The removal of capped drone brood: an effective means of reducing the infestation of varroa in honey bee colonies

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Some acaricides used as alternative controls against *Varroa destructor*, for example formic acid or essential oils, are not always sufficiently effective. We propose as complimentary measures the removal of drone brood or the division of young colonies in spring. These interventions serve to retard the development of varroa populations, and thus reduce the pressure of infestation. They have the advantage of being able to be carried out at the height of the beekeeping season when recourse to chemotherapy would present serious risks of contamination of the honey harvest.

Why does removal of drone brood influence varroa populations?

The preference of the parasite *Varroa destructor* for the drone larvae in *Apis mellifera* rather than worker larvae, has already been described in 1977 by Grobov[7] and in 1980 by Ritter.[15] This preference (ratio of varroa in drone cells versus varroa in worker cells) is calculated to be 8.6 by Schulz,[20] 8.3 by Fuchs[6] and 6 by Rosenkranz.[16]

Ruttner and his colleagues[18] proposed in 1980 to use this preference of varroa for cells occupied by drone brood as a vehicle for their own end. Other writers have shown that in their respective locations partial removal of drone brood allowed them to significantly reduce the population of parasites in colonies.[21,14,17,5 11,16]

Purposes of the trial

The trial presented in this paper had two objectives:

- To evaluate under central European conditions the impact of removal of drone brood on populations of varroa.
- To determine whether removal of drone brood is valuable in a control scheme based on autumn treatment with formic acid.

Design of the experiment

This trial was carried out in a production apiary of about 20 colonies of *A. mellifera* established in Dadant Blatt hives. Formic acid was the only acaricide previously used in this apiary located near Berne, Switzerland. All hives were equipped with a mesh-

