Experimentation of an Anti-Varroa Screened Bottom Board in the Context of Developing an Integrated Pest Management Strategy for Varroa Infested Honeybees in the Province of Quebec

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Final Report

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SUMMARY

The anti-varroa screened bottom board was tested on a large scale during the beekeeping seasons of 2000 and 2001 in the l'Estrie region of Quebec. Used with its bottom closed by a sampling drawer, this bottom board succeeded in reducing, on average, by 37% the varroa populations of the colonies during the season of 2001. The global results obtained however were not statistically significant except for certain sampled sub groups where the experiment conditions were more homogeneous. These results reinforce the conclusions drawn from two recent studies performed in the United States that were also statistically non significant. A 14 months comparison by T.C Webster posterior to our work showed a 70% highly significant reduction of the varroa population (17) with the screened bottom. The performance of the bottom board varied according to the apiary sites and it is possible that certain environmental factors affected its efficiency. More research is necessary to better comprehend this aspect. The anti-varroa bottom board must never be used with its bottom hole opened as this leads to a lowering of cluster temperature resulting in ideal conditions for varroa development. As confirmed in 2000, this situation not only negated the beneficial effects of the bottom board, it also resulted in a net increase in the mite infestation rate (29.2% more varroa mites, non significant) as compared to the control group. The performance of the bottom board also varied from one colony to another. It was observed that the strength of the colony in the spring and especially the lineage of the queen were significant factors in the rate of infestation.

The anti-varroa screened bottom board appears to also increase the effectiveness of varroacidal treatments and its use could delay the development of mite resistance to chemical medications.

The anti-varroa screened bottom board is readily modified to include a removable drawer for sampling purposes. The bottom boards used in our tests were thus equipped with removable trays which greatly simplified screening and enabled us to use natural varroa drop over prolonged periods of time as indicators of the level of infestation of colonies. This advantage is a bonus, specially during periods of nectar flow.

The use of the anti-varroa screened bottom board is an easy, economical, long lasting and environmentally friendly method to combat the varroa mite. It constitutes, in our opinion, an indispensable tool in an integrated pest management strategy not only because it contributes to slowing down the rate of infestation but also because we can easily determine, at any time, the level of infestation. It then becomes an important tool for decision making, re choosing control methods and the timing of applications. It can also be used in conjunction with other methods of control such as the use of resistant queens and the punctual application of essential oils or formic acid. With its use, dependence on chemical treatments can be greatly reduced if not eliminated. Such a set-up could probably constitute an adequate integrated pest management strategy.

The anti-varroa screened bottom board promotes the natural grooming behavior of the honeybee. The process of selection could further develop this behavior. The screened bottom board also presents an opportunity for a different perspective on developing control methods that would simply consist of causing the mites to drop off of adult bees.

Introduction

During the beekeeping seasons of 2000 and 2001, the apiary "Les Reines Chapleau" located in the l'Estrie region launched a project, with the goal of testing an anti-verroa screened bottom board within the context of beekeeping in Quebec. This project received financial assistance within the framework of the program, "Appui du développement de l'agriculture et de l'agroalimentaire en région 2000-

2003" of the "Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (Regional district of l'Estrie).

Context

Beekeepers are facing the varroa mite, a parasite that infests a majority of the beehives in the province of Quebec. Beekeepers must treat their hives or risk losing them. Two miticidal products are registered for use in Canada. The first is formic acid. This product is dangerous to handle and its efficiency is questionable due to the climatic conditions in Quebec where the cool temperature slows the evaporation of the acid. Presently, beekeepers are avoiding this alternative. The current option is the use of the fluvalinate sold under the brand name "Apistan". Treatment costs are expensive, from $3.50 to $8.00 per hive for medication only. At the time of this report, this product is functioning very well. The downside is that it contaminates the beeswax. Furthermore, as seen in other countries, its use has a life of rarely more than ten years. The appearance of Apistan resistant varroa mites has already been confirmed during the fall of 2001 in some Canadian provinces. For these reasons and also in the context of developing an integrated pest management strategy against varroa mites, it is critical that alternative methods of control be found.

Initial hypotheses and description of anti-varroa screened bottom board

The initial general hypothesis was that a particular type of bottom board known as anti varroa bottom board could slow the population growth of varroa without any intervention by the beekeeper. It could also contribute to a lessening of dependence on chemical treatments. This would result in lesser costs for the beekeepers and reduced risks of contamination of hive products. This type of bottom board could very well become an important tool in the integrated pest management kit.

Here's how the anti varroa screened bottom board functions. A large portion (approximately 20%) of the varroa mites in a colony are attached to adult bees. Several of these varroa mites for various reasons lose their grip on the bees and fall to the bottom board. Often, the bees themselves remove the mites during grooming activities. Unfortunately these fallen mites re-attach themselves to bees circulating on the floor of the standard bottom board and re-integrate themselves into the colony where they continue to parasitize and reproduce. In a nutshell, the anti-varroa bottom board is constructed in such a way that it eliminates all varroa mites who fall to the hive floor.

The percentage of reduction of varroa populations that can be achieved with the use of the anti varroa bottom board are presently the subject of debate. Several studies have yielded variable results (5,1,2). However, several of these studies relied on very small samples. The anti varroa bottom board was never tested within the context of conditions in Quebec.

The second hypothesis was that this bottom board would facilitate estimating the significance of the mortality (either natural or miticide induced) of varroa mites in a colony. These figures could be used as indicators of the level of global contamination as the two figures are related. The bottom board used is equipped with a removable drawer located below the screen. Cardboard or white "corroplast" smeared with vegetable grease can be applied to hold the varroa mite in place. The anti varroa screened bottom board would thus constitute a permanent monitoring tool in regards to the varroa mite situation in an apiary.

Project Objective

The object of the project was to verify the value of the use of an anti varroa screened bottom board within the context of developing an integrated pest management strategy focused on the varroa mite.

Bottom Board Technical Specifications

The outside dimensions of the bottom board are similar to a standard bottom board (figure 1). It has an opening that measures 43 cm (17 ¼") by 32 cm (12 ½") covered by a .32 mm (1/8") screen mesh. Varroa mites fall through the screen and are unable to re-integrate themselves into the colony. Theoretically, the opening could be enlarged which may increase the bottom boards efficiency. The height of the supports of the bottom board was increased to 45 mm (1 ½") to allow for a bottom drawer on which one could place a sampling cardboard. Grooves were placed on these supports for this purpose (figure 2). When the sampling drawer is in place, it closes off the bottom of the hive more or less duplicating temperature and ventilation conditions of a hive with a standard bottom board. The super rest is 9 mm (3/8") high thereby reducing the entrance of the hive compensating for air loss around the bottom drawer. The distance between the sampling drawer and the screen is 4 cm (1 5/8"). To avoid re-integration of fallen varroa mites into the colony, we would be hesitant to reduce this distance as we have observed that naturally fallen varroa mites are quite mobile.

