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Efficacies of Chemical and Biological Products Employed in the Integrated Treatment of *Varroa destructor* in Algeria

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Abstract

The fight against the *Varroa destructor* has become a major concern for beekeepers around the world in general and in Algeria in particular. Indeed, several related chemicals have been released to the market but the problems of efficiency and development of resistance by this parasite to some of these compounds worry beekeepers. The objective of this study was to test efficacies of several approved chemicals as well as some natural products that are based on thymol and oxalic acid in treatment of *Varroa destructor*. The experiment was conducted on 60 colonies of *Apis meliffera intermissa* in the region of Tizi-Ouzou, Algeria. Of the products approved in Algeria and tested in the present study, Bayvarol recorded the highest efficiency (94.69%), followed by Apivar (91.59%) and Apistan (76.92%). Efficiencies of the natural treatments were 93.96% for Apilife Var, 89.32% for Oxuvar, and 90.57% for Apibioxal. Our study showed a very low efficacy of Apistan, which is widely used by beekeepers, in treatment of *Varroa destructor*. The effectiveness of organic products in treating *Varroa destructor* is highly promising for integration into an alternative control strategy.

Key words: *Varroa destructor*, acaricides, honey bee, control, efficiency.

1. INTRODUCTION

The *Varroa destructor* mite is an ectoparasite of the honey bee *Apis mellifera* (Anderson and Trueman 2000) that develops in the brood and on the adult bee (Donzé, 1995). It is prevalent worldwide and responsible for numerous cases of colony damage due to the association of this parasite with several bee viruses (Rosenkranz et al., 2010). In view of this, it has become the main agent of weakening and loss of colonies (Fries et al., 1994, Rosenkranz et al., 2010).

Since the appearance of this disease, several chemical preparations have been synthesized and released to the market. But high use of these products has led to many problems such as residues in

bee products, possible toxicity to bees, and the appearance of mites that are resistant to certain acaricidal molecules (Elzen et al., 1988, Sammataro et al. 2005

In Algeria, there has been little published work on the effectiveness of acaricides in treatment of the *Varroa destructor* (Alloui et al 2002, Loucif-Ayad et al 2010, Adjlane et al. 2013, 2016). Therefore, the aim of this study was to investigate the efficacies of several approved chemicals and some natural products that are based on thymol and oxalic acid in treatment of *Varroa destructor*. The tested treatments included three chemical preparations impregnated in plastic straps (amitraz 500 mg (Apivar®, VETO-PHARM), 0.06% flumethrin (Bayvarol®, Bayer HealthCare), and 0.8 g tau-fluvalinate (Apistan®, VitaEurope)) and three natural products: Apilife Var (LAIF Chemicals, Vigonza PD, Italy), which contains thymol besides menthol, camphor, and eucalyptol as the active ingredients, and two formulations of oxalic acid (Oxuvar (Andermatt BioVet GmbH, Switezrland) and Apibioxal (Chemical Life, VIGONZA (PD) Italy)).

2. MATERIALS AND METHODS

Experimentation was carried out in a private apiary in the village of Azib Ahmed in Tizi-ouzou region in northern Algeria, during the period of three months, extending from September to November 2016. The apiary is surrounded by highly-varied melliferous flora composed mainly of spontaneous plants; fruit trees, including citrus fruits; olive trees; and eucalyptus trees. The average temperature in this period varied from 16°C to 24.3°C.

Sixty colonies of *Apis mellifera intermissa* housed in Langstroth hives were selected based on the number of frames occupied by the bees and their levels of infestation. Each hive is equipped with a mesh tray made of a fine mesh metal grid (4-5 mm) which covers the sticky sheets deposited on the surface of the floor of the hive. These trays are usually used to collect the falling *Varroa* and prevent the access of bees to eliminate them.