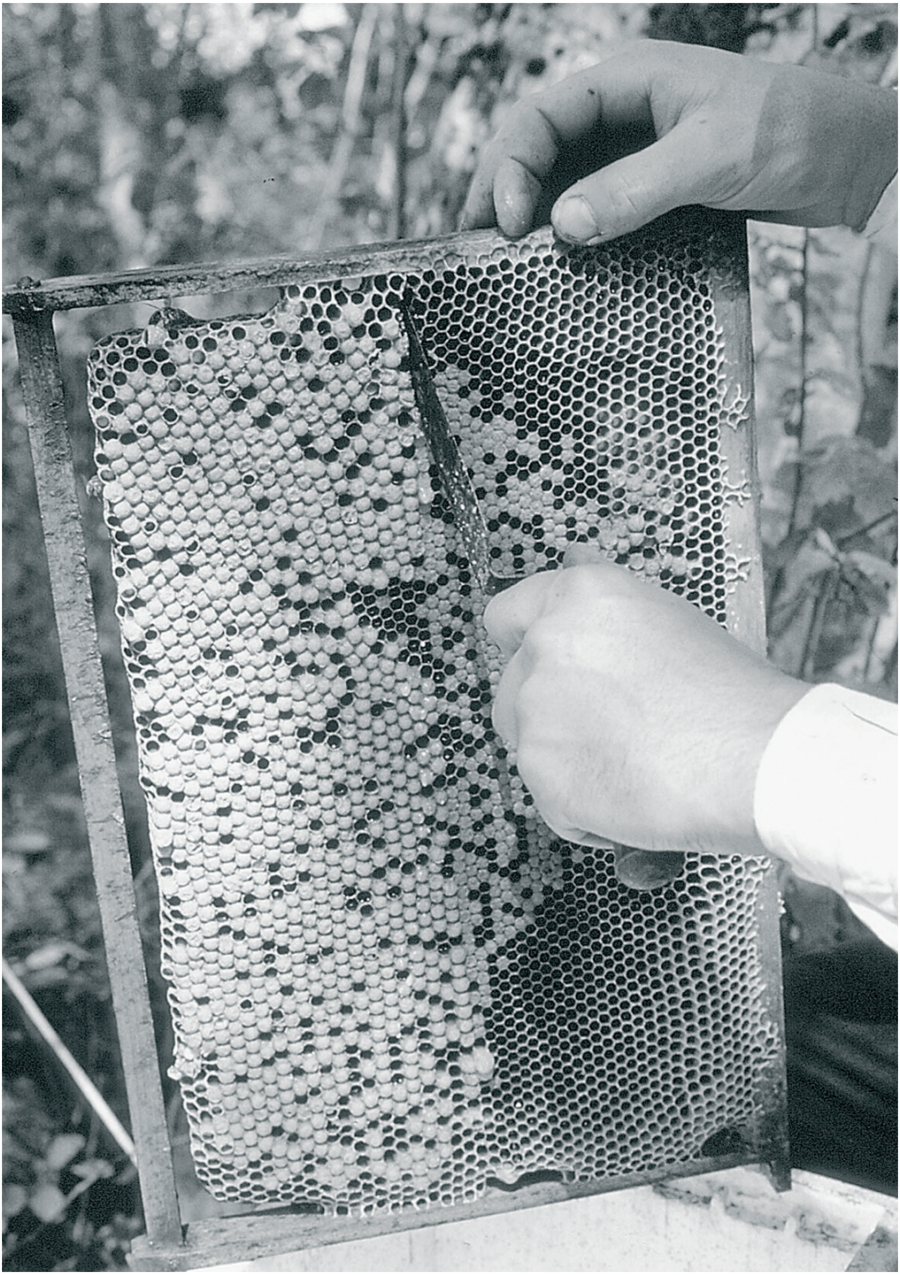

FIG. 1. A brood frame from which we have removed the lower part of the comb acts as a drone frame. The frame is placed in the brood nest so that it is quickly build and laid in.

protected floorboard over the whole bottom of the hive. We divided the hives into two homogeneous groups on the basis of the natural fall of varroa in October of the preceding year, which gives a reliable indication of the number of overwintering mites[10,12] and on the strength of the colonies in spring.

The drone frame

One frame of brood, from which we had removed the lower half of the comb, became the drone frame. One such frame was introduced to the side of the brood nest of each hive in the test group at the end of March. During the whole period of brood rearing we regularly removed the capped drone brood from this frame by cutting out the capped cells, whenever it exceeded a minimum of 1 dm^2 (fig. 1). Drone brood around the edges of other frames was not removed. Normally, the drone combs are rapidly constructed as the amount of drone brood built in a nest is governed by negative feedback from drone comb already constructed[13] and availability of sucrose sources (e.g. good nectar flow or honey stores in the hive).

Criteria evaluated

The number of capped drone cells removed from the colonies was determined, and the number of varroa in this comb was counted. All colonies were managed following the same apicultural practice. The strength of the colonies was estimated from mid-March until September using the Liebefeld method[8] in order to evaluate any impact of the removal of drone brood on population development. Honey production was measured. During the whole period of the trial the natural fall of varroa was measured once a week, giving an indication of the progress of infestation of the colonies. During August and September we made two series of three short-term treatments with formic acid, then we checked the efficiency of these treatments by the natural fall in October.[9] The trial was carried out in 1993, and repeated in 1994.

Effect on varroa populations in 1993

The year 1993 was marked by an early spring and a good nectar flow which

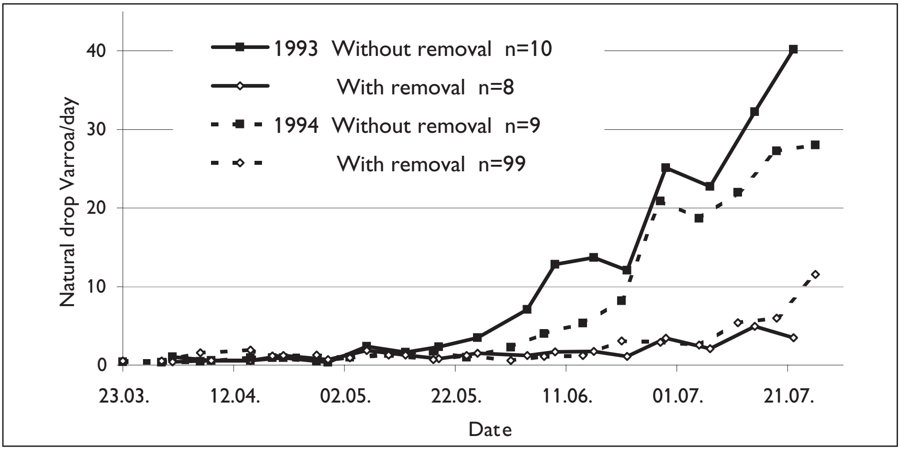

FIG. 2. Effect of the removal of drone brood on the natural drop fall of varroa in 1993 and 1994 (average).

