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Original article

A comparison between the efficiency of summer treatments using formic acid and Taktic® against *Varroa jacobsoni* in beehives

A Lupo, D Gerling

The George S Wise, Tel Aviv University, Faculty of Life Sciences, Department of Zoology, Ramat Aviv 69978, Israel

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Summary — There is a need to control the mite *Varroa jacobsoni* following the citrus honey extraction in Israel. The mite population was very large at that time, and the hives were weakened by the dry summer conditions. We demonstrated that 8 consecutive treatments with formic acid during the month of August gave satisfactory mite control without harming or irritating the bees. The experiments also showed that 8 formic acid treatments during June suffice to keep a hive through the summer until control activities during requeening in the Autumn.

***Apis mellifera* / *Varroa jacobsoni* / chemical control / formic acid / amitraz**

INTRODUCTION

Studies conducted in Europe showed that the development of *Varroa jacobsoni* is relatively slow and that unchecked mites would cause the collapse of the colony after only 3–4 yrs of continuous infestation (Ritter, 1981). It is only necessary, therefore, to carry out 1 treatment each year in order to avoid severe economic damage. In Israel, colonies were found to collapse following less than 1 year of mite infestation, due to the different phenology of the bees in a subtropical climate. Consequently, 30 or more treatments are required. Many of these can be replaced by integrating 1 or 2 treatments with re-queening during the fall (Lupo and Gerling, 1987), thereby leaving the hive in a healthy and vigorous state until after the main honey–flow period. The quick natural spread of the mites, their artificial dissemination due to the use of blowers during honey–harvesting, and moving of the hives to other flowering regions, in conjunction with rapid development of the mites, require summer treatments to be performed in order for the bees to survive until the fall requeening time. These treatments must follow each other closely and last long enough to cover the period when brood cells are sealed, because the mites are sheltered within such cells.

During 1985-1986 the main material used for *V jacobsoni* control in Israel was Taktic as specified by Csaba and Kavai (1983) and recommended by the veterinary services and the Ministry of Agriculture. We carried out experiments with the purpose of replacing Taktic with formic acid. Formic acid is preferable because :

— it is normally present in low concentrations in the honey (Crane, 1976);

— it may be used as a food additive (Fao, 1981);

— formic acid concentrations diminish in treated hives and reach near–normal concentrations after a few weeks (Stoya *et al,* 1986);

— and it is not implicated as a carcinogenic chemical and, not being an insecticide, it is safer to the user.

Two methods of application of formic acid in hives were tested in Germany:

— Kramer's method using sheets of absorbing pressed wood containing formic acid (Wachendörfer *et al,* 1984);

— and "Illertissen Mite Plate" (Wachendörfer *et al,* 1985).

The goals of the present work were to compare the efficiency of formic acid with that of Taktic and with that of an untreated control.

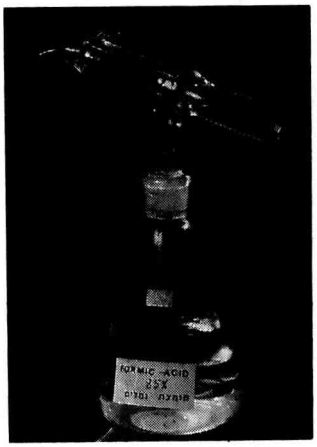

Fig 1. A 25 ml automatic pipette used for dispensing the formic acid. This device allowed a safe, rapid and accurate dispensing of the acid.

MATERIALS AND METHODS

The experiment was conducted with 18 hives in the coastal plain of Israel, in an area where mostly cotton and citrus are grown. Citrus honey was collected until the beginning of May. About a month later, between 25 May 1986 and 21 June 1986, all the hives were given 8 consecutive treatments of formic acid, in order to reduce the high mite populations and to keep all the hives in an equally mite-free condition. After the treatments, the hives were divided into 3 groups of 6 hives each.