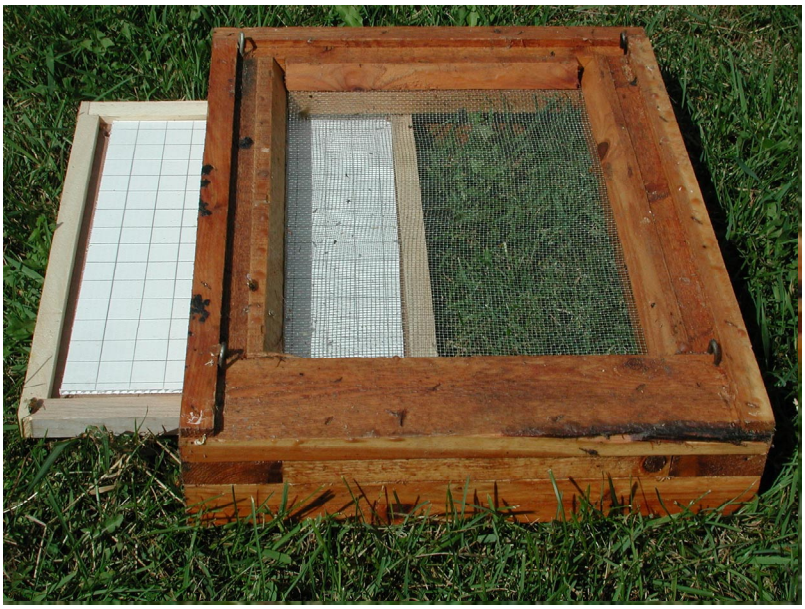

Figure 1: Anti-varroa screened bottom board with sampling drawer used in our experiment

Figure 2: The sampling drawer slides into groves on the supports of the bottom board

Method

Several studies have concluded that the anti-varroa bottom board can be used with or without a closed in bottom. During the beekeeping season of 2000, we decided to use the bottom boards without a closed in bottom. This method seemed more practical in the context of a commercial apiary. These trials involved 184 colonies of which 106 were equipped with an anti-varroa bottom board and 78 served as the control group. The results of this trial during the first season were contradictory. They suggested that the fact of using an open screened bottom board created favorable conditions for varroa development thus canceling the advantages of its use. These results will be detailed later. It was thus decided that in the second trials (2001) the screened bottom board would be used with a drawer that would close in the bottom. Here is the method used.

These trials were performed within the context corresponding to the normal operations of a commercial apiary. These conditions imply a variation in the parameters such as colony strength in the spring, the queens' lineage, and the rate of infestation at outset as well as environmental factors related to various apiary locations. Individual data of these parameters however was catalogued for each of the tested colonies. We were therefore able to analyze the potential impact of these variations. The influence of these variations was, up to a certain point, counterbalanced by the significant size of the samples. For certain restricted groups within the large sampling, the testing conditions were definitely more controlled and more homogeneous. In all cases, recognized statistical tests were used to validate the results and the statistical analysis took into account the stated variations.

A total of 234 colonies were used in a comparative test in 2001 to evaluate the impact of an anti-varroa screened bottom board on the varroa populations in the course of a beekeeping season. Of this number, 133 colonies were equipped with an anti-varroa screened bottom board (sub group AV) and 101 colonies were equipped with a standard bottom board thereby serving as the control group (sub group S). The sampling was divided into three groups corresponding to slightly different experiment conditions. With the exception of a small group, the colonies equipped with an anti-varroa screened bottom board were operated with the drawer in place (closed bottom). Comparative results were collected for 120 and 79 colonies respectively for each of the sub groups.

The first group (large group) was made up from 170 standard colonies of greatly varying strength, having been wintered outdoors in ten separate locations. Of these 170 colonies, 100 were equipped with an anti-varroa bottom board (sub group AV). The number of colonies in each location differed. The anti-varroa screened bottom board of group AV was maintained in a closed fashion during the entire season by means of a permanent sampling drawer. All of the colonies involved in the evaluation had queens that were identified according to their genetic source (15 different lines). In each apiary, the queens were descendants of 3 or 4 lineages more or less equally represented. These 170 colonies received an Apistan treatment of a duration varying from 15 to 21 days in the fall of 2000. All colonies were also the subject of a screening using two strips of Apistan during a 24-hour period on the first of May. The goal was to estimate the varroa population at the outset of the experiment season. The average number of varroa collected on sampling cardboard was 127 for the AV group and 90 for the control group. This number was considered as being too high as it would compromise the survival of the colonies until the end of the season. This consideration was made in view of the fact that hardly any brood had hatched in the colonies and that the generally accepted ratio of 1 varroa mite on an adult bee to 4 varroa mites in the brood would have, in this specific case, led to an under estimate of the total population of varroa. A verification performed on a restricted number of colonies permitted an estimation that the total varroa population was situated at between 1000 and 2000 individuals. A three-week treatment with two Apistan strips was performed as of the beginning of May on all colonies of this group. We estimated that the total varroa population remaining in the colonies after the treatment to be around an average of 300. Given that the treatment was of short duration, we estimated that the varroa mites remaining in the colonies of each sub group (AV and control) was proportional to the number estimated on the first of May. Of the 170 colonies at the outset, 143 could be sampled at the end of the season, 92 in the AV group and 51 in the control group. This sampling took place between September 5 and September 15. All the colonies in a specific location were always sampled at the same time. All of the colonies retained for the final compilation were rigorously run in the same manner during the trial period.

At the outset, the second group (YBO) comprised of 41 nucleus colonies was made up on the 14th of June with 3 frames of brood from colonies randomly chosen in the large group at several locations. All of these new colonies were placed in the same location and one half of them, randomly chosen, were equipped with an anti-varroa screened bottom board. Queens from three different lines were introduced in equal proportion to each of the two sub groups. Sampling at the end of the season was performed on the 12th and 13th of September. Of the 41 colonies, 34 were retained for final sampling. All colonies of this group equipped with an anti-varroa screened bottom board were operated for the entire season with the bottom opened (no drawer).

