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The study on *Ferula ovina* fumigation to control *Varroa destructor* (Acari: Varroidae), a sever pest of *Apis mellifera* (Hymenoptera: Apidae)

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The honeybee, *Apis mellifera* L. (Hymenoptera: Apidae), is one of the most economically important insects because of long providing humans with honey and beeswax. In addition to honey production, honeybees are the principal species used for crop pollination worldwide (Free 1993). The pollination services of honeybees in the United States have been estimated to worth \$14.6 billion in 2000 (Morse and Caldrone 2000). The honeybees have been recently used as vectors of beneficial pathogens to control those plant pathogenic pests that are associated with plant flowers (Shafir *et al.* 2006). Honey production and pollination of honeybees are negatively influenced by a variety of pests and diseases (Romeh 2009). The *Varroa* mite, *Varroa destructor* Anderson & Trueman (Acari: Varroidae), is probably the most important parasite of *A. mellifera*, causing tremendous damage to honey bees and great economic loss to the beekeeping industry. Parasitism by *V. destructor* may results in the loss of adult weight, severe wing deformations and reduced longevity of worker and drone honey bees (De Jong *et al.* 1982). Sever infestation can lead to reduced worker bee populations and collapse of untreated colonies, not only due to mite infestation, but also as a result of secondary viral, bacterial and fungal infestations (Hung *et al.* 1996).

The aerial parts of ferula plants (Apiaceae), including leaves and stems, were collected from Alamut, Qazvin Province (36° 26' 41" N 50° 35' 11" E) during June 2013. The plant materials were transferred into Entomology Laboratory (University of Tehran) and air-dried for two weeks. Identification of plant species was approved at the Department of Horticulture, College of Agriculture and Natural Resources, University of Tehran. One species, *Ferula ovina* Bioss, which is one of the most common species growing in different parts of Iran, was selected for the current study.

The shaking method was used to estimate the infestation intensity of bee hives to *V. destructor* and nine hives with nearly equal infection status were selected for this study. Briefly, 100 bees were randomly selected from each hive and were put in a sealed container containing flour. After severe shaking of the container, the fell down mites were collected and counted. Estimation of infestation status was conducted three and six days before the experiment.

A sticky plastic sheet was placed on the floor of the hives to determine the number of fallen mites in each hive and replaced weekly. In positive control treatment, 5 ml formic acid (65%) was placed in a Petri-dish inside the hives and refreshed weekly (Bahreini *et al.* 2003). In the other treatment, the hives were fumigated with the burning smokes of *F. ovina*. Ten grams of the aerial parts of *F. ovina* was weighed by a digital

scale. After burning, the plant materials were used to smoke the hives by a bee smoker (15 puffs) through the hive's entrance (Romeh 2009). The entrance was then closed for one hour to promise the persistence of the smoke in the hive. In control treatment, the hives were left without any treatment.

The treatment of hives by either formic acid or ferula smoke was repeated weekly for four weeks. During this period, the numbers of mites fell onto the plastic sheets were recorded weekly. At the fifth week, 5 ml of formic acid 65% was placed in all studied hives to compare the rate of infestation and the efficiency of treatments. At the end of the fifth week, the plastic sheets were collected from the hives and the number of mites, fell during the formic acid treatment, was counted in all studied hives. This study was conducted in a completely randomized design with three replicates for each treatment. The differences between numbers of mites fall from different hives were tested by analysis of variance (ANOVA) using SPSS computer software (version 17.1).

