# The effect of drone comb on a honey bee colony's production of honey

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**Original article**

# The effect of drone comb on a honey bee colony's production of honey*

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**Abstract** – This study examined the impact on a colony's honey production of providing it with a natural amount (20%) of drone comb. Over 3 summers, for the period mid May to late August, I measured the weight gains of 10 colonies, 5 with drone comb and 5 without it. Colonies with drone comb gained only 25.2 ± 16.0 kg whereas those without drone comb gained 48.8 ± 14.8 kg. Colonies with drone comb also had a higher mean rate of drone flights and a lower incidence of drone comb building. The lower honey yield of colonies with drone comb apparently arises, at least in part, because drone comb fosters drone rearing and the rearing and maintenance of drones is costly. I suggest that providing colonies with drone comb, as part of a program of controlling *Varroa destructor* without pesticides, may still be desirable since killing drone brood to kill mites may largely eliminate the negative effect of drone comb on honey yields.

**comb foundation / drone / drone comb / honey bee / honey production**

## 1. INTRODUCTION

Modern beekeeping is based on four key inventions from the 1800s: the movable frame hive, the bellows bee smoker, the honey extractor, and comb foundation (Crane 1990). Comb foundation – thin sheets of beeswax embossed with the hexagonal pattern of worker cells on which the bees build their combs – benefits beekeepers in several ways. It helps ensure that the bees build planar combs, it saves the bees much wax synthesis during comb construction, and it inhibits the bees from rearing drones, by doing away with most of a colony's drone comb. Langstroth (1866, p. 51) stated emphatically this third benefit of using worker comb foundation:

> "... the breeding of so many drones should be discouraged. Traps have been invented to destroy them, but it is much better to save the bees the labor and expense of rearing such a host of useless consumers. This can be readily done, when we have control of the comb; for by removing the drone-comb, and

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supplying in its place with worker-cells, the over production of drones may easily be prevented."

Although it may seem self-evident that reducing the number of drones ("useless consumers") in a colony will result in greater honey production, it would be good to know just how much a beekeeper benefits by removing drone comb from his hives. This is especially true now that the mite *Varroa destructor* is a problem for beekeepers. One method for controlling this mite without pesticides involves supplying colonies with drone comb and periodically removing and freezing the drone brood, thereby killing the mites, which parasitize preferentially the drone brood (Sammataro and Avitabile 1998). Clearly, giving colonies drone comb provides benefits in the control of *Varroa* (and in the production of drones, needed for the proper mating of queens). Presumably, however, it also imposes costs in the production of honey. How much is a colony's honey production depressed by giving it drone comb? Surprisingly, there are just two studies (Allen, 1965; Johansson and Johansson, 1971) that have examined the impact on a colony's honey production of providing it with plentiful drone comb. In both studies the authors conclude that providing colonies with drone comb, and so increasing their drone populations, does not reduce the capacity of a colony to produce honey. I have studied the matter further and now report the results of a 3-year investigation of the effect on a colony's honey production of providing it with a natural amount of drone comb.

## 2. MATERIALS AND METHODS

### 2.1. General plan

To measure the effect on a colony's honey production of providing it with drone comb, I compared the weight gains from mid May to late August of 5 honey bee (*Apis mellifera* L.) colonies occupying hives with drone comb to those of 5 colonies occupying hives without drone comb. This was done with 10 different colonies in each of 3 summers: 1998, 1999, and 2000. Because 17 ± 3% (mean ± SD) of the comb area of natural nests of honey bees is devoted to drone comb (Seeley and Morse, 1976), the hives with drone comb were equipped with 20% drone comb, hence a normal supply.

### 2.2. Study site and colonies

The study was performed in one apiary located in Ellis Hollow, a rural valley several kilometers east of Ithaca, New York State. This apiary belongs to Cornell University and contains about 20 colonies. They are arranged in a line, face south, and sit in pairs (two colonies per hive stand), with approximately 2 m between each pair of colonies. Each spring, I went to this apiary, identified 5 pairs of healthy colonies for the study (see below), and requeened each of the 10 colonies with a Buckfast queen purchased from Weaver Apiaries, Navasota, Texas. Thus, even though a particular hive may have been used more than once during the 3-year period of this study, the study was performed with 30 genetically distinct colonies.

