POWDERED SUGAR DUSTING FOR THE CONTROL OF VARROOSIS

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Introduction

According to RITTER (1999) and SHIMANUKI (2000), anecdotal references to dusting procedure exist for the control of Varroa destructor but are not published. The scientific literature does not report results from any of these trials. Only some notes (SHAH and SHAH, 1988) have been published in extension type articles in Italian (LOGLIO and PINESSI, 1991; 1993; LOGLIO, 1996) or in the proceedings of some apicultural conferences (RAMIREZ, 1987). Their reports of “encouraging results” are obtained by combatting V. destructor with a non-toxic dust in the hive. A fine powder of ground pollen or glucose (RAMIREZ, 1987; 1989) or wheat flour was dusted onto the bees to control V. destructor in bee colonies (e.g., SHAH and SHAH, 1988; LOGLIO and PINESSI, 1991; 1992) or detect living mites (LOGLIO and PINESSI, 1993; LOGLIO, 1996).

The hypotesis explaining why dusting might help to knock down the mite is based on the fact that V. destructor, like other mites, has ambulacra which allow it to adhere to a substrate. The dust on the bees adheres to the ambulacra of V. destructor, and this prevents the mite from attaching to the bees' surfaces (RAMIREZ, 1988). It loses its grip and falls on the floor of the hive, where it dies of starvation (RAMIREZ 1987; 1994) as it is unable to move on the dusty surface (RAMIREZ and MALAVASI, 1991). In addition, dust many cover important sensory organs of mites. The mite has no known optical system. It has appropriate sensory setae located on the first pair of legs (tarsus I) for the realisation of high body temperature (35-40°C) of its host (BRUCE, 1997). Encouraging results were obtained by using a blowing equipment to dust the wheat flour onto the bees in colonies (LOGLIO and PINESSI, 1992). Unfortunately the particle size used in dusting the bees is not reported in any of the above studies. In a preliminary investigation wheat flour was replaced by finely ground pure white sugar and 35 g were dusted per colony. As many as 750 Varroa mites were collected below a hive after a single dust application. Powdered sugar application seemed to have no obvious negative side effect. Earlier observations indicated that bees with misshapen wings and malformed body walked out and fell down from flight board after dusting. It seems that other bees reject them by choosing not to clean them.

Methodology

These studies were carried out during 1996-2001 to determine how to combat V. destructor with sugar. Notwithstanding the fact that the development of highly efficient method to control V. destructor was not the only outline of these trials. Safety of individual adult worker bees undergoing such sugar treatments as well as their colony development were equally as important. Super-fine ground pure white sugar was implemented in all trials (including preliminary since 1990) and are referred to as “confectioner sugar” or “powdered sugar” with a nominal mean particle size of 25-40 µm according to the manufacturer (Finnugar Ltd.: Helsinki, Finland). A simple apparatus (FAKHIMZADEH, 2000) assisted in air dusting the bees.

In laboratory

Samples of 49 to 107 bees (mean 78) were taken from 6 colonies. Five treatments were used with a completely randomised design and 5 replicates each. Two methods of sugar application were studied (FAKHIMZADEH, 2001): direct dusting and air assisted dusting with 5 g and 0.5 g of confectioner sugar, respectively. Both application methods were examined with and without preanaesthetisation of the bees by CO₂. The efficiency of mites recovered with the two methods of sugar dusting were studied.

As a possible side-effect of the sugar dusting, the accumulation of sugar particles in the T2 spiracles and their ducts of treated bees was investigated under SEM (scanning electron microscope) (FAKHIMZADEH, 2001: Experiment 2) due to some unexplained bee mortality in the former experiment (FAKHIMZADEH, 2001: Experiment 1). In this trial of probable accumulation of sugar in imagos' respiratory system, five treatments similar to the first trial were assessed; these were followed by SEM observation of imagos’ first thoracic spiracles and their ducts executed 24 h after treatment. The main thoracic tracheal ducts leading from T2 spiracles of 100 bees (n=200 ducts) were dissected lengthwise and observed under SEM, chiefly at magnifications of 500 and 4000x. The ambulacrum of female V. destructor was also examined. Investigation of particulate matters in the ducts, both immediately after the treatments, and also 48 h from performance of grooming behaviour of bees seemed both difficult and less trustworthy.
CO₂ anaesthesia was implemented with the assumption that it might drive the mites out from between the bees’ segments and also in order to anaesthetise the bees so that they would not inhale the confectioner sugar during treatments. The impact of CO₂ alone and in combination with sugar dusting methods in accelerating the mite fall was investigated. The impact of CO₂ anaesthesia and sugar dusting on bees survival were studied in highly mite infested bees as well as on bees with low mite infestation (FAKHIMZADEH, submitted).