Group 1 was treated with technical grade (85%) formic acid. A Petri dish with a cotton wad was saturated with 25 ml of acid (fig 1) and was placed into a 5 cm space created above the comb frames through the introduction of a spacer frame (fig 2) or by using an inverted feeder (Lupo, 1986). Eight treatments were given between 10 August 1986 and 31 August 1986 at 3-d intervals.

Group 2 was treated with Taktic by fumigation on the same dates as Group 1. A cardboard strip (10 x 2 cm), which had been saturated with KNO_3 and air dried, was supplied with 2 drops (ca 0.1 ml) of Taktic (12.5% Amitraz). The strip was ignited and placed in the hive in the same manner as the formic acid dishes.

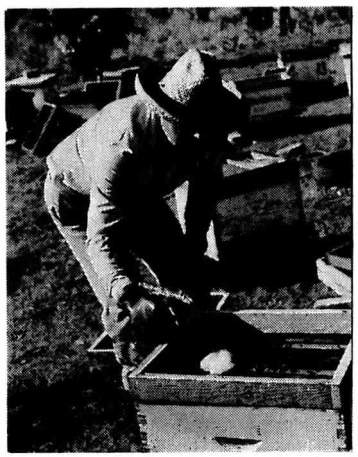

Fig 2. Use of the automatic pipette in dispensing the formic acid. Note the 5 cm spacing frame lying on top of the hive.

Group 3 was the untreated control.

Relative infestation by *V jacobsoni* was examined twice: on 10 August 1986, 3 d before the start of the treatments, and on 3 September 1986, 3 d after their termination. The examination was conducted using the following protocol: 3 combs were removed from each hive and the adhering bees were shaken into a bucket. A sample of the bees was taken using a container with a diameter of 60 mm and a height of 45 mm, and placed in 70% EtOH. This method produced an average of 388 bees per sample (range: 314–466). Care was taken that the queen was left in the hive.

Each sample was placed into a 500 ml container with a 6 mesh bottom (De Jong *et al*, 1982), which allowed the mites to pass but retained the bees. The container was placed in a larger, round plastic box full of EtOH. The boxes were shaken with a mechanical shaker for 30 min after which they were opened, the bee container removed, and the mites counted. Infestation was calculated as the number of mites per 100 worker bees.

In addition to checking the overall infestation by the mites, we checked the effectiveness of each treatment by putting a white masonite tray on the floor of each hive, to which a window screen was attached. The trays were removed 3 d after each treatment, and the fallen mites were counted.

A final treatment during requeening, in which no sealed brood was present (Lupo and Gerling, 1987), was applied to all 18 hives. A white masonite tray, covered with a window screen, was used for collecting and counting the fallen mites. The number of mites counted was considered to be the total number present in each hive at that time, since it has been shown that practically all of them drop out during such treatments (Lupo and Gerling, 1987).

The differences in numbers of mites resulting from the different treatments were tested for significance using analysis of variance.

RESULTS AND DISCUSSION

The numbers of dead mites collected from the masonite board during the 1st 3 d following each treatment declined from the 1st to the 8th treatment. Two-way analysis of variance showed that the numbers of fallen mites did not differ significantly between the 2 treatments (P = 0.563 8), whereas they were significantly lower in the control than in the formic acid treatment (P = 0.0005) and the treatment with Taktic (P = 0.0003).

The infestation levels before and after the treatments differed only slightly between the hives treated with formic acid (group 1) and Taktic (group 2). Following the treatments, numbers of mites per 100 bees declined in treatments 1 and 2 from an average of > 8 mites per 100 bees to < 0.5 mites. The control hives (group 3) averaged 6.1 mites per 100 bees at the beginning of the experiment and 5.65 at the end (fig 3, table I).