### 2.3. Colony management

All the colonies in the apiary were overwintered in two, 10-frame Langstroth hive bodies with full-depth frames (total surface area of 2200 $cm^2$/frame), with the upper hive body filled with honey at the start of winter. In the spring, at the earliest time possible (early to mid April) all the colonies were given a standard spring inspection: bottom boards were scraped clean of dead bees and debris, frames were scraped clean of burr comb, entrance reducers were removed, strips of the miticide Apistan were installed to kill *Varroa*, and each colony was checked for a laying queen and absence of American foulbrood. At this point, I chose the 5 pairs of colonies (both colonies on the same hive stand) for the experiment. To be included in the study, both colonies in a pair had to be queenright and at least moderately strong for this time of year. I then examined each frame in the hives of the 10 study colonies, looking for frames of worker comb that also contained drone cells. Any frame with a patch of drone cells greater than 10 $cm^2$ on either side was removed and replaced with a frame with worker cells only. Each frame that was removed was replaced with one matching it as closely as possible (with respect to brood and food) from another colony in the apiary that was not one of the 10 study colonies. Next, each study colony in a pair was assigned randomly (by a coin toss) to a treatment, i.e., with or without drone comb. Colonies receiving drone comb were given 4 frames of drone comb. This was done by removing 4 frames of empty worker comb from each colony's hive and replacing them with 4 frames of empty drone comb (comb that had been built on drone comb foundation). The combs in each hive were rearranged, as necessary, so as to minimize disruption of the broodnest while positioning the drone comb in the #3 and #7 frame positions in the two hive bodies of each colony's hive. This was done to position the drone comb in its natural location, on the edge of the broodnest (Seeley and Morse, 1976). Note that there was no change in the brood or food condition of each colony that received drone comb.

In late April, I revisited the colonies. To minimize swarming, I reversed the two hive bodies of each colony's hive, thus putting most of the bees and brood in the lower hive body. I also requeened each of the 10 colonies with a mated Buckfast queen. This was done by removing the queen from each colony and combining it with a third full-depth hive body containing a new Buckfast queen. The Buckfast queens that I introduced to the colonies were ones that I had received a few weeks previously, in mid April, from Weaver apiaries. Each spring, when the shipment of queens arrived, I labeled each queen with a paint mark and installed her in a 5-frame hive containing 2 frames of brood, 1 frame of pollen and honey, and 2 empty frames, with all 5 frames containing only worker comb. Shortly before uniting each nucleus colony with a study colony, I placed the 5-frame nucleus colony in a 10-frame hive body along with 5 more frames of empty comb. For colonies in the group with drone comb, 2 of the 5 additional frames contained drone comb, but for colonies in the group without drone comb, none of the 5 additional frames contained drone comb.

In mid May, hence before any of the nectar flows in the Ithaca area, I installed a queen excluder between the second and third hive bodies of each colony and made sure each colony's queen was below the excluder. I also gave each colony a fourth, full-depth hive body of empty combs. This fourth hive body contained either 2 or 0 frames of drone comb, according to whether the colony was in the group with drone comb or in the group without it. At this point, each colony had 2 full-depth hive bodies for brood rearing, and two full-depth hive bodies for honey storage. This configuration is typical for colonies managed for honey production in the Ithaca area. Finally, I weighed each of the 4 hive bodies of each colony's hive. This was done by temporarily dismantling each hive and weighing each hive body to the nearest 0.1 kg on platform scales (Detecto, model 4510KG). These weighings were performed on 12 May 1998, 15 May 1999, and 14 May 2000. Thus for each colony I knew the total weight of its hive (minus bottom board and cover), its bees, and its food early in the season, before it had produced much, if any, honey.

In late May, I removed the Apistan strips from each hive. Other than this manipulation, I left the colonies undisturbed from mid May to late August. During this period they were free to exploit the various nectar flows in the Ithaca area. The principal nectar sources over this time period are dandelion *(Taraxacum officinale)*, black locust (*Robinia pseudoacacia*), raspberry (*Rubus* spp.), sumac (*Rhus* spp.), basswood (*Tilia americana*), white clover (*Trifolium repens*), and purple loosestrife (*Lythrum salicaria*).

