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STUDY ON THE TECHNOLOGY USED FOR ADAPTING THE BEES TO THE PEDOCLIMATE CONDITIONS OF ROMANIA

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Abstract

The paper presents the study done on the frame model technology used for adapting the bees the pedoclimate conditions of Romania. It is based on the observation done on four models, two widely used ones (Dadant and Layenes) and two models than provide conditions closer to the ones the bee hive experiences in nature (Warre and Dellon). Considering the current weather conditions and taking into account that bee family should have a strong development in the spring time to acquire a large quantity of bee forage in the first major harvesting of the year (harvesting canola), we concluded that the pattern of the hive most used in Romania (Dadant hive) no longer meets the requirements. To better understand the development of bee colonies in natural conditions, we began to study swarms of bees who have found shelter in hollow trees in the wilderness. By studding a swarm of bees that form a family in natural conditions (in a hollow tree and without any human intervention), we can see that they prefer a round enclosure and stat building combs from the top down. As bees begin to bring in nectar reserves, honeycomb building will continue so that the queen cans oviposition, while food reserves will be stored in the top of the hive. Bees prefer not to overcome the honeycombs with honey, and concentrate in the center where the area is more easily heated. Best results were observed in hives with an inner diameter of 25-35 cm and a height of 70-120 cm. If we take into account that the winter mat has a diameter of 26 to 30 cm, we can see that these families enclosures in the winter conditions were entirely occupied by the wintering ball and that the displacement occurred only vertically. Higher temperatures were observed above the wintering ball so than honey is kept a higher temperature, and thus keep its liquid state and be ready for consumption by the bees. If the temperature drops below a certain level and the bees only have food reserves in one side of the ball, they cannot move left or right to consume the honey and starve, even though they have food reserves in the hive. The conclusion reached after the research is that the Layens frame with the internal dimensions of 310x370 mm and a total area of 11.47 dm^2 best suits this purpose, but the technology of the Layens frame model can be adapted to the pedoclimate conditions of Romania.

***Key words**: bees, frame, hive, pedoclimate, Romania.*

INTRODUCTION

Apiculture in Romania is a remarkable success due to the favorable pedoclimatic conditions and the valuable traits of the Romanian bee (*Apis mellifera carpatica*). The most used bee in apiculture in Romania is a cross between the local bee (*Apis mellifera carpatica*) with Italian species (*Apis mellifera ligustica*), Carniolan bee (*Apis mellifera carnica*) and other hybrid species from Banat and Wallachian plain (Bura et al., 2005; Marghitas, 2005). This species has successfully adapted to the climate changes of the past years, but the apiculture technology must also adapt. In the current climatic condition and considering the fact that the bee family must grow intensely in the spring for it to have great numbers of working bees in time for the first harvest (rapeseed harvest), we have come to the conclusion that the beehive model most used in Romania (the Dadant beehive) is no longer adequate. For all those passionate about apiculture, the beehive has always been a special topic, always improving it for better results. Due to the new concepts of ecologic apiculture and the need to have a working beehive full by the time of the first harvest near the end of April (Iordache et al., 2008), we have tried adapting the beehive model and technology to maximize the results.

The goal of this paper is compare four beehive models: two of the most used in Romania (Dadant and Layens) (Bura, 1996) and two that provide closer conditions to ones found in nature (Warre and Delon), to modify and adapt the beehive and apiculture technology to the current pedoclimatic conditions.

To better understand the development of a bee family in natural condition, we began studying bee families that found shelter in tree hollows in the wild. If we study a bee family in these natural conditions, we will observe that they prefer a round enclosure, where they will begin constructing honeycombs from the bottom up (Volcinschi, 1988). As bees begin to bring into the hive nectar supplies, the honeycomb will continue to grow so that the queen can lay the eggs, while the future supplies will be stored in the upper part of the comb structure. Thus it appears that bees prefer not to cross over the full honeycombs, in order to protect them. It also seems that the round enclosure is easier to adapt into a hive.

If we are to follow the development of the winter cluster we will notice that as the outer temperature drops, the bees form the cluster right under the full honeycombs, proffering the empty cells beneath the supplies to better anchor onto the combs. The best results were with bee families within enclosures of 25 to 35 cm diameter and 70-120 cm in height. Considering that the winter cluster is 26 to 30 cm in diameter, we can observe that these families occupied the entire diameter of the enclosure and the movement occurred only on the vertical plane. Higher temperatures were kept above the winter cluster and thus the honey was kept at a good temperature to ensure it's liquid state, prime for bee consumption. If the temperature drops too much and the bees have the food supplies on the sides of the winter cluster, they cannot move left or right to consume the honey, and even if they are able to reach that point, the honey is at a low temperature and requires an even greater effort to warm up and liquefy. Thus, the bees can starve to death with honey supplies in the hive.