The third group (ATH) was made up on the 21st of May from 23 small colonies of variable strength. These colonies were in fact leftovers from colonies partially broken down for the sale of nucs. The new queens introduced into these colonies were of unknown lines. There is also no information on the distribution of these lines between the two sub groups. These colonies were moved outside from a wintering facility on the 4th of April and were the subject of a screening with Apistan (24 hr.) on the 17th of April. The counts varied from 6 to 119 varroa mites for an average of 45. A 30-day Apistan treatment was applied to all of the original colonies of this group. We can thus state that at the outset of the period of experimentation, these colonies had extremely low rates of infestation. The strength of these colonies was evaluated when making up the group and varied from 4 to 8 frames of bees. They were separated into two groups reflecting their strength and one of the two groups was equipped with an anti-varroa bottom board. The average strength of the AV group at the outset was 5 frames of bees while that of the control group was 5.2 frames of bees. These colonies were run for the entire season in the same conditions and in the same location. The fall sampling was performed on the 5th and 6th of September. At that time, 22 colonies could be subjected to sampling. Of these, 12 were equipped with an anti-varroa screened bottom board (with sampling drawer in place) and 10 were equipped with a standard bottom board.

For all groups, the end of season varroa populations were evaluated by means of a fluvalinate (Apistan) sampling lasting 48 hours. The results were then extrapolated to a base of 24 hours. To verify the validity of this indicator, we compared the counts obtained in 48 hours with the total varroa population count (obtained by 37 consecutive days of fluvalinate treatment). This verification was done on a small sample of 11 colonies and demonstrated a strong positive correlation (r=.89). To rigorously homogenize the sampling conditions, all the colonies in the control group (standard bottom boards) were equipped with anti-varroa bottom boards at the same time that the miticide strips were placed in the hives. We had in effect concluded in September 2000 that it was very difficult to protect the sampling cardboard from the cleansing activities of the bees in colonies equipped with standard bottom boards. The sampling cardboards were covered with a thin coat of vegetable grease to ensure that the varroa mites were held in place. All of the varroa mites on the sampling cardboard were counted with the exception of a few cardboards from colonies that were heavily infested (1000 varroa mites and more). For these colonies, the count was limited to 25% of the sampling cardboard surface and the result multiplied by four. When using the anti-varroa screened bottom board, the fallen mites are spread out in an equal fashion on the surface of the sampling cardboard.

Results

Several significant differences were observed in the September sampling results in regards to individual colonies, apiary location averages as well as the results of the three groups. Such differences were also observed in the year 2000. To eliminate the bias of the location factor, the impact of the bottom board was evaluated by comparing the number of varroa mites for each colony in the AV group to the number in the control group at the same location. The results were expressed by a relative value (percentage). These results were also weighted by location so as to permit their inclusion in a global result. The weighting index attributed to each location was the smallest number of colonies in sub group AV or sub group S at this location.

Large Group

Bearing in mind the infestation rate of the outset and the weighting index of each location, the progression rate of the end of season varroa populations for sub group AV was 52% lower than the control group (figure 3). However, because of the variations in the individual results of the colonies, this difference was not statistically significant. There were also significant differences in the performance of the AV groups at different locations. These differences will be analyzed further.

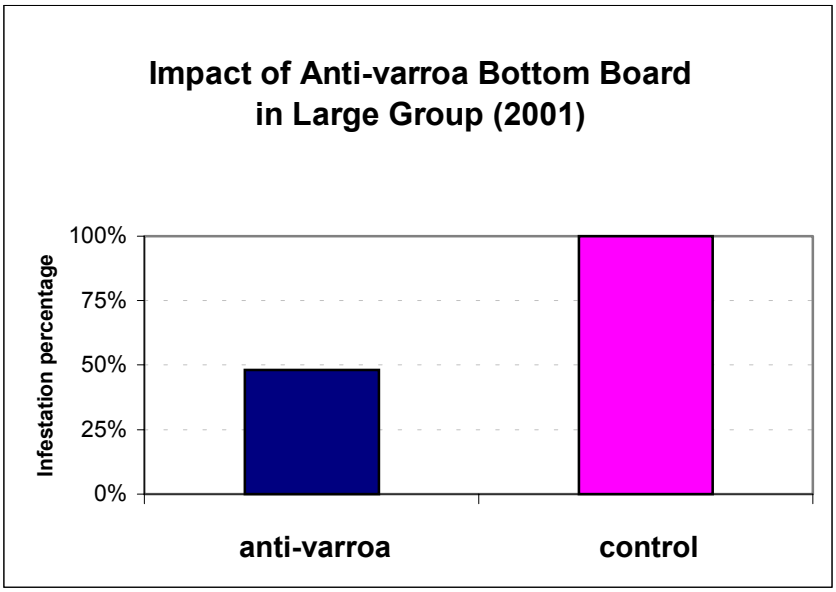

Figure 3

YBO Group

The net gain for sub group AV of the YBO group was 35% (figure 4). This gain was statistically significant (p=0.03). In other words, there is a 97% statistical certainty that the 35% lower average infestation level for the AV group is not due to chance. It should be noted that 4 colonies from the S group having abnormally high counts compared to sub groups AV were excluded in the comparison. These nucs perhaps originated from colonies that may have inadvertently been missed during the spring miticide treatments. Without this exclusion, the gain would have been 67% (non-significant) for sub group AV.

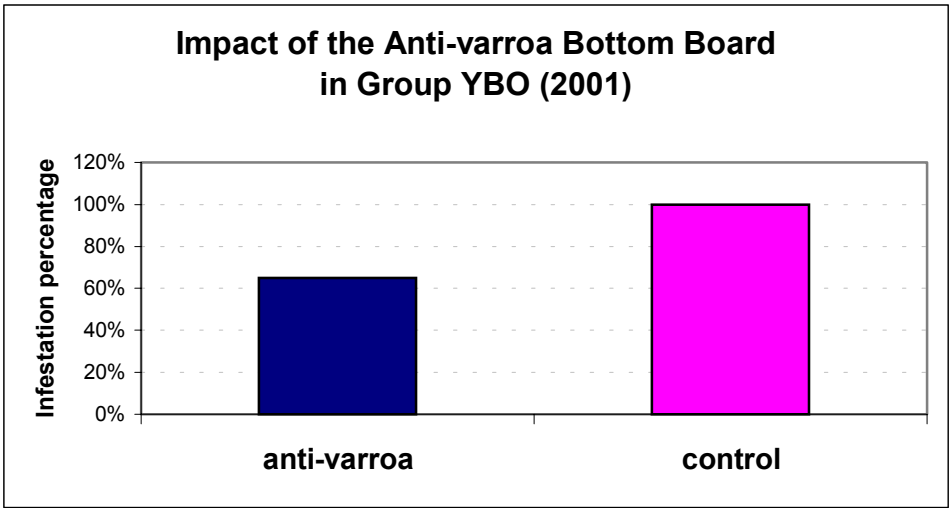

Figure 4

ATH Group

The colonies of sub group AV from the ATH group demonstrated an inferior performance in comparison to the control group. In effect, their performance was 21% inferior to the control group but this difference was not statistically significant (p=0.12) (figure 5).