In late August, hence after all the major nectar flows except the autumnal ones from goldenrod (*Solidago* spp.) and aster (*Aster* spp.), I reweighed the 4 hive bodies of each colony's hive. These weighings were performed on 22 Aug 1998, 31 Aug 1999, and 25 Aug 2000. Also, I checked each frame of worker comb in the lower two hive bodies of each colony's hive to see if the bees had added a patch of drone comb, either within the wooden frame or outside it as burr comb. All frames with a patch of drone cells greater than 10 $cm^2$ were counted. Furthermore, I checked each colony's queen for a paint mark, to see if there had been queen turnover, since April. I also replaced each colony's queen excluder with a bee escape board, in preparation for removing the two honey supers, now partially or completely filled with honey. These were removed several days later, at which time I installed Apistan strips and left the colonies alone to prepare for winter.

### 2.4. Drone counts

In the third year of the study, I checked whether the colonies with drone comb were rearing and maintaining more drones than the colonies without drone comb. I did so by measuring the rate at which drones departed each colony during 3 warm and sunny afternoons (1 June, 3 July, and 4 August 2000). On each afternoon, from 14.00 h to 16.30 (the period of drone flight), I cycled among the colonies, visiting each one once every 15 min, and during each visit I counted the number of drones exiting the hive during a 1-min sample period. Thus on each day, for each colony, I obtained 10 measurements of the rate of drone departures. The average of these 10 measurements was my measure of a colony's level of drone flight on each sampling day.

### 2.5. Mites counts

Also, in the third year of the study, I compared the levels of *V. destructor* between the two groups of colonies at the time of the second weighing. To do this, I installed a *V. destructor* screen and sticky board (purchased from Dadant and Co.) on the bottom board of each hive when I dismantled it temporarily for weighing on 25 Aug 2000. After 48 h, I removed the screens and sticky boards and counted the mites.

### 2.6. Statistics

All numerical results are given as the mean ± 1 SD. Student's t-test was used to test for a significant difference between the means of the two colony types (with or without drone comb) for four variables: colony weight gain, drone departure rate, mite count, and frames with patches of drone comb. The chi-square test was used to test whether the probability of a colony experiencing queen turnover was independent of its type (with or without drone comb). Spearman's rank correlation coefficient was calculated for the variables of *V. destructor* count and weight gain, for both groups of colonies, to see if the rankings of colonies with respect to mite levels and honey yields are in substantial agreement (in the opposite order of the ranks).

