

NOTES AND COMMENTS



Revisiting powdered sugar for varroa control on honey bees (*Apis mellifera* L.)

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Dusting bees with powdered sugar has been examined as a remedial control for *Varroa destructor* Anderson and Trueman (varroa). Two modes of action have been proposed: one being that fine dust impedes the locomotion of phoretic mites and induces them to fall off bees (Ramirez, 1994), and another being that dust induces a grooming response in bees that similarly dislodges mites (Macedo *et al.*, 2002). When measured as a percentage of phoretic mites dislodged, powdered sugar dusting has achieved experimental knock-down rates ranging from 77% (Aliano and Ellis, 2005) to more than 90% (Fakhimzadeh, 2001; Macedo *et al.*, 2002), but a persistent problem has been translating these kinds of results into practical field applications.

The most comprehensive examination of powdered sugar as a field-level varroa control was the work of Ellis *et al.* (2009) in Florida. These authors dusted the top bars of brood combs with powdered sugar every two weeks from April until the following February (11 months), compared numerous parameters of colony strength and varroa populations against a control group, and found no treatment effects on any parameter of interest. In spite of these negative, yet convincing results, we wanted to do a field study that: 1. exploited a brood-free period of the season when all mites are phoretic on adults and vulnerable to dust treatment (bee colonies in sub-tropical Florida are rarely brood-free); 2. compared more than one dust delivery method, and; 3. compared more than one treatment timing interval. We felt that these outstanding questions should be resolved before we abandon powdered sugar as a bee-safe (Fakhimzadeh, 2001) and chemical-free varroa control option.

We set up 64 equalized, queen-right colonies (single-body Langstroth hives with screen floors) and divided them equally between two apiary sites in Oconee County, Georgia, USA (33° 50' N; 84° 34' E). Once in their respective apiaries, each colony was randomly assigned one of 8 (2³) treatment combinations: 1. initiation of powdered sugar treatment (a) in January (broodless period) or (b) in March (brood area rapidly expanding); 2. treatment applied at an interval of (a) every other

month for a duration of 9 days (4 treatments 3 days apart) or (b) treatment applied one day at an interval of every 2 weeks, and; 3. powdered sugar applied as (a) a dusting of 120 g (250 ml) powdered sugar with a sifter over the top bars of brood combs then brushing the sugar down between frames using a bee brush or (b) powdered sugar (same quantity) blown into the hive entrance with forced air from a shop vacuum cleaner custom-fitted with a chamber made of polyvinyl chloride (PVC) plumbing components holding the powdered sugar. There were 8 colonies (replicates) per treatment combination. The treatment interval ran from January to October, inclusive.

As an appendage to this balanced design, we set up and managed an additional 8 colonies as negative, untreated controls (never treated with powdered sugar or any remedial action), raising the experiment to n = 72 colonies. These colonies provided an additional treatment group for comparison in one-way ANOVAs against the simple effect of powdered sugar.

After colonies were established, they were managed optimally for swarm control and honey production while administering the prescribed treatments. In January prior to administering the first treatments and again in May and October, we collected the following measures of colony strength and mite numbers using published methods (Ellis *et al.*, 2009): bee population, brood area (cm²) (only in May and October), brood viability (72 hr survivorship of open larvae), and number of phoretic mites per 100 bees (derived from strained alcohol samples of ~300 bees). Additionally, the number of mites retrieved on 3-day bottom board sticky sheets (adjusted for mite catch per 24 h) was collected for each surviving colony on 19 January, 8 March, 16 April, 1 June, 25 June, 30 July, 17 August, 25 September, and 11 October. All statistical analyses were done with SAS JMP (version 8.0.2).

Our first question was simply whether varroa mite levels were affected by powdered sugar treatment. To test this, we pooled all 64 colonies in the balanced experiment into one "treated" group

(irrespective of the $2^3 = 8$ sugar combinations described above), assigned each a random number, and sorted them by random number, thus creating 8 randomly-assigned groups of 8 treated colonies. Each of these treated groups thus presented a comparison group to the 8 untreated control colonies, essentially letting us perform 8 separate ANOVAs on the dependent variables. In 2 of 8 ANOVAs (25%), powdered sugar significantly reduced colony mite levels. In one analysis, the number of phoretic mites per 100 bees averaged across January to October was significantly ($F = 4.4$; $df = 1,14$; $P = 0.0537$) lower in the treated group (3.0 ± 0.98 (mean \pm SE), $n = 8$) than the control group (6.0 ± 0.98 , $n = 8$). In another analysis, the number of mites caught on sticky sheets per 24 h averaged across January to October was significantly ($F = 4.7$; $df = 1,14$; $P = 0.0475$) lower in the treated group (24.4 ± 7.3 , $n = 8$) than the control group (46.9 ± 7.3 , $n = 8$). No other parameters of interest responded to powdered sugar in these tests.

We next turned our attention to the balanced experiment in order to tease out the effects of month of treatment initiation, mode of dust application, treatment interval, and any interactions thereof. The only significant effect in a whole-model analysis was an interaction between mode of application and treatment interval for cm^2 brood in May. Deeming this uninteresting, we simplified the analyses by treating month of initiation, mode, and interval as simple effects in one-way ANOVAs. The number of phoretic mites per 100 bees in October was significantly ($F = 4.8$; $df = 1,22$; $P = 0.0401$) lower in colonies in which powdered sugar treatment began the previous January (3.4 ± 0.9 mites (mean \pm SE), $n = 11$) compared to colonies in which treatment was delayed until March (6.1 ± 0.8 , $n = 13$). This suggests that powdered sugar dusting is more efficacious when it can be applied early and exploit a winter brood-free period. Colony bee population in May was significantly ($F = 3.9$; $df = 1,61$; $P = 0.0524$) higher in colonies in which powdered sugar had been blown into hive entrances (8496 ± 710 bees, $n = 32$) compared to colonies which had received powdered sugar by sifting onto exposed brood comb top bars (6493 ± 721 , $n = 32$). This suggests that applying powdered sugar with forced air at the hive entrance was less disruptive to bee populations than exposing and dusting comb top bars. No other parameters of interest responded to independent variables in these one-way ANOVAs.

A final observation of interest is the number of colonies surviving at the end of the experiment. Of the 8 non-treated control colonies, three ($3/8 = 38\%$, $n = 1$) were alive in October. Average survival among the 8 sets of randomly-derived treated colonies was $39 \pm 6.4\%$ (mean \pm SE), $n = 8$).

In conclusion, powdered sugar treatment resulted in lower colony varroa levels in 2 of 8 (25%) separate analyses. We thus have evidence that powdered sugar is most efficacious when it can be applied early in the season and exploit a winter brood-free period. A labour-saving technique of applying powdered sugar dust at hive entrances with forced air appears to be less disruptive to colony bee populations than the more invasive practice of sifting sugar onto exposed brood comb top bars. In spite of these highlights, we cannot pretend that these results are a strong affirmation of powdered sugar in the fight against varroa. The method was ineffective at reducing varroa in 75% of our analyses. Moreover, 10-month colony survival between treated and non-treated colonies was virtually identical, and poor, at 38-39%. Powdered sugar is thus, at best, another "weak" IPM component that may contribute toward varroa management when used in conjunction with other components.

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