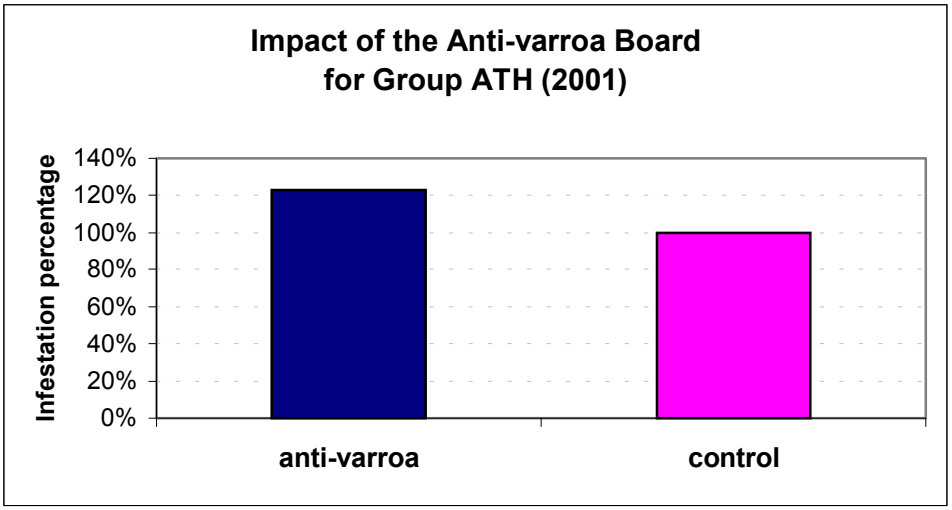

Figure 5

Global Results for 2001

When all of the colonies from the three groups are compared using the relative results compiled from each location, the gain in favor of the AV group is 37% (figure 6). This advantage however is not statistically significant (p=0.24): the probability that the 37% gain for the AV group was not due to chance is 86%. In general, to be statistically significant a 95% probability is required before being considered as a significant result.

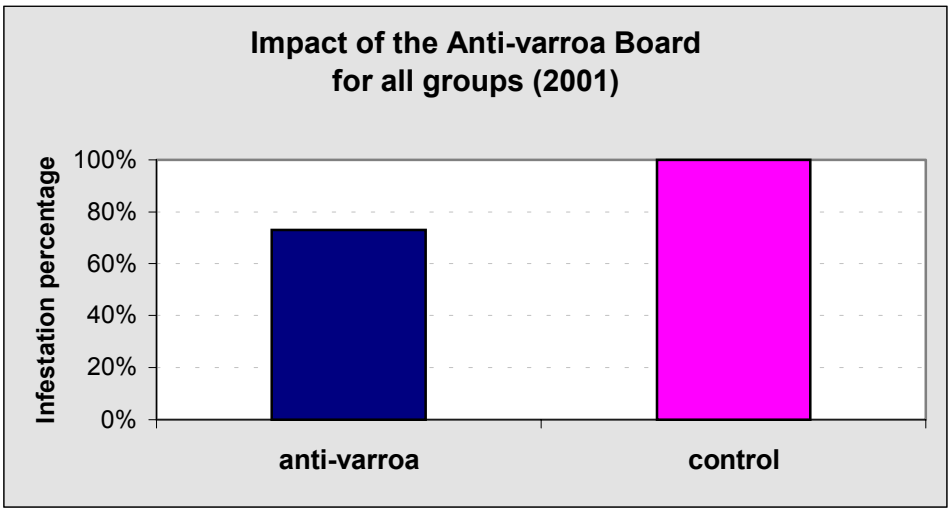

Figure 6

Review of Results of 2000 tests

After including the weighting index in the results of the year 2000, we observed that at the end of the season, the colonies equipped with an anti-varroa bottom board had 29.2% (figure 7) more varroa

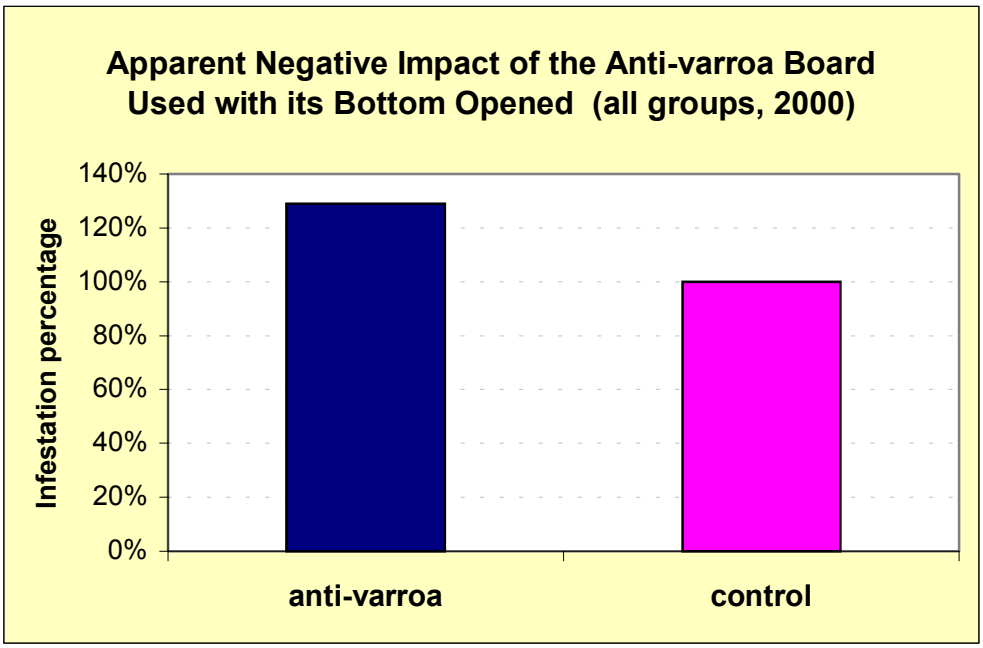

Figure 7

mites than the control group. These results however were not statistically significant. There was also a large disparity between the results of the groups at different locations. The results obtained at the different locations varied from 66% less to 119% more varroa mites for the sub group AV. It should be noted that the infestation level of the colonies at the outset was unknown. Nevertheless, all colonies had received a complete Apistan treatment the preceding fall. The sampling of a restricted number of colonies (24) in May demonstrated a very low mite drop varying from 1 to 35. The hypothesis applied at that time to explain the negative results was that the open bottom of the anti-varroa bottom boards affected the thermal condition of the hives, which could influence the development of the varroa mite population. However, a restricted number of colonies (apiary MAI) where experiment conditions were rigorously controlled and where the air circulation beneath the bottom boards was restricted demonstrated a statistically significant (p=0.041) positive result (66% less varroa mites) (figures 8, and 9). To be specific, end of season sampling was performed on all groups over a period of 24 hours as opposed to 48 hours in 2001.