The average numbers of fallen mites for treatments 1 and 3–8 are given in figure 4 (no data were collected for the 2nd treatment). It is evident that the largest proportion of the mite population was exterminated during the 1st 3–4 treatments and that there was a continuous dropout of dead mites even in the untreated hives. This

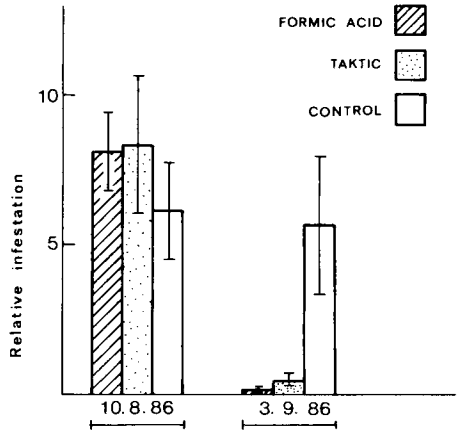

Fig 3. Relative infestations by *V jacobsoni* before (10.8.86) and after (3.9.86) treatments. Vertical lines indicate the standard error of the mean.

Table I. Levels of infestation (mites/100 bees) in each colony in each of the 3 groups.

	FA		*AMI*		*Control*	
	Group 1		*Group 2*		*Group 3*	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*
1	3.2	0.3	5.0	0.0	12.9	16.4
2	8.9	0.0	5.3	0.5	4.3	6.3
3	8.4	0.0	10.9	0.2	6.0	2.1
4	10.5	0.2	8.4	0.7	2.8	3.7
5	12.1	0.3	18.1	1.4	2.5	1.0
6	5.5	0.3	2.2	0.01	8.0	4.4
$\bar{X}$	8.1	0.13	8.3	0.47	6.1	5.65
SE	1.33	0.06	2.31	0.22	1.60	2.28

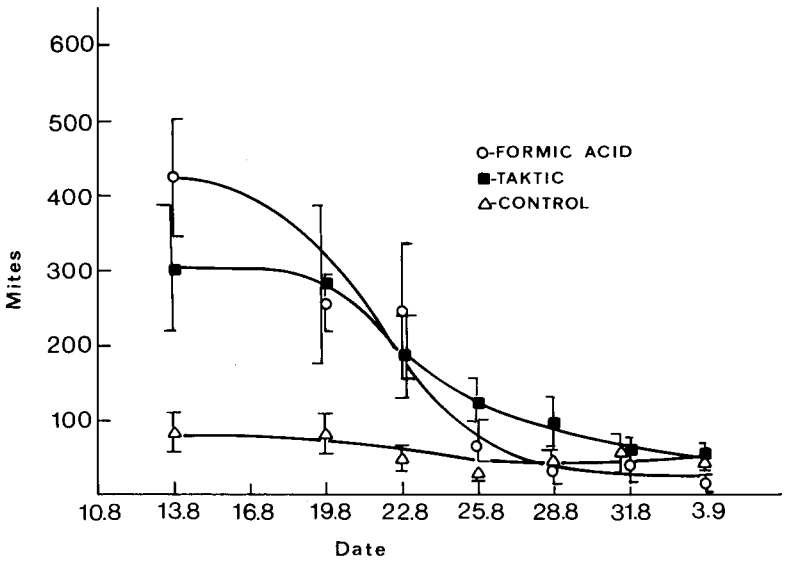

Fig 4. Average numbers of mites falling on the white masonite boards during 3 d following each treatment. Vertical lines indicate the standard error of the mean.

dropout was similar in size for the treated and untreated hives from the time of the 6th, 7th and 8th treatments. However, the final treatments during requeening (fig 5) showed a significant difference between the numbers of mites present in the treated and control hives. We assume that whereas in the treated hives the fallen mites actually represented additional mortality due to treatments within a small mite population, in the control they represented natural mortality in a very large mite population.

We conclude that a series of 8 successive treatments with formic acid significantly reduces the mite infestation when compared with the untreated control, and that its efficiency is comparable to that of Taktic. Moreover, whereas Taktic irritates the bees (some may react to fumigation by departure from the hive and form a large cluster at the entrance), formic acid, when applied as described herein, does not visibly affect the bees.