## 3. RESULTS

### 3.1. Colony weight gain comparison

Figure 1 shows the distributions of weight gain/colony for colonies with and

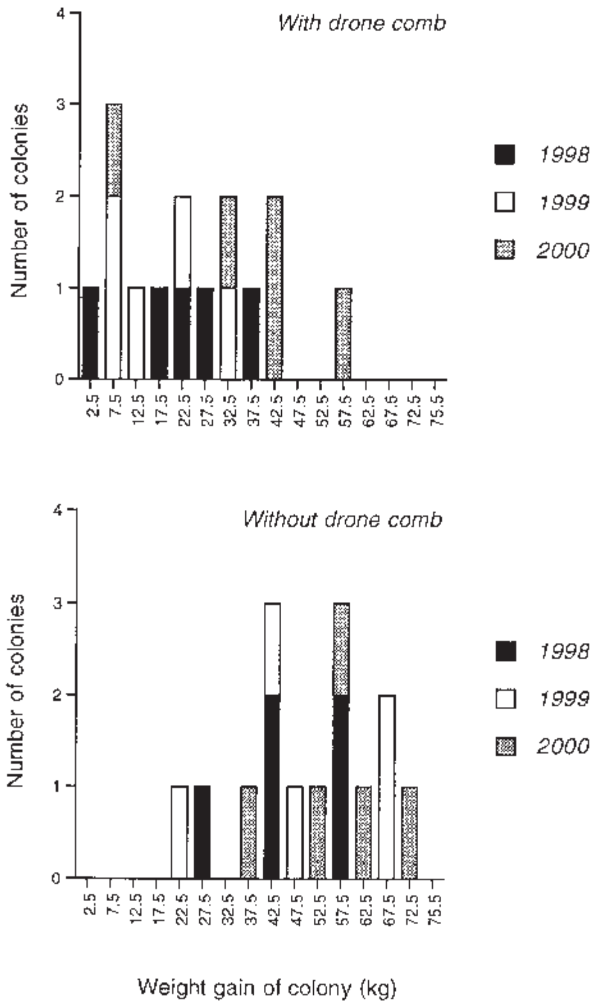


**Figure 1.** Comparison of the weight gains, between mid May and late August, of colonies with and without drone comb. The study was conducted over 3 years with 10 new colonies each year, 5 with drone comb and 5 without drone comb.

without drone comb. Although the distributions for the two types of colony overlap considerably, their means differ markedly: colonies with drone comb, 25.2 ± 16.0 kg; colonies without drone comb, 48.8 ± 14.8 kg ($P < 0.0001$). A year-by-year comparison shows the same trend. Each year the mean weight gain of colonies with drone comb was well below that of the colonies without drone comb: 1998, 20.9 vs. 45.7 kg; 1999, 17.3 vs. 49.0 kg; 2000, 37.2 vs. 51.9 kg. The difference between the means was statistically significant in 2 of the 3 years: 1998, $P < 0.01$; 1999, $P < 0.005$; 2000, $P = 0.09$.

### 3.2. Drone departure rate comparison

The mean rate of drone departure was 4–13 times higher for colonies with drone comb than for colonies without drone comb (see Tab. I). This difference was confirmed when I temporarily dismantled each hive for the August weighings and made a visual inspection of the drones in each hive. Colonies with drone comb overflowed with

**Table I.** Comparison of the mean rates of drone departure from colonies with and without drone comb.

| | Rate of drone departure from hive (drones/min) | | |
|---|---|---|---|
| Date | With drone comb | Without drone comb | *P* |
| 1 June | 38.5 ± 16.7 | 9.6 ± 5.3 | < 0.01 |
| 3 July | 74.5 ± 23.8 | 14.2 ± 5.6 | < 0.001 |
| 4 August | 51.0 ± 25.1 | 3.9 ± 0.8 | < 0.01 |

drones whereas colonies without drone comb contained noticeably fewer drones.

### 3.3. Drone comb building comparison

The mean number of frames of worker comb to which the bees added a patch of drone comb over the summer was much lower for colonies with drone comb (0.6 ± 0.7 frames/colony, n = 15) than for colonies without drone comb (4.6 ± 3.3, n = 15). This difference is statistically significant ($P < 0.005$).

### 3.4. Queen turnover comparison

The probability of a colony experiencing queen turnover between mid-May and late August was independent of colony type. Of the 15 colonies with drone comb, 4 had a turnover in their queen, and of the 15 colonies without drone comb, 3 had a turnover in their queen. This difference is not statistically significant ($P > 0.80$).

### 3.5. *V. destructor* count comparison

The mean number of mites caught on a sticky board in 48 h was somewhat higher for colonies with drone comb (26, 29, 111, 127, 271; hence 113 ± 100) than for those without drone comb (24, 25, 54, 80, 183; hence 73 ± 66). However, the difference between the two groups' means is not statistically significant ($P > 0.40$). In neither group was the ranking of colonies according to mite level in substantial agreement with the opposite ranking of colonies according to honey yield: with drone comb, $r_s = 0.10$, $P > 0.50$; without drone comb, $r_s = 0.60$, $P > 0.20$.

## 4. DISCUSSION

### 4.1. Why was drone comb associated with lower honey yields?

All of the colonies gained weight between mid May and late August, and there is little doubt that each colony's weight gain was due mainly to an accumulation of honey (McLellan, 1977). Each colony had stored much honey in the honey supers, and some colonies had completely filled these supers. There was, however, a marked difference in the amount of weight gain (honey production) between the colonies with and without drone comb: 25.2 and 48.8 kg, respectively. Because the difference found in the first year, 1998, was surprisingly large, I repeated the study for 2 more years to see if colonies without drone comb would consistently produce more honey than ones with it. This is what I found in 1999 and 2000 as well, so I conclude that colonies with a natural amount of drone comb do indeed produce less honey than those with little or no drone comb. Why is this? Let us consider three hypotheses.