Individual Results for Group MAI (2000)			
hive number	type or bottom board	number of varroas May	September
271	anti-varroa	1	182
673	anti-varroa	1	182
357	anti-varroa	0	404
648	anti-varroa	2	137
159	anti-varroa	2	215
293	anti-varroa	2	556
348	anti-varroa	2	1246
766	anti-varroa	3	871
418	anti-varroa	4	759
866	anti-varroa	5	361
333	anti-varroa	22	637
699	anti-varroa	35	481
average	***anti-varroa***	***7***	***503***
231	standard	1	552
869	standard	1	791
757	standard	2	625
342	standard	2	737
407	standard	2	768
875	standard	4	1110
845	standard	17	3372
012	standard	29	3994
average	***standard***	***7***	***1494***

Figure 8

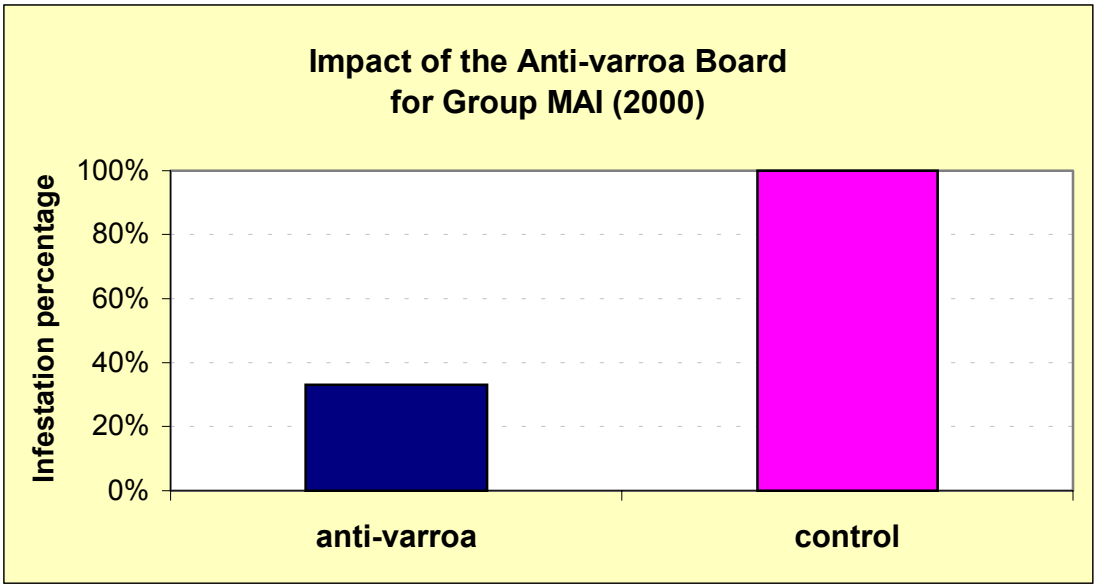

Figure 9

Discussion

Validation of the function principle of the anti-varroa bottom board

The principle of the AV bottom board hinges on the hypothesis that some varroa mites are alive when they fall naturally off of adult bees. We wanted to verify the validity of this hypothesis. By sampling

six hives for natural mortality during a period of 24 hours, we observed that 16% of fallen varroa mites were alive (figure 11). In his study, C. Webster (4) concluded that the percentage of live fallen varroa mites varied from 39% to 50%. The proportion of living fallen varroa mites seems to vary according to different conditions. The confirmation that a part of the falling varroa mites are still alive validates the principle behind the use of the AV bottom board and explains the positive results obtained during the 2001 trials.

The thermal factor and the anti-varroa bottom board

The important difference in the global results obtained in 2000 (29.2% more varroa mites) and 2001 (37% less varroa mites) for sub group AV suggest a confirmation of the negative thermal influence assumed in the 2000 trials. In 2000, all of the anti-varroa bottom boards were operated with the bottom opened while in 2001, with the exception of the YBO group, the bottom boards were operated with the bottom closed. To our knowledge, this is the only operational factor that was systematically different between the 2000 and 2001 trials. The results strongly suggest a connection between this factor and the negative results obtained with the use of anti-varroa bottom boards during the 2000 trials. We can legitimately assume that the brood cluster temperature was lowered with the use of the opened anti-varroa bottom board. Numerous references can be found in scientific literature confirming that lower temperature conditions enhance the development of varroa populations. Ingemar Fries (12) states: "(…) mite population seems to grow faster in cooler climates than in warmer areas (…) it has been suggested that climatic factors are decisive in determining the mite population growth although the mechanism remains unclear." We can believe that a longer period of time in the capped brood stage resulting from a lower temperature favors an increase in the reproductive rate of the varroa mite's population. An increase of time in the capped brood stage enables the young female varroa mites to reach maturity before the bee emerges from its cell. Kraus and Velthuis (14) found that artificially reducing the brood temperature of colonies had the effect of doubling the mite population in comparison with control groups. Their laboratory tests allowed them to determine that 33 C was the optimal temperature for varroa mite reproduction. Kraus and Velthuis (14) suggest that beekeepers adopt practices that aid colonies in maintaining brood temperature at 35 C. The results obtained by Kraus and Velthuis were not available when planning for the 2000 trials as they were published in October of the same year. Reference to the influence of temperature on the rhythm of natural varroa drop can also be found in recent scientific literature. Thomas C. Webster (4) found that this drop is correlated to the average outdoor daytime temperature. J.T. Ambrose (13) also found (2001) that when infested adult bees were exposed to variable temperatures in laboratory conditions, the percentage of varroa mites falling from the bees increased with the elevation of the ambient temperature. Here again we can deduce that the brood chamber temperature should not be lowered.

