70 - 96.7% reported for similar thymol-based blends in North America (Calderone 1999, Calderone & Spivak 1995). In Georgia the bottom screen numerically increased mite control in Apilife-treated colonies, but this benefit was not apparent in South Carolina (Table II).

There were no differences among treatments for the percentage of varroa mites phoretic on adult bees (Table I). The hypothesized mode of action for the bottom screen is that it hides dislodged mites from re-occupying adult bees (Rodionov & Shabarov 1986, Pettis & Shimamuki 1999). We reasoned that if this hypothesis is true, then we may expect to see in colonies with bottom screens an average reduction in the fraction of the mite population on adult bees, which did not occur. It remains to elucidate the mode of action for the bottom screen.

Conclusions

Although there is evidence that it reduces brood production, Apilife VAR can provide varroa mite control in North America at a level comparable to that of Apistan. Our data support the conclusion of Pettis & Shimamuki (1999) that the bottom screen increases brood production. Additionally, our data suggest that bottom screens can enhance varroa mite control in colonies with chemical resistant mites. The addition of bottom screens to colonies lowered average mite population numerically by 14.9% compared to non-treated controls, but it is important to stress that this effect was not statistically significant.

To our knowledge, in North America only Ostiguy et al. (2000) have reported a statistically significant benefit of using bottom screens against varroa; however, the trends of all studies (Pettis & Shimamuki 1999, Ostiguy et al. 2000) including ours have been consistently favorable. It is reasonable to conclude tentatively that the effects of bottom screens are subtle, but real. The fact that their effects are small does not necessarily diminish the value of screens.
because it is common in integrated pest management to incorporate many diverse control strategies, any one of which may be insufficient when used alone. In this respect bottom screens may prove useful when used with other practices such as mite removal (Dung et al. 1995, Fakhrizadeh 2000), genetically resistant bees (Spivak 1996, Harbo & Harris 1999), and apiary isolation (Delaplane & Hood 1999). A concerted use of such strategies holds promise for slowing the achievement of treatable mite thresholds (Delaplane & Hood 1997, 1999) and for reducing the overall quantity of chemicals used in beekeeping.

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REFERENCES