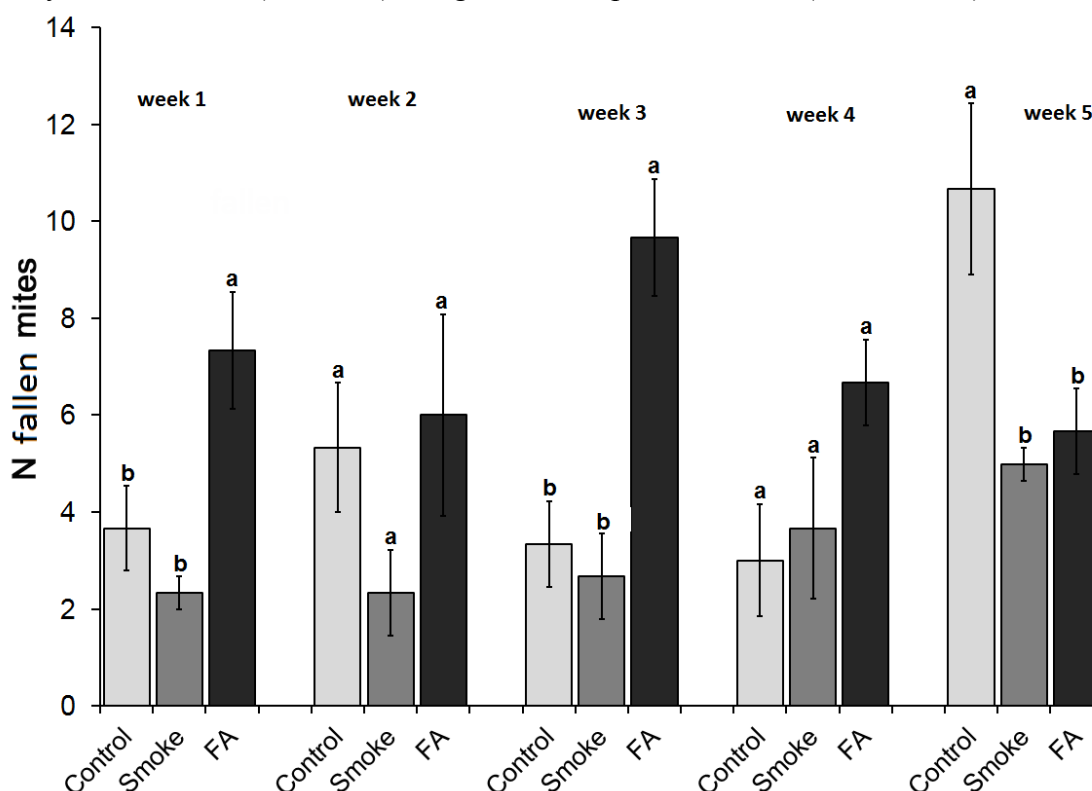


Figure 1. The average numbers of *Varroa* mites collected from the bottom boards of beehives treated by formic acid and ferula smoke during a 4-week period and the final fall of mites when all hives were treated by formic acid at the fifth week.

The average numbers of mites collected on the plastic sheet on the floor of beehives have been shown in Fig. 1. As the figure shows, the highest numbers of mites were counted in the hives treated by formic acid during the first four weeks, while those hives treated by *F. ovina* smoke experienced lower mite downfall. During the first four weeks of the experiment, the number of mites collected on the plastic sheet in formic acid-treated hives was significantly higher than those of control and *F. ovina* treatments (one-way ANOVA, $F = 7.4$, $df = 2$, $P < 0.05$) (Fig. 1). As all hives, selected in the current study, were nearly equally infested by *V. destructor*, it may be concluded that formic acid have a better efficiency in *Varroa* control because it causes more mites to be downfall from

the hives compared to *F. ovina* treated hives. However, by integrating the results obtained from the fifth week, we found that the total number of mites collected from *F. ovina* treated hives was not statistically different from formic acid treated hives. This implies that, despite lower mite fall in *F. ovina* treated hives during the four first weeks, *Varroa* mite was controlled by smoke. Plants have a wide variety of defensive compounds, called secondary metabolites, which are used against herbivores (Lopes *et al.* 2009). These compounds have been suggested to interfere with the normal growth, development and reproduction of target pests (Nanasahe *et al.* 2008). Therefore, effect of *F. ovina* smoke on *V. destructor* may be attributable to the emission of the defensive secondary metabolites by *Ferula* materials. However, the precise effects of *Ferula* on life table parameters and biological characteristics of *V. destructor* remains to be cleared in the future studies. With respect to the harmful effects of synthetic chemicals, such as formic acid, on honey bees and honey production, plant derived materials may be more safe agents for integrated management of *V. destructor*. These compounds may be applied solely or in integration with other control methods to decrease the volume of chemical pesticides currently used to control honey bee pests and diseases. However, it would be necessary to evaluate the precise effect of this smoke on honeybees and honey production. Additionally, the best method of smoking should be achieved by repeating this experiment by other doses of smoke as well as considering other smoking intervals.

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