Nevertheless, the negative impact of the use of open anti-varroa bottom boards was not universal since in 2000, the AV sub groups of two locations (MAI and JOY) demonstrated positive results despite opened bottoms. Similarly, in 2001, the only location where the open bottom board was used yielded a positive result (YBO 35%). However these exceptions can be logically explained. For location MAI in 2000 as well as YBO in 2001, the manner of placing the hives on the ground and the terrain conditions limited the air circulation under the open bottom boards and therefore limited the cooling effect on the hive. Furthermore the colonies in the MAI group in 2000 were maintained in a crowded two super condition for the production of queen cells. No doubt, this condition contributed to higher brood chamber temperatures. The third location (JOY) was situated in a well sheltered clearing fully exposed to the sun. It is possible that for these locations and in these circumstances, the open bottom boards did not cause a lowering of temperature of the brood chamber. In light of these facts, the use of the anti-varroa board with an open bottom seems completely inadvisable in environmental conditions comparable to those in Quebec. The enclosed table can be consulted in regards to the average minimum and maximum temperatures of the area where the tests were performed (meteorological station of Bromptonville).

	May	June	July	August	September
Average minimum daily temperature in Celsius degrees	5,5	10,7	13,7	12,7	8,1
Average maximum daily temperature in Celsius degrees	18,2	23,1	25,5	23,8	19,2

Influence of the Apiary Location Factor

The screening performed at the end of the 2000 season demonstrated that the varroa mite populations vary greatly from one location to another (figure 10). The level of infestation of the colonies was theoretically identical at the outset, as each had received a complete fluvalinate treatment in the fall of 1999. A limited screening in May of several randomly chosen hives (Apistan 24 hr) yielded varroa mites drops of between 1 and 35.
Nevertheless, the average drop by location at the end of the season (Apistan 24 hr.) varied from 499 to 2893 varroa mites. These averages were established uniquely from hives with a standard bottom board. By all indications, the apiary location factor exerts a major influence on the varroa mite progression in the hives. In our opinion, the recontamination of colonies was not a factor due to the low density of hives in this region. The possibility exists that temperature was a factor but one must not exclude other mitigating environmental factors. Ostiguy and Sammataro (16) equally found significant differences between the average rate of infestation between different apiary locations and attributed it to the same factor. As stated earlier, the method chosen to compare the results eliminated the influence of this variable.

In 2000 and 2001, the performance of the anti-varroa bottom board varied greatly from one apiary location to another. In 2001, its use yielded negative results in certain apiary locations despite having been operated with closed bottoms. The results of the experiment at the apiary locations where anti-

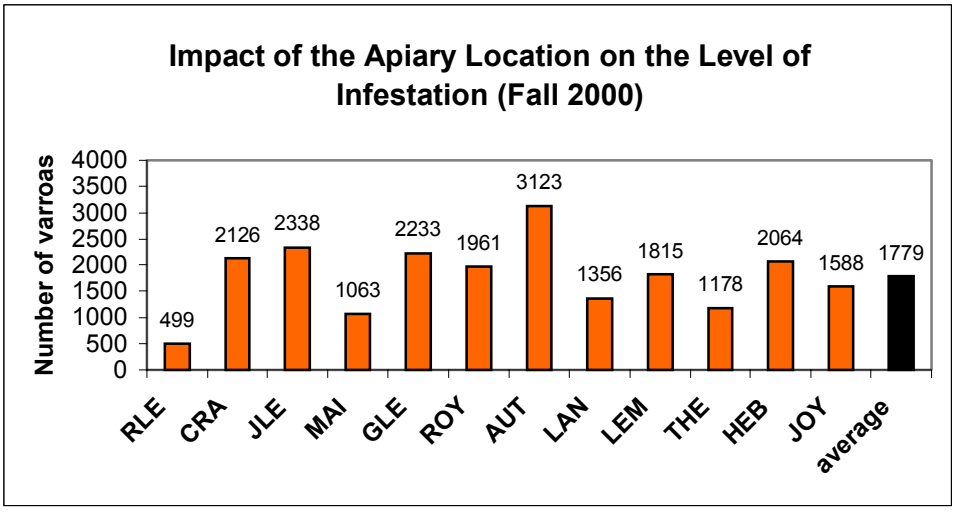

Figure 10

varroa bottom board were used from one year to the next seem to correlate (r=0.75). One must exercise great caution in interpreting these results and keep in mind that a relatively small number of colonies were tested in the different apiary locations. The probable correlation suggests that we check for the existence of an environmental factor related to the apiary location that could influence and even negate the performance of the anti-varroa bottom board. It is possible that this environmental factor is the temperature but other environmental factors could also be blamed.

Influence of the anti-varroa board on the impact of varroacidal treatments

As utilized in 2001, the anti-varroa bottom board resulted in an average reduction of 37% on the population levels of varroa mites. This impact is greater than the results obtained by Pettis and Shimanuki (1) in 1999 and by Ellis (2) in 2000 in the United States. They both recorded a reduction of 15% in the infestation. It should be noted that their results were not statistically significant. The greater impact obtained in our case could be explained by the fact that a partial three-week fluvalinate treatment was applied to all colonies during the test period. The use of the anti-varroa bottom board during this partial treatment probably contributed to its enhanced effect. In a communication posterior to the present study, Webster also reported a 70% reduction in mite population growth during a long-term study of 14 months (17). A significant proportion of the varroa mites that drop after the introduction of Apistan strips are still alive. When using a conventional bottom board, these mites could re-integrate themselves into the colony before being potentially killed or dislodged again. By counting the number of varroa mites fallen on sampling cardboards in two hives following a 24 hour Apistan test, we have observed that 40% and 49% respectively (average of 44%) of the fallen varroa mites were still alive (figure 11). All of these fallen varroa mites are eliminated after their first drop with the use of the anti-varroa bottom board. This could in effect render a miticide treatment more effective especially in the case of an incomplete short-term treatment.