#### *4.1.1. Drone comb fosters drone rearing and drone rearing stimulates swarming*

It has been suggested that the presence of drones in a colony promotes queen rearing and swarming (reviewed by Ribbands, 1953, pp. 264–268). There is little doubt that providing colonies with drone comb stimulates their drone rearing, for colonies with drone comb had far higher rates of drone departure than the colonies without drone comb (see Tab. I). But this study provides no evidence in support of the suggestion that the presence of drones in a colony promotes queen rearing and swarming. Only 7 out of 30 colonies experienced queen turnover (for swarming or supersedure), and 4 were with drone comb while 3 were without drone comb.

#### *4.1.2. Drone comb fosters drone rearing and drone rearing (and maintenance) is costly*

By giving colonies a natural amount of drone comb, one enables a colony to invest in a normal way in reproduction through males. It may be that in honey bee colonies, as in many plants and animals (reviewed by Stearns, 1992, p. 86), the impact of reproduction on physiological condition – including food reserves – is dramatic. When not deprived of drone comb, a colony will devote 5–15 percent of its investment in producing bees to the production of drones, thereby rearing to adulthood between 5 000 and 15 000 drones per year (Weiss, 1962; Allen, 1965; Page and Metcalf, 1984). Given that the weight of an adult drone is approximately 220 mg (Mitchell, 1970), we can estimate the annual cost to a colony of rearing its drones at 2.2–6.6 kg of honey, assuming a 50% efficiency of converting honey into bees (5 000–15 000 drones × 0.220 g/drone × 2 = 2.2–6.6 kg). Of course, this estimate of the cost of rearing drones does not take into account the "opportunity cost" of drone rearing, that is, the cost that is incurred when (productive) workers are not reared because (non-productive) drones are reared. This opportunity cost is probably considerable. A drone's wet weight is about 3 times that of a worker, hence in rearing about 10 000 drones a colony presumably forgoes rearing about 30 000 workers, which is roughly 20% of a colony's annual production of approximately 150 000 workers (Seeley, 1985, p. 82). Assuming that having 20% more workers would result in 20% more honey, we can estimate that the opportunity cost of drone rearing is about 5 kg of honey (20% of 25 kg). Overall, then, a colony sacrifices some 7–12 kg of honey to rear its drones.

What about the cost of maintaining these drones, especially the cost of fueling their mating flights? Assuming that a colony produces 10 000 drones, each drone lives for 20 days after reaching sexual maturity, and makes 4 mating flights per day (drone statistics from Winston, 1987, pp. 56 and 202), we can calculate that a colony bears the cost of some 800 000 mating flights by drones per year. The energy expended per drone per mating flight can be calculated using the allometric equations determined by Wolf et al. (1989) from measurements of rates of oxygen consumption of flying bees. Because the respiratory quotient of honey bees is nearly 1.0 (Rothe and Nachtigall, 1989), these allometric equations for rates of oxygen consumption (ml $O_2$/h) can be directly converted to equations for rates of energy consumption (J/s), using the standard conversion factor that 1 ml $O_2$ corresponds to 20.1 J. The converted equation for a flying bee is $MR = 0.00287\ M^{0.629}$, where MR is the metabolic rate (J/s) and M is the body mass (mg). For a 220 mg drone, the metabolic rate during flight is approximately 0.085 J/s. Hence the energetic cost of an average mating flight of 30 min (1800 s) is approximately 153 J. Using 17 J/mg of sucrose as the value for the energetic equivalence of sucrose (Kleiber, 1961), we can calculate that an average mating flight requires 9.0 mg of sucrose, or about 10.5 mg of honey (an 86% sugar solution). Hence the cost of fueling all 800 000 matings flights is approximately 8 kg of honey.

Thus it appears that the annual cost per colony of rearing and maintaining a crop of drones is approximately 15–20 kg of honey. This is, however, somewhat less than the 23.6 kg average difference in weight gain (mainly honey production) that was found between colonies with and without drone comb. Evidently, either the production and maintenance costs of drone have been underestimated, or there is another cost associated with giving colonies drone comb. The third hypothesis considers one possibility for what this other cost might be.