The colonies were divided into six groups of 10 colonies each and every group was subjected to one of six treatments. The six groups of treatment were the following:

- **Group** 1:
This group of colonies was treated with Apistan® whose active molecule is fluvalinate. In this treatment, two bands were placed between brood frames for 6 weeks.
- **Group** 2:
Colonies of this group received the treatment of Apivar® whose active molecule is amitraz. The treatment entailed placement of two bands between the broods for 6 weeks.
- **Group** 3:
This group of colonies was treated with Bayvarol® whose active molecule is flumetrine. In this treatment, four bands were placed between the frames near the brood for 6 weeks.
- **Group** 4:
Colonies in this group received the treatment of Apilife Var, which consists of 76% thymol, 3.8% menthol, 3.8% camphor, and 16.4% eucalyptol. This treatment entailed placement of one strip (sometimes two) between the brood frames at two-week intervals for 4 weeks.
- **Group** 5:
This group of colonies was treated with Oxuvar, which consists of an oxalic acid dihydrate aqueous solution. In this treatment, a 40 ml volume of Oxuvar was added dropwise (using a syringe) to the frames occupied by the bees for a period of 6 weeks.
- **Group** 6:
Colonies of this group received the treatment of Apibioxal, which consists of oxalic acid. The treatment entailed administration of 40 ml of Apibioxal to the colonies using a syringe at a rate of 5 ml per hive.

At the end of the duration recommended for each treatment, the colonies of each group were treated with Apiguard (control treatment) in order to evaluate treatment effectiveness. Apiguard comes in the form of trays (box of 50-g trays), each containing 25% thymol (12.5 g of thymol coated with a slow diffusion gel). Accordingly, the main active ingredient in this preparation is thymol.

Efficacies of the aforementioned products were calculated as follows:

Efficacy (%) = [Number of *Varroa* dying during treatment T / Number of *Varroa* deaths during (T_c + T)] X 100

where
T: Treatment used in group; and
T_c: Control treatment

3. RESULTS AND DISCUSSION

The results of visual counting of the dead *Varroa* on the diapers before and after each treatment and in the control treatment are shown in Figure 1. It is noticed that the mortality rate of *Varroa* was very high in the first week of application of the different treatments. However, of the chemical treatments, Bayvarol led to the highest average rate of mortality of the *Varroa destructor* (877 *Varroa*), followed by Apivar (761 *Varroa*), then Apistan with 627 *Varroa*. In the case of the biological treatments, the average rate of parasite mortality was associated with Apilife Var (837 *Varroa*), followed by the two formulations of oxalic acid, i.e., Oxuvar and Apibioxal, which marked average parasite mortalities of 573 and 517 *Varroa*, respectively. Then, mortalities dropped, even after the application of the control treatment (Apiguard).