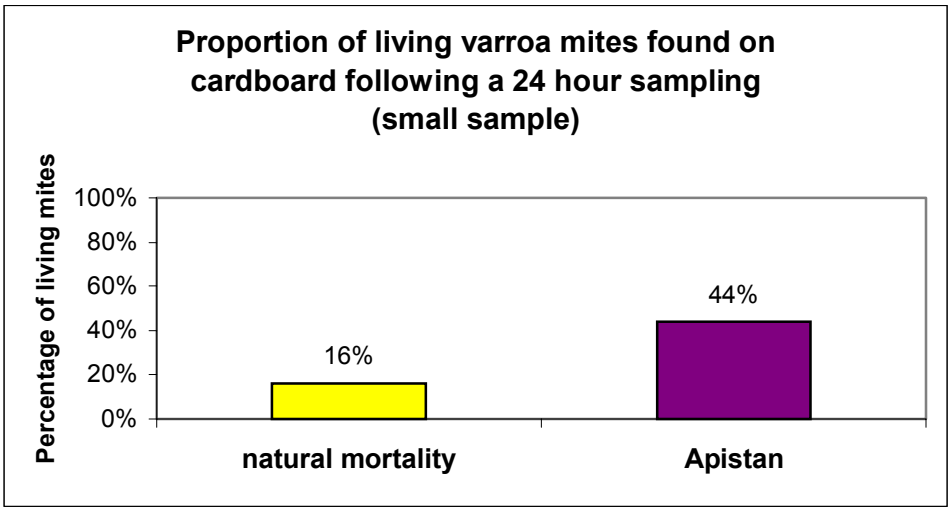

Figure 11

Causes of significant variations observed in the results of individual colonies

The significant variations between the results of individual colonies noted in 2000 and 2001 prevented, for the entire group, a statistical validation of the global results. We were able to make certain assertions from the facts on hand concerning external factors that could have a major influence on the population curve of the varroa mites. We considered it important to analyze the influence of these external factors to ensure the reliability of our results. This analysis creates interesting possibilities for research on alternative methods of varroa mite control. It is clear that neither the thermal factor nor the anti-varroa bottom board can explain the considerable variations observed, as these conditions were identical at each apiary location. As a result of the supplementary data that we gathered, we have attempted to evaluate the influence of the strength of the colony in the spring and the genetic line of the queen.

Influence of Spring colony strength

An analysis of the relationship between colony strength in the spring and the relative infestation rate in the fall demonstrates that this data is well correlated (r=0.67). This correlation is most evident (r=0.95) in colonies with 9 frames of bees or less (figure 12). The average fall infestation rate for weak colonies (5 frames of bees or less) is only 73% of the average while the average is 126% for strong colonies. The sampling on which we based these figures corresponds closely to the large group and was comprised of 70 weak colonies versus 116 strong colonies. Consequently we ensured that the groups being compared for our study on the impact of the anti-varroa bottom board were equal in terms of colony strength. In regards to the large group in 2001, sub group AV had an average strength of 7.2 frames of bees while sub group S had an average strength of 6.6 frames of bees. The slight difference between the two sub groups did not favor sub group AV because according to the stated correlation, superior colony strength in the spring should normally result in a higher infestation rate in the fall.

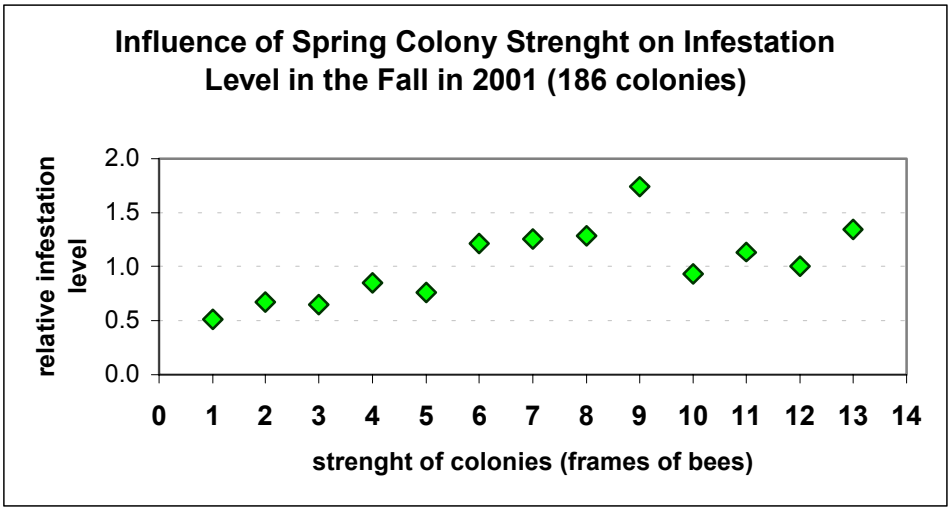

Figure 12

Influence of lineage

When we compared the infestation level of colonies in the fall based on the genetic line of their queen, we noted that there were significant differences (figures 13 and 14). Statistically significant differences were found between four of these lines in a proportion varying from 27% to 150%. Therefore lineage is an important variable capable of having a greater influence than the anti-varroa bottom board on the rate of infestation in the fall. This presents an interesting perspective on selection based on natural resistance to varroa. Nevertheless, we believe that this variable did not bias our results: several lines were in effect represented in each apiary location and the distribution of these lines between the two sub groups vis-à-vis the apiary locations was random.

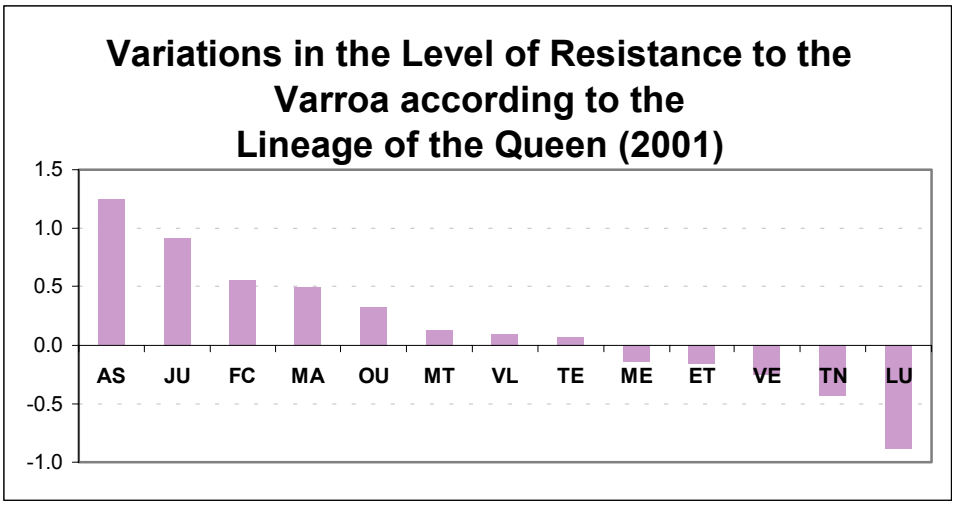

Figure 13

Relation between Queen Lineage and Fall Relative Infestation Level (2001)

nb of queens	queen lineage	average relative infestation level		resistance index	average strenght
		fall	spring		
5	AS	0.52	1.77	1.25	5.8
8	JU	0.79	1.71	0.92	8.6
5	FC	0.78	1.33	0.55	8.2
8	MA	0.83	1.32	0.49	7.8
4	OU	0.89	1.22	0.33	9.3
10	MT	0.66	0.79	0.13	6.5
6	VL	0.83	0.93	0.10	6.5
8	TE	1.02	1.09	0.07	6.4
6	ME	1.13	0.99	-0.14	5.0
6	ET	0.90	0.74	-0.16	8.0
5	VE	1.19	0.94	-0.25	5.2
5	TN	1.18	0.75	-0.43	8.2
7	LU	1.67	0.78	-0.89	8.7

Figure 14

Is the anti-varroa bottom board efficient in slowing infestation rate?