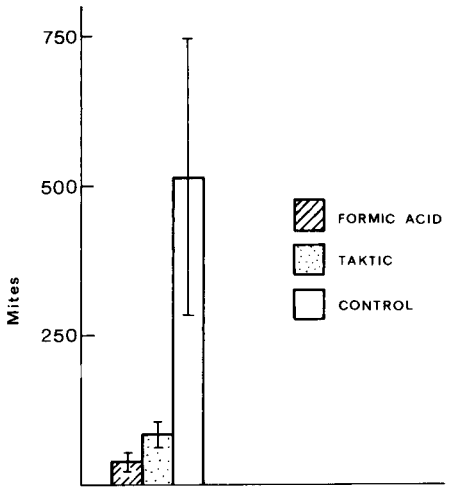

Fig 5. Average numbers of mites collected on white masonite boards following a treatment conducted after requeening in colonies without sealed brood. Vertical lines indicate the standard error of the mean.

Practical use of this system of 8 treatments during June in the following year proved that the colonies were able to survive well until the autumn when *Varroa* control was carried out again, combined with the requeening routine.

The mild reaction of the bees to formic acid, its ready availability, low cost, lower toxicity compared to other synthetic insecticides and acaricides, and the low residue levels (minimizing contamination of honey and hive products), make it a good candidate for use in *V jacobsoni* control.

ACKNOWLEDGMENTS

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Résumé — Comparaison de l'efficacité des traitements à l'acide formique et au Taktic® contre *Varroa jacobsoni*, effectués sur les ruches en été. En 1985-1986, une méthode efficace a été mise au point pour maîtriser les populations d'acariens durant l'automne, l'hiver et le printemps, en utilisant 1 à 3 traitements associés au remérage (Lupo et Gerling, 1987). Des méthodes de lutte complémentaires à la fin du printemps et en été se sont révélées nécessaires en raison de la très forte augmentation des populations d'acariens après la miellée des cultures d'agrumes. Les fortes populations d'acariens et le déclin naturel des colonies d'abeilles, dû à la diminution des ressources florales à cette période, mettent en danger la survie des colonies, à tel point que bon nombre d'entre elles ont été anéanties. L'emploi de la lutte chimique a donc été nécessaire. Le but de l'expérimentation est de tester l'acide formique comme agent de lutte à la place de l'acaricide Taktic® (substance active : amitraze).

Dix huit ruches ont reçu 8 traitements consécutifs à l'acide formique afin de réduire les populations d'acariens avant l'expérimentation. Les ruches ont été divisées en 3 groupes : l'un d'eux a servi de témoin, les 2 autres ont été traités 8 fois à 3 jours d'intervalle, l'un avec l'acide formique, l'autre avec Taktic®. Les effets des traitements ont été appréciés en examinant l'infestation relative par *Varroa jacobsoni* d'environ 400 abeilles au début et à la fin des séries de traitements. Durant toute l'expérimentation, on a également suivi le nombre d'acariens tombés sur les langes et un examen complet de ruche a été fait pour les colonies qui n'avaient pas de couvain operculé en fin d'expérimentation.

Les 2 méthodes de lutte ont eu des résultats équivalents : moins de 0,5 acarien/100 abeilles (fig 3). L'examen des langes montre que la mortalité a lieu principalement au cours des 6 premiers traitements, mais qu'elle existe tout au long de l'expérimentation (fig 4). Les 2 ruches traitées n'ont été que très faiblement infestées à la fin de l'expérimentation, contrairement aux témoins (fig 5).

Les 2 produits présentent la même efficacité pour traiter les colonies contre *Varroa*. Néanmoins, l'acide formique ne présente pas le risque de la contamination du miel, car le produit se dégrade rapidement (Stoya *et al*, 1986). Il est présent à l'état naturel dans le miel et même autorisé comme additif alimentaire. En outre, Taktic® est impliqué dans la carcinogenèse alors que l'acide formique ne l'est pas. Par ailleurs, nous avons observé que les ruches témoins, bien que fortement infestées, fonctionnaient encore correctement à la fin de l'été, alors qu'elles n'avaient reçu qu'une série de traitements au cours de l'été, à savoir les 8 traitements à l'acide formique avant expérimentation. Il est donc tout à fait probable qu'une telle série de traitements peut suffire dans les programmes de lutte post-miellée, jusqu'au remérage.