#### *4.1.3. Drone comb fosters drone rearing and drone rearing fosters Varroa reproduction*

Higher levels of *V. destructor* may contribute to the lower yields of honey from colonies with drone comb. All colonies were treated thoroughly with Apistan in the spring, so the mite level in each colony should have been low early in the summer. By the end of August 2000, however, in 3 of 5 colonies with drone comb, but only 1 of 5 without drone comb, the mite count on the sticky board was greater than 100, indicating a heavy infestation of mites (Sammataro and Avitabile, 1998). Although these data must be considered preliminary, because they come from only 10 colonies and from only one year, they suggest that more drone brood in a colony does create a more favorable environment for mite reproduction. Hence it is possible that the colonies with drone comb experienced greater stress from this parasitic mite than did the colonies without drone comb, and this contributed to the lower honey production by colonies with drone comb. If this was the case, then one might expect a negative correlation between mite level and honey yield for the colonies within each group. But when I were measured both variables in August 2000, for both groups of colonies, I found no such correlation between the rankings of colonies according to their mite levels and honey yields. However, my sample sizes were small and my means of assaying the mite levels in colonies (measuring the mite drop in 48 h) was not precise. Hence my results provide only a preliminary test of the hypothesis that drone comb fosters *V. destructor* reproduction and thereby depresses a colony's honey production.

### 4.2. Why did prior studies not report an effect of drone comb on honey yields?

Allen (1965) and Johansson and Johansson (1971) both report no effect of providing drone comb on honey yields of colonies. Actually, however, Johansson and Johansson (1971) found in both years of their study that the colonies with drone comb produced markedly less honey than colonies without drone comb: 1965, 31.8 vs. 61.6 kg; 1966, 39.9 vs. 57.8 kg. The difference that they found in 1965 is statistically significant ($P < 0.01$), but the authors attribute it to the colonies with drone comb losing worker brood and gaining drone brood when frames were transfered between colonies to create the two groups. The difference that they found in 1966 is not statistically significant ($P > 0.10$), but this may be due mainly to a low sample size; 25% of their study colonies died in the winter of 1965-66. I suggest that the results of Johansson and Johansson (1971) are actually consistent with the hypothesis that providing drone comb reduces honey yields. Certainly their results do not firmly contradict this hypothesis.

The difference between my results and those of Allen (1965) may be due to any number of differences in the methods, times, and places of our studies. I suspect that one of the principal sources of the difference in our findings is a large difference in the strength of our colonies. Allen's colonies started out relatively weak following a severe winter in northern Scotland in 1962-63 and a poor summer there in 1963. Only 11 of her 21 colonies had overwintered in her apiary; the remainder were either started from packages (5 colonies) or were "delivered" (5 colonies). In contrast, my colonies started out strong after the unusually mild winters in the northeastern United States in 1997-98, 1998-99, and 1999-2000. The level of drone rearing by a colony probably depends on it's condition, so it is possible that Allen's colonies with drone comb reared many fewer drones than did my colonies. If so, then one would expect a smaller effect of providing drone comb. From measurements of drone brood, Allen estimated the total drone production of each colony that she gave drone comb and calculated a mean of 3 547 drones, indicating a relatively low level of drone production. Also, she reported that on average her colonies with drone comb reared brood in just 2 frames of drone comb, whereas I observed that my colonies with drone comb reared brood in all 4 frames of this comb.

A second possible cause of the difference between my results and those of Allen (1965) is the presence of *V. destructor* in my colonies but not in Allen's. Because these mites reproduce preferentially on drone brood, providing drone comb to colonies may increase the negative effects of these mites, by fostering their reproduction. Of course, this negative effect of drone comb would not have occurred in Allen's study because *V. destructor* was not present in Scotland in the 1960's.

### 4.3. Implications for beekeepers

The findings of this study have two practical implications. The first is that installing drone comb in hives does result in "cleaner" frames of worker comb, that is, frames of worker comb without patches of drone comb. I found that in hives with drone comb, the bees added drone cells to only 4% (0.6 of 16 frames in the brood chamber) of the frames of worker comb, whereas in hives without drone comb, the bees added drone cells to fully 23% (4.6 of 20 frames in the brood chamber) of the frames of worker comb. This result is consistent with the findings of Allen (1965), Free (1967), and Pratt (1998), who all report that the amount of drone comb built in a hive is controlled by negative feedback from the drone comb already present.