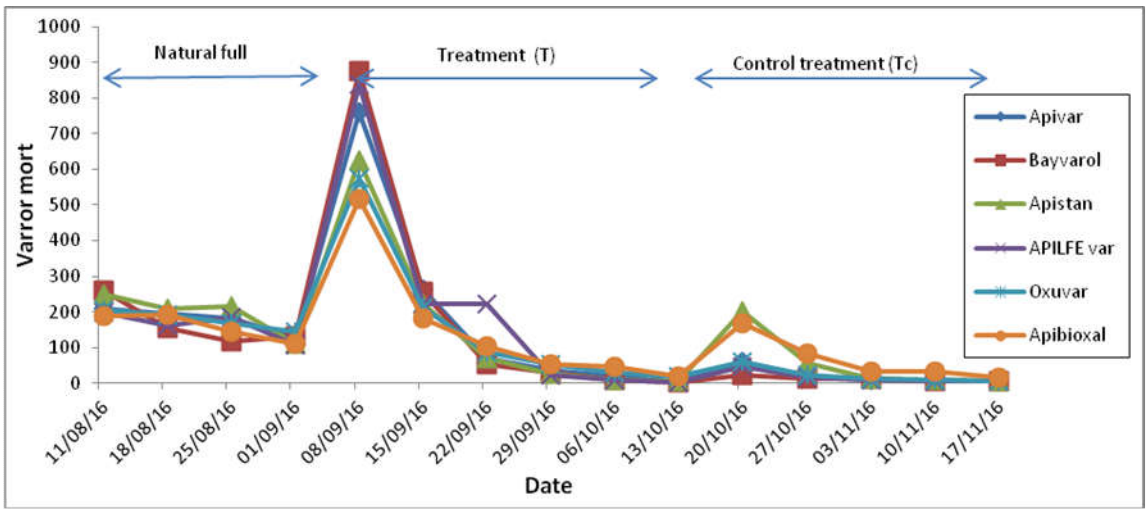

Figure 1: Temporal evolution of *Varroa* adult mortality before and after treatment

Figure 2 reports the average efficacy of each treatment. In all the tested treatments, Bayvarol, which represents a chemical treatment, proved to be the most effective varrocide, with an average efficacy of 94.69%, followed by the two biological treatments Apilife Var (93.96%) and Apivar (91.5%). As regards the oxalic acid formulations, this study found that Oxuvar is more effective than Apibioxal (average efficacies of 89.32% and 90.57%, respectively). As for Apistan, which is a chemical reagent that is widely used in Algeria for treatment of the *Varroa destructor*, the average efficacy was 76.92%.

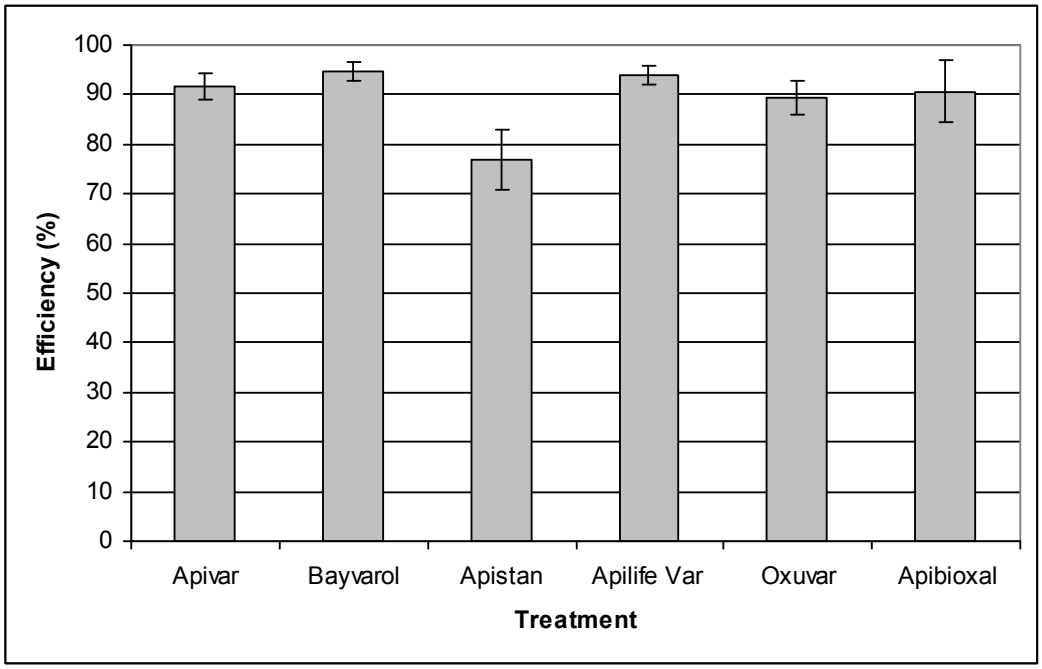

Figure 2: Efficacies of the treatments tested in the current study

Since appearance of *Varroa destructor* in Algeria in 1982, the fight against it entailed the use of several chemical preparations like Amitraz, Fluvalinate, and Flumethrin. However, the efficacies of these products differ from one region to another and from one period of time to another.