In apiary

In a Finnish apiary at Viikki in Helsinki (60°13'N, 25°02'E), 24 naturally infested colonies of *Apis mellifera* were assigned randomly to five treatments (groups) with 4 and 6 replicates in treated and control groups, respectively. Similar sugar treatment was applied by aerating confectioner sugar (with the simple apparatus) sequentially at intervals of three, seven and 14 days during July (FAKHIMZADEH, 2000). Debris samples were secured under a wired frame (USDA 1987; HERBERT et al., 1989; PETTIS and SHIMANUKI, 1999). The whole debris sampled prior to treatment was termed as BT, and samples after treatment as SD (6 h) and ND (18 h). AT (24 h) is a summational value, and its subdivision to SD and ND alleviated the vulnerability of the experiment to missing data. Mite fall per hour was studied.

The impact of sugar dusting every 3, 7 and 14 days on the colony development and the queen bee supersedure were also studied (FAKHIMZADEH, Accepted). In order to quantify the pattern of colony growth, the amount of capped brood cells and a census of a colony’s population of adult worker bees in each colony were recorded before, during and after the treatment period.

Results

In laboratory, the values of treatments with and without anaesthesia were pooled to compare the dusting treatments, since the CO₂ anaesthesia did not affect the mite fall significantly (Mantel-Haenszel chi-square for odds ratio homogeneity = 0.018, P = 0.89). Direct dusting by 5 g of confectioner sugar resulted in 91% mite fall compared to only 62% for the air dusting of 0.5 g sugar, and this difference was significant (G=15.89, P=0.001). The CO₂ had no impact on mite fall. No sugar contamination was found inside the tracheal ducts of sugar treated bees in any of the treatments.

In experiment 1, mortality of non-anaesthetised sugar treated bees was higher than anaesthetised treatments. However at low infestation opposite was true. It was concluded that the reduction in bees’ lifespan in experiment 2 (FAKHIMZADEH, submitted) was attributed to the use of CO₂ (Figure 1). In preanaesthetised bees, no significant impact was found by using either method of sugar application.

![Fig. 1 – Number of dead bees in high and low infested bees (by V. destructor) in laboratory experiment 1 (E1) and experiment 2 (E2), respectively.](image)

The treatments were: A; direct dusting with 5 g sugar, B; air-assisted dusting with 0.5 g sugar, CA; CO₂ anesthesia + A, CB; CO₂ anesthesia + B, and control. All bee samples were shaken and rolled after dusting (A, B, CA, CB).

The second Y axis shows the percentage of mite recovery in each treatment in the experiment 1. Vertical lines represent SE.

Under field conditions, the mite fall per day after treatment in all sugar-treated groups was significantly higher than the levels measured before treatment, and that in the control colonies. For the first sugar treatment (n=12), the mean mite fall per day was 23 times greater in AT samples, in contrast to BT samples of the same treatments. The dusting treatment significantly accelerated mite fall. The ±S.E. for BT was 0.17±0.06 (n=12), and for same day (SD) samples 5.8±1.7 and for ND 3.3±2.5 mites per hour. The mite fall of SD and ND were combined to form the AT, which was 3.8±1.8 mites per hour.

No statistical differences were found among the experimental treatments in the total number of capped brood cells in colonies, before (F=1.515, df=4, P=0.237), and after (F=0.481, df=4, P=0.749) the ex-
Experimental period. Adult bee population of chemical control group was significantly higher than mite infested groups at the start of the experiment (F=7.629, df=4, P<0.001). However, no statistical differences were found among treatments in bee population growth, which was estimated 20 days after the start of the experiment (F=0.553, df=4, P=0.7). No queen bee supersEDURE occurred in sugar treated colonies during the treatment period.

Discussion

The mean efficiency of mite knock down with powdered sugar was 91% with direct dusting and 62% with air-assisted dusting. The former value is consistent with the 80% effectiveness reported by Macedo and Ellis (2000) and also with the results of previous studies on dusting with fine glucose and wheat flour that gave results for mite control in the absence of brood (Shah and Shah, 1988; Ramirez, 1989; Loglio and Pinessi, 1992) and also for the detection of live Varroa mites (Loglio and Pinessi, 1993; Loglio, 1996). Sugar dusting efficiency in knocking down the Varroa in some cases was similar to that reported for mite kill in studies using chemical applications. For example the efficiency of amitraz and fluvinate on package bees were 83% and 87%, respectively, at the concentration indicated by the manufacturers (Henderson, 1988).

The present results are in agreement with Tustain and Faulke (1979) in which CO₂ anaesthesia reduced longevity of caged honey bees. Fakhimzadeh (2001) showed that CO₂ in combination with sugar or alone did not increase the mite fall. Hence, for the control of V. destructor CO₂ should not be used.

The results suggest that powdered sugar treatment as described does not have any obvious side effect on the capped brood nor the growth of the bee population. These results are in agreement with other studies in which wheat flour was dusted to colonies frequently for the control of Varroa and they did not observe any side-effect on brood or bees development (Ramirez, 1989; and Shah, 1988; Loglio and Pinessi, 1991; 1993; 1996). Loglio and Pinessi (1992) applied wheat flour to experimental colonies with the help of an agricultural duster and observed no side-effect on the colony development. No queen loss occurred even if the treatment is applied as frequently as every three days for a period of one month. It was concluded that sugar dusting alone is sufficient and a useful tool, which could be included to integrated mite management programs.

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