The second, and more important, implication of this study's findings is that providing a colony with drone comb will lower substantially the colony's honey yield. It may be, however, that if a beekeeper removes and freezes the frames of capped drone brood, to control *V. destructor*, he will largely eliminate the negative consequences of adding drone comb to hives. Certainly, by steadily killing the drone brood, a beekeeper will reduce the stresses caused by mites and he will reduce the cost of fueling the drones' mating flights. But will the steady removal of drone combs filled with capped brood erase fully the negative effect of drone comb on a colony's honey yield? The answer to this question awaits further research.


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**Résumé – Influence des rayons de mâles sur la production de miel d'une colonie d'abeilles domestiques.** L'une des innovations de l'apiculture moderne, les feuilles de cire gaufrée, est sensée apporter à l'apiculteur l'avantage de pouvoir réduire le nombre de rayons de mâles. Ce faisant il empêche les abeilles (*Apis mellifera*) d'élever des mâles ce qui augmente la production de miel de la colonie. Cette étude examine dans quelle mesure le rendement en miel d'une colonie est diminué si on laisse à la colonie la quantité naturelle de rayons de mâles. Ce problème a acquis récemment de l'importance car l'un des moyens pour lutter contre l'acarien parasite *Varroa destructor* sans pesticides consiste à donner des cadres de mâles et à tuer périodiquement le couvain mâle infesté. Pour mesurer l'effet exercé par l'introduction de rayons de mâles, j'ai comparé les gains de poids de mi-mai à fin août de cinq colonies occupant des ruches avec rayons de mâles (colonies AM) et de cinq colonies dépourvues de rayons de mâles (colonies SM). Les dix colonies étaient dans le même rucher. L'étude a porté sur trois ans, 1998-2000, et les dix colonies étaient différentes chaque année. Les colonies AM étaient équipées avec 20 % de rayons de mâles, quantité correspondant approximativement à ce que l'on trouve dans les colonies sauvages. Les colonies AM n'ont pris que 25,2 ± 16,0 kg tandis que les colonies SM ont pris 48,8 ± 14,8 kg ($P < 0{,}0001$). Pour vérifier que les colonies AM élevaient et maintenaient plus de mâles que les SM, j'ai comparé les taux de départ de mâles chez les deux types de colonies. Le taux moyen d'envol des mâles était en moyenne 7,5 fois plus élevé chez les colonies AM que chez les SM. En outre les colonies AM construisaient moins de rayons de mâles et avaient vraisemblablement fin août un taux d'infestation par *V. destructor* plus élevé que les colonies SM. Aucune différence n'a été remarquée entre les deux types de colonies en ce qui concerne la probabilité de renouvellement de la reine par supersédure ou essaimage. Les rendements en miel inférieurs chez les colonies AM sont apparemment dus en partie au fait que les rayons de mâles stimulent l'élevage des mâles et que l'élevage et le maintien des mâles est coûteux pour la colonie. Une autre raison possible est que cela encourage l'élevage des mâles, ce qui favorise la reproduction de l'acarien. Deux études antérieures (Allen, 1965 et Johansson et Johansson, 1971) ne signalent aucun effet des rayons de mâles sur le rendement en miel mais, pour des raisons qui sont ici discutées, les résultats de ces études antérieures ne contredisent pas fortement ceux de l'étude présente. Finalement les résultats de cette étude ont deux conséquences pour les apiculteurs : (i) insérer des rayons de mâles dans les ruches aboutit à des rayons d'ouvrières « plus propres » (sans portions comportant des cellules de mâles) et (ii) fournir des rayons de mâles à une colonie diminue nettement le rendement en miel de la colonie. Reste la possibilité que des colonies avec rayons de mâles se montrent plus intéressantes dans la lutte sans pesticides contre *V. destructor* puisque tuer le couvain mâle pour tuer l'acarien pourrait largement compenser l'effet négatif des rayons de mâles sur le rendement en miel.