Indeed, the study performed by Adjlane et al (2013) in the Mitidja region in northern Algeria reported efficacies of 91.62%, 86.50%, and 77.75% respectively for Bayvarol®, Apivar®, and Apistan®. In addition, Loucif-Ayad et al. (2010) reported in their work which they carried out in Annaba (eastern Algeria) the efficacies of 89% for Bayvarol® and 85% for Apivar®. The efficacies of Bayvarol® reported by these two studies are lower than the efficacy of 99% that was reported by Alloui et al (2002) for flumethrin in the Constantine region (eastern Algeria). As a result, resistance of parasites to synthetic acaricides is evident. The phenomenon of parasite resistance to fluvalinate and amitraz has been recently confirmed by Adjlane et al (2013) and Adjlane et al (2017), respectively.

Gregorc et al (2018) tested efficiencies of four acaricides; Apiguard®, Apistan®, Apivar®, and HopGuard® in treatment of honeybee pests. They found that the efficiencies of these acaricides were 86%, 84%, 79%, and 64%, respectively. In a study conducted in Saudi Arabia by Al Ghamdi (2007) to determine the acaricidal effects of five synthetic products (Apistan, Bayvarol, Apivar, Perizin, and Bee strips), it was found that amitraz is more effective as an acaricide than fluvalinate and flumethrin. Pileckas et al (2011) also reported a low effectiveness of Apistan in Lithonia (81.7%). On the other hand, Faucon et al (2007) reported that Apivar ND could eliminate 99.5% of the *Varroa* population in France. However, Al Naggar et al (2016) reported an efficiency of 76.5% whereas Floris et al (2001) and Mar Leza et al (2015) found an efficiency of 70%.

Many previous studies (e.g., Londzinet Sledzinky (1996), Elzenet al. (1998), Milani and Della Vedova (2002), Garcia-Salinas et al. (2006), and Semkiwet al. (2013) have shown that following intensive use of these chemical acaricides for several years the *Varroa destructor* develops resistance to these compounds. However, in all these studies, the developed resistance to acaricides was variable; evidence supports that some populations of *Varroa* are highly sensitive, whereas some others are moderately resistant and others are highly resistant to these acaricides. The development of resistance

is the result of the interaction between many factors, including the level of exposure to the toxicant, the rate of reproduction of the agent, and other ecological factors.

Mite mortalities following natural treatments reveal that Apilife Var is more effective than the two oxalic acid formulations, which both have a similar efficacy of 93.96%. Our results agree with those of LoucifAyad (2010) which reported a 96% efficacy for thymol. Coffee and Breen (2013) reported an efficiency of 53.80% whereas Gracia et al (2017) and Floris et al (2004) reported an efficiency of 80%.

Maggi et al (2015) tested a formulation composed of four cellulose strips impregnated with a layer of solution based on oxalic acid. Their results indicated that this formulation had an efficiency of 93.10%. In Slovenia, SmodišŠkerl et al (2010) reported in their work, which they conducted between 2007 and 2008, the efficacies of 73.62% for flumethrin and 70.12% for oxalic acid. In the same country, Gregorc and Planinc (2012) found that treatment with oxalic acid brought about elimination of 41% of the *Varroa* mite because at that time the brood was present. Marcangeli et al (2004) reported an Oxuvar efficiency that varies between 75.7% and 85.6%.

Several studies (e.g., Colin (1997), Imdorf et al (1997), and Charriére et al (1998)) have reported an efficiency that is greater than 95% for the spray application of 3.0% aqueous solution of oxalic acid. Imdorf (2001) reported that drop application of 4.5% oxalic acid aqueous solution to brood-free colonies showed an average efficiency of 97% in elimination of the *Varroa* mite. However, several reports (e.g., Charrière and Imdorf (1999) and Nanetti (2001)) showed that a high concentration of oxalic acid administered in autumn by flow weakens the colony.

4. CONCLUSION

The fight against *Varroa destructor* is an essential component of beekeeping. It helps to save the domestic bee sentinel from the threats in the environment. Some factors are involved in reducing the effectiveness of some products that are of common use. For this, the alternative fight against this mite based on alternation of the control methods, natural and biotechnical, by combining essential oils, organic acids, and cereals is highly recommended.

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