TABLE 1. Results of th

Year		**Number of cuts**	**Drone cells removed**
Variable			
1993			
with removal	mean (n = 10)	4.1	3374
	s.d.	1.4	1681
without removal	mean (n = 8)	-	-
	s.d.	-	-
1994			
with removal	mean (n = 9)	2.3	3588
	s.d.	1.1	1657
without removal	mean (n = 9)	-	-
	s.d.	-	-

[1]Natural drop of varroa measured in the week before treatment with formic acid
*The means of the groups with and without removal of drone brood in the same year are statistically different (t test; $P \leq 0.05$)

encouraged the raising of drones, and thus permitted the frequent removal of capped drone cells. It was thus possible to take an average of 4.1 cuttings of drone brood per colony (minimum 1, maximum 6) between 15 April and 15 July.

We removed an average of 3374 capped drone cells per colony carrying 788 varroa (table 1). For these two figures there are important variations per hive.

The average natural falls of the test and control groups (fig. 2) differed progressively from the month of May. While the fall of mites remained low in the hives where we had cut out drone brood, it rose very rapidly in the hives without removal. This increase is an indication that the progress of varroa populations is to a large extent retarded by the elimination of mites found in the drone brood.

The formic acid treatments in August and September confirmed the effect of the biotechnical measures: the populations of mites in the test hives at the end of the season were 3.5 times less than in the control hives. In this latter group five hives out of eight showed an infestation greater than 5000 mites with a maximum of 12 928. Bees with deformed wings were seen in some of the control hives because of the excessive load of parasites.

Effects on the bees in 1993

The honey harvest and colony development were not significantly affected by the removal of cells of drone brood (fig. 3). Also, there was no significant difference between the two groups in the total quantities of worker brood raised during the year: test, 140 551 ± 22 675 cells; control, 142 852 ± 16 853 cells (average ± s.d.).

Effects on varroa populations in 1994

The spring of 1994 was cold and rainy, characterized also by a weak nectar flow, which

…e 1993 and 1994 trials.

Varroa in removed drone brood	Natural drop before treatment[1] mites/day	Mites killed by treatment with formic acid	Honey harvest (kg)
788	3.50	1531	6.6
677	2.18	696	3.4
-	40.20*	5693*	7.7
-	34.49	3853	4.3
434	11.54	2093	
352	11.42	1104	
-	28.02	4437*	
-	26.27	2948	

permitted an average of only 2.3 cuttings of drone brood per colony (minimum 1, maximum 5) between 3 May and 28 June. We were able to remove 3588 capped drone cells per colony with 434 varroa (table 1). As in 1993 the natural fall of mites in the control group hives rose rapidly from mid-May, while the rise in the test hives did not happen until six weeks later, and in a more gradual manner (fig. 2).

The controlled treatments with formic acid showed that in spite of the reduced number of cuttings, this biotechnical method had restricted the consequent development of varroa populations. During the formic acid treatments we counted more than double the parasites in the hives without drone brood removal.

Effects on the bees in 1994

The unfavourable nectar flow in 1994 did not allow any harvest of honey, and thus made a comparison between the two groups impossible. The colony strength and total number of worker cells raised was not significantly influenced by the removal of drone brood.

The removal of drone brood removes the pressure of infestation without hindering the colony

These results show that under central Europe conditions the removal of drone brood is an efficient means of slowing the development of varroa populations, even when the number of cuttings is reduced. Under our climatic conditions, and in the context of an alternative control programme using only short-term formic acid treatments in autumn, these biotechnical measures are shown to be indispensable in preventing colonies from perishing as early as July. The results are probably the same as for long-term treatment with formic acid.