***Apis mellifica* / *Varroa jacobsoni* / lutte chimique / acide formique / Amitraze**

Zusammenfassung — Vergleich der Wirksamkeit einer Sommerbehandlung mit Ameisensäure und Taktic gegen *Varroa jacobsoni* in Bienenstöcken. In den Jahren 1985-1986 arbeiteten wir eine wirksame Methode aus, durch 1–3 Taktic-Behandlungen in Verbindung mit Umweislung die Varroa-Population im Herbst, Winter und Frühjahr unter Kontrolle zu halten (Lupo und Gerling, 1988). Aber ein sehr rasches Ansteigen der Milbenpopulation nach der Citrus-Blüte machte noch zusätzliche Bekämpfungsmethoden im späten Frühjahr und im Sommer nötig. Die starken Milbenpopulationen zusammen mit dem natürlichen Rückgang des Bienenvolkes in Folge fehlender Tracht zu dieser Zeit gefährdeten das Überleben der Völker so sehr, daß sie in großer Zahl zusammenbrachen und verloren gingen. Um die Bienenvölker vor diesem Schicksal zu bewahren, sind chemische Bekämpfungsverfahren erforderlich. Unsere Versuche sollten die Frage klären, ob für diesen Einsatz an Stelle des Akarizids Taktic nicht Ameisensäure verwendet werden könnte.

Für den Versuch wurden 18 Völker benutzt. Zunächst wurden alle 8mal hintereinander mit Ameisensäure behandelt, um die Milbenpopulation vor dem Experiment zu vermindern. Dann wurden die Völker in drei Gruppen geteilt; eine diente als unbehandelte Kontrolle, die anderen beiden wurden 8 mal in dreitägigen Intervallen entweder mit Ameisensäure oder mit Taktic behandelt. Die Wirksamkeit der Behandlungen wurde durch Bestimmung des relativen Befalls mit *V jacobsoni* von

etwa 400 Bienen vor und nach der Anwendung ermittelt. Während des Versuchs wurde außerdem der Milbenabfall auf weißen Einlagebrettern bestimmt. Am Ende des Versuchs wurde der Gesamtzustand der brutlosen Völker festgestellt (Lupo und Gerling, 1987).

Beide Methoden erbrachten mit weniger als 0,5 Milben je 100 Bienen etwa dieselben Ergebnisse (Abb 3). Wie die Kontrolle des Milbenabfalls zeigte, erfolgte die Hauptmortalität nach den ersten sechs Behandlungen, aber der Abfall setzte sich während der gesamten Behandlungsdauer fort (Abb 4). Im Gegensatz zu den unbehandelten Kontrollen waren beide Behandlungssgruppen bei Versuchsende nur sehr mild befallen (Abb 5).

Beide Medikamente zeigten in der Milbeneindämmung dieselbe Wirksamkeit. Ameisensäure schafft jedoch keine Probleme von Rückständen im Honig, da etwaige Reste sehr rasch verschwinden (Stoya *et al,* 1986). Dieser Stoff kommt auch natürlich im Honig vor und ist selbst als Nahrungsmittelzusatz zugelassen. Außerdem wurde Taktic mit einer carcinogenen Wirkung in Verbindung gebracht, was bei Ameisensäure nicht der Fall ist. Zusätzlich zu der von uns gesuchten Information stellten wir noch fest, daß die Kontrollvölker trotz schweren Befalls zu Ende des Sommers noch gut arbeiteten. Sie hatten während des ganzen Sommers mit den 8 Ameisensäure-Anwendungen vor Versuchsbeginn nur eine einzige Behandlungsserie erhalten. Es ist somit sehr wahrscheinlich, daß eine derartige Behandlungsserie nach der Tracht bis zu der vorgesehenen Umweiselung ausreichend ist.

***Apis mellifera* / *Varroa jacobsoni* / chemische Bekämpfung / Ameisensäure / Amitraz**

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