**rayon de mâles / rendement en miel / feuille de cire gaufrée / abeille domestique**

**Zusammenfassung – Einfluss von Drohnenwaben auf die Honigproduktion im Bienenvolk.** Eine der Neuerungen in der modernen Bienenhaltung – der Einsatz von Mittelwänden – soll den Imkern den Vorteil bringen, dass er die Zahl der Drohnenwaben erheblich reduzieren kann. Dadurch werden die Bienen gehindert Drohnen zu erzeugen, wodurch wiederum die Honigernte erhöht wird. Mit diesen Versuch wird ermittelt , um wieviel die Honigernte vermindert wird, wenn im Volk die natürliche Anzahl von Drohnen vorhanden ist. Diese Frage gewann in letzter Zeit an Bedeutung, weil eine Möglichkeit der pestizidfreien Bekämpfung von *Varroa destructor* im Einstellen von Drohnenwaben besteht, um

dann in regelmäßigen Abständen die Brut zu entnehmen und mitsamt den Milben abzutöten.
Um den Einfluss des Einstellens von Drohnenwaben in Völkern auf die Honigproduktion zu untersuchen, verglich ich von Mitte Mai bis Ende August die Gewichtszunahme von 5 Völkern mit besetzten Drohnenwaben mit 5 Völkern ohne Drohnenwaben. Die 10 Völker befanden sich auf demselben Bienenstand. Der gleiche Versuch wurde mit jeweils 10 anderen Völkern in den Sommern 1998, 1999, und 2000 durchgeführt. Die „Drohnenvölker" wurden mit 20 % Drohnenwaben versehen, das entspricht etwa der Menge in natürlich lebenden Völkern.
Das Gewicht der Völker mit den Drohnenwaben stieg nur um 25,2 ± 16,0 kg, während es bei Völkern ohne Drohnenwaben um 48,8 ± 14,8 kg ($P < 0.0001$) stieg. Zur Überprüfung, ob Völker mit Drohnenwaben mehr Drohnen erzeugten und pflegten als die Völker ohne Drohnenwaben, verglich ich die Anzahl abfliegender Drohnen bei beiden Volkstypen. Die durchschnittliche Zahl der Drohnen war im Mittel 7,5 mal höher bei den Völkern mit Drohnenwaben als bei den anderen. Außerdem bauten die Völker mit Drohnenwaben weniger zusätzliche Drohnenzellen und hatten wahrscheinlich Ende August einen höheren Befallsgrad mit *Varroa destructor* als die anderen Völker. Zwischen den beiden Volkstypen bestand kein Unterschied in der Wahrscheinlichkeit eines Wechsels der Königinnen, weder durch Ersatz noch durch Schwärmen.
Offensichtlich beruhen die niedrigeren Honigerträge zum Teil auf einer Stimulierung der Drohnenaufzucht durch die Drohnenwaben, denn die Aufzucht von Drohnen und ihre Pflege sind mit hohen Kosten verbunden. Ein weiterer Grund für den geringeren Honigertrag liegt an der erhöhten Reproduktion von *Varroa destructor*, die mit der vermehrten Drohnenaufzucht zusammenhängt. Zwei frühere Untersuchungen (Allen, 1965; Johansson und Johannson, 1971) ergaben keinen Einfluss von Drohnenwaben auf den Honigertrag der Völker, aber wegen der hier diskutierten Gründe widersprechen die vorherigen Ergebnisse den hier beschriebenen Ergebnissen nicht vollständig.
Aus den Ergebnissen lassen sich für die Imker zwei Folgerungen schließen:
(1) Das Einstellen von Drohnenwaben fördert den Erhalt von reinen Arbeiterinnenwaben (ohne Ecken mit Drohnenzellen) und (2) verringert den Honigertrag deutlich. Eine Zugabe von Drohnenwaben für eine Milbenbekämpfung ohne Pestizideinsatz könnte dennoch attraktiv bleiben, da das Abtöten der Milben zusammen mit der Drohnenbrut den nachteiligen Einfluss der Drohnenwaben auf die Honigernte bei weitem aufwiegen könnte.

**Mittelwand / Drohnen / Drohnenwaben / Honigbiene / Honigertrag**

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