The results obtained are statistically significant for the YBO group in 2001 (35%, p=0.03) and the MAI group in 2000 (66%, p=0.041). But they are not statistically significant if we include the results of all of the groups. All of the recent studies on screened bottom boards, demonstrated positive results, but only one yielded statistically significant results (Webster 17). Cumulatively, these positive results tend to confirm that the use of the anti-varroa bottom board is a means of slowing the progression of varroa mite infestation. One must not forget that in our tests, two groups achieved results that could be statistically confirmed. The experimental conditions of these groups were more homogeneous. In 2001, the colonies of the YBO group had the same starting strength and their queens originated from only four lines equally distributed between the two groups. As for the MAI group in 2000, all colonies were of equal strength at the outset. The queens' lineage was also known (large number of lines randomly distributed). Furthermore, the infestation rate at the beginning of the season was known and the average infestation rate of each of the sub groups was equal (mirror groups). Experiment conditions for these two groups were well controlled and we are confident in the results obtained. As

far as the results obtained in 2001, it is not possible to decide which portion of the gain was due to the efficiency of the spring treatment while using the anti-varroa bottom board and which portion of the gain was due to its continued use through the season. The significant reduction of 66% for the MAI group in 2000 however was obtained in the absence of all treatments during the trial period.

Summary Table of 2000-2001 results

group	year	nb AV	nb sd	bottom	reduction percentage	statistically significant
ATH	2001	12	10	closed	-21.3%	no
LARGE	2001	92	51	closed	52.0%	no
YBO	2001	15	15	opened*	35.0%	yes
ALL	**2001**	**107**	**66**		**37.0%**	**no**
MAI	2000	12	8	opened*	66.0%	yes
ALL	**2000**	**106**	**78**	**opened***	**-29.2%**	**no**

* see explanations in text

Figure 15

Conclusions, Recommendations and Perspectives

Recommendations

Based on the results obtained during the two years of trials, we are convinced that the anti-varroa bottom board is a good means of slowing the progression of the varroa mite population in the colonies. Our conclusion reinforces those of several other studies, which demonstrate the same tendency. We therefore recommend its use within the Canadian context. The anti-varroa bottom board should however be used with a closed bottom in order to not, contrary to the desired result, encourage an accelerated increase in the varroa mite population which would follow a lowering of the hive temperature. This word of caution is very important. The bottom must be closed by means of a movable drawer that permits, at regular intervals, a cleaning of accumulated hive debris. This drawer is also useful for sampling purposes. We also recommend that the distance between the bottom of the sampling drawer and the screen be at least 4 cm (1 5/8") to prevent the re-entry of the varroa mites into the hive unless future studies prove that this distance can be reduced.

Our recommendation concerning the use of the anti-varroa bottom board is based not only on its ability to eliminate living varroa mites that fall naturally but on several other observations and facts:

- The anti-varroa bottom board seems to increase the efficiency of fluvalinate and could in principle increase the efficiency of all treatments.

- The anti-varroa bottom board could slow the development of fluvalinate resistant varroa mites. The varroa mites momentarily weakened by the miticide but not killed are eliminated from the hive and cannot reproduce. In the context of the beginning of resistance development to a medication, the anti-varroa bottom board by its action provides a prolongation of the useful life of the medication.

- The anti-varroa bottom board enormously simplifies the sampling for varroa mites in the colonies. It is no longer necessary to cover the sampling cardboard with a screen to protect it from the cleaning activities of the bees. It is also no longer necessary to disturb the bees or to pry open the hive to insert a sampling cardboard in a narrow space often obstructed by burr comb and the presence of dozens if not hundreds of bees. In addition to conventional sampling performed with the help of a miticide, the anti-varroa bottom board enables sampling based solely on the natural mortality of the varroa mites. With the anti-varrroa

bottom board, sampling for natural mortality can be extended to a period of up to one week or more permitting more accurate estimates. This type of sampling can even be performed during honey flows.

- Two studies have also noted a significant increase in the surface area of brood when the anti-varroa bottom board is used (Pettis & Shimanuki (1), Ellis, Delaplane & Hood (2)). We did not however measure this parameter in our trials.

- We did not observe any negative effects with the use of the anti-varroa bottom board provided that it was used with a closed bottom during the beekeeping season. We must nevertheless mention that the sampling drawer should be cleaned once a month to avoid the accumulation of hive debris, which could favor a wax moth infestation.

Anti-varroa bottom board and integrated pest management

The use of anti-varroa bottom board for the control of varroa mites is economical, easy, durable and environmentally friendly. It meets the criteria for organic production. By itself, the anti-varroa bottom board cannot maintain the varroa mite population below an economical level but in our opinion, it is a key tool in an integrated pest management strategy against the varroa mite for four good reasons:

1. Without intervention, it slows the rate of infestation and eventually reduces the frequency of treatments. It could eventually lead to relying solely on non-chemical miticides (essential oils, organic acids, etc.)

2. The determination of the state of infestation is easily known at all times during the beekeeping season. As a result, it facilitates an informed decision in regards to the necessity of resorting to a control method, the type of treatment to apply and the timing of the application.

3. Without intervention, it increases the efficiency of miticides.

4. Its function can be combined with other control methods such as the use of mite-resistant queens, the removal of drone brood, the use of natural or chemical miticides, etc.

Prospects for the development of new methods to deal with varroa brought about by the use of the anti-varroa bottom board

This tool presents interesting perspectives. It opens the door for research on techniques that would provoke or increase the drop of varroa mites from the adult bees. It also adds value to the development by selection of the grooming behavior trait of our bees. This behavior is a recognized and efficient method of the bees' defense against the varroa mite. It can contribute to increasing its natural resistance to this parasite

Paths for further research

The efficiency of the anti-varroa bottom board seems to vary according to certain circumstances. It would be useful to deepen our comprehension of the factors that affect its efficiency. In particular, we wonder about the probable apiary location effect and the thermal effect. We would suggest that future experiment devices be created so as to minimize the interference of external factors such as genetic lineage, the spring strength of the colony and its level of infestation at the beginning of the season.

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