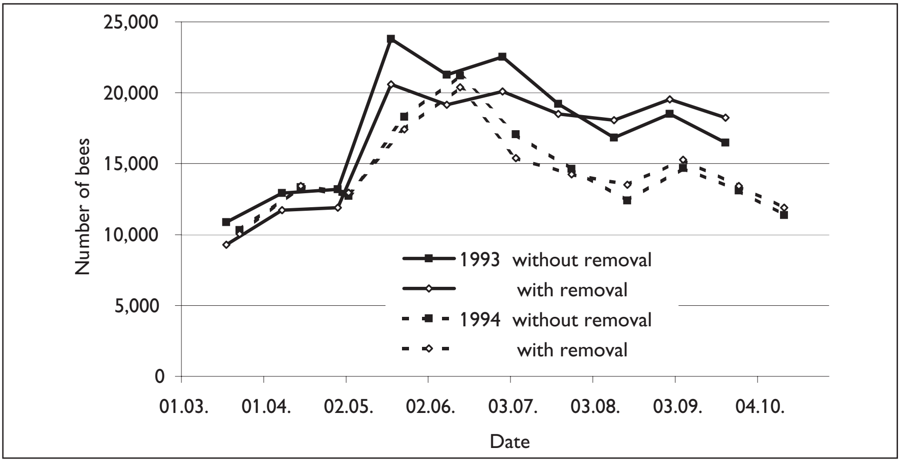

FIG. 3. Colony development for the groups with and without drone brood removal in 1993 and 1994 (average).

The removal of drone brood as we have described is only one measure of a system, and does not in any case allow the abandonment of other treatments, as has been confirmed by the observations of Rosenkranz,[17,16] Schulz,[21] Marletto[11] and Wilkinson.[24] Some authors have suggested the introduction of uncapped drone brood into colonies with no other brood with the aim of trapping the mites.[4,19,3,2] This method is comparatively labour intensive, and even though an efficiency of up 90% can be attained, it does not relieve the beekeeper of using some acaricide treatment.

In our trial the removal of drone brood had no negative effect on the development of the colonies and on honey production. Seeley,[22] by providing colonies with added drone combs, measured a significant reduction of honey yields in comparison with colonies without addition. But he concluded that providing colonies with drone combs might still be desirable since eliminating mites may compensate for the negative effect of drone comb addition on honey yields.

Allen[1] and Seeley[22] claimed that colonies given a frame of drone comb had less drone cells on the edges of the other worker brood frames. An additional advantage is a significant harvest of wax. The number of drones in our colonies is sufficient to guarantee the fertilisation of queens.

Examination of drone brood? Not viable for diagnosing varroosis

Our results showed that it is not possible to calculate the size of the varroa population parasitising a colony simply by examining the infestation rate of drone brood. This is probably influenced in part by the cycles of drone brood production in each colony and in part by the cyclical nature of the infestation of cells by varroa. The parasite load of drone cells was seen to vary from one- to six- times in the space of a week, without any relation to the actual varroa population. This confirms the observations of Ritter & Ruttner[15] who also observed the weakness of the infestation of drone brood as a measure of colony infestation. Wilkinson & Smith,[24] on the other hand, concluded using a theoretical model, that sampling naturally produced drone brood is valuable for estimating the level of mite infestation in a colony.

Will varroa adapt itself to this biotechnical control?

The often expressed fear that removal of drone brood will select for a population of varroa that prefer worker brood does not seem to be justified. We should remember that the removal of drone brood occurs only during a short period, and for the rest of the year the mites are obliged to breed in worker cells. Even during the drone raising season there will always be more varroa in worker cells simply because there is usually 10-times more worker brood in a normal productive colony as the area of drone combs in feral colonies is only around 17% of the total[23].

Implications for beekeepers

This trial has shown the efficacy of removal of drone brood in retarding the development of varroa populations. This biotechnical control allows the deferral of acaricide treatments until the end of summer without damaging infestation of the colony. This method is important for the success of some strategies of alternative control, as for example that which relies exclusively on autumn treatments with formic acid. On its own however the removal of drone brood is insufficient to keep the parasite under control.

Properly planned, the removal of drone brood can be integrated without much increase of work into the normal management of modern apiaries.

What to do in practice?

Three points to note:

- Introduce the drone frame into the colonies sufficiently early (end of March-beginning of April).
- The drone frame should be introduced into the brood nest so that it can be quickly built-up and have eggs laid in it. In this position the drone brood will also capture many more parasites[16].
- Avoid at all cost the emergence of drones from the drone frame, as this will increase the varroa population. If the following visit cannot be planned to occur before the emergence of drones, then the frame should be removed and replaced with a full frame of worker cells. To avoid an increase in work, it is necessary to integrate the removal of drone comb into the normal apiary management for this time of year. Given the normal growth of colonies, swarm control, placing and checking of honey boxes, the removal of drone brood should result in little increase in work.

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