MATERIALS AND METHODS

The research was conducted on our own 50 beehives and of those of Mr. Mierlesteanu Valentin, situated in Tamadau, Calarasi County. Thee hives are stationary and receive the same care in the same timeframe.

Knowing the major influence of the bee queen quality on the development of the bee families, only queens obtained by double transfusion, of the same age, from the same original bee family were used

The power of the bee family was determined by weighting at certain times: during the winter preparations, and the end of the winter, at the beginning of the harvest and at the beginning of the summer

The determination of the hatchlings and honey quantities was made by measuring the surface occupied at certain times: 1 dm^2 of honeycomb contains on one side 175gr of honey or 400 worker bee cells

The number of beehives used was twelve, three for each model, with the following characteristics:

a) The Dadant hive (Photo 1) (systematic hive), invented by Ch. Dadant, American beekeeper of French nationality, who also invented the wax sheet of the frame (Nicolaescu, 1928). The innovation was the frame that suits centrifuging very well.

Photo 1. Vertical Dadant hives during spring harvest

The hive's sizes are:
- hive body – 446 mm X 370 mm X 306 mm (interior size);
- harvest magazine – 446 mm X 370 mm X153 mm (interior size);
- hive bottom – 586 mm X 410 mm;
- inner cover – 466 mm X 390 mm (multiple parts);
- outer cover – 486 mm X 390 mm X 150 mm (interior size).

The hive is built out of fir boards 2 cm thick and can use one or two harvest magazines (Antonescu, 1979).

The frames are from basswood and have interior size of 414mm x 272mm with a surface of 11.26 dm^2, with frames used in the harvest magazine at half that height. The hive has a volume of 0.05 m^3, a surface of 112.6 dm^2 on the 10 frames inside and 56.3 dm^2 honeycomb surface inside a magazine harvest.

b) The Layens (Photo 2) hive was designed and built by M. de Layens, and was an adaptation from the hive of Abbot Voirnot, to improve the winter conditions.
The hive's sizes are:
- hive body – 342 mm X 333 mm X 404 mm (interior size);
- harvest magazine – 342 mm X 333 mm X 404 mm (interior size);
- hive bottom – 482 mm X 373 mm;
- inner cover – 362 mm X 343 mm (multiple parts);
- outer cover – 382 mm X 373 mm X 150 mm (interior size).

The hive is built out of fir boards 2 cm thick.
The frames are from basswood and have interior size of 310mm X 370mm (Gustav, 1972) with a surface of 11.47 dm^2. The hive has a volume of 50.28 cm^3, a surface of 103.23 dm^2 on the 9 frames inside.

Photo 2. Layens hives during spring harvesting

c) The Warre hive (the popular hive) with fixed frames. Was designed by Abbot Emile Warre (Antonescu, 1966), initially built only with fixed frames, but wanting to centrifuge the frames and control the swarming, the mobile frames model was built.
The hive's sizes are:
- module height – 208 mm (interior size);
- module length – 296 mm (interior size);
- module width – 296 mm (interior size).

The frames are from basswood and have interior size of 264mm X 174mm with a surface of 4.59 dm^2.
In the upper side of the modules, on opposite walls, channels must be made to support the frames. These 8 frames are 296 mm X 25 mm X 18 mm. There is a 12 mm space where the bee can pass (between the frames and the walls). The particularity of this hive is that the bee can built the honeycombs without a wax sheet and the cell will have a distance between two opposite sides of 4.9 mm (the natural cell size built by bees) instead of 5.4 mm in the Dadant frame. With this size reduction, an increased resistance to the parasite Varroa Destructor (named in 2000 by Anderson and Trueman) was noticed, by the mechanism called "VSH". The hive is formed by a bottom, 3 modules and a cover. During the winter only 2 modules will be used, a third to be added beneath following the coming of spring. This system ensures that the interventions on the hive are reduced, thus cutting down the beekeeping time.

Photo 3. Hives during spring harvesting (original)

d) The Delon hive, designed by beekeeper Roger Delon (1919-2007), introduced the concept of Stable Climate Hive. He built a hive with a 300 mm x 300 mm base and a 215 mm height, with a volume of 0.019m^3 on each module. He also invented the Alpine frame, from a V shaped body and a metallic wire support. This type of hive can stack up to 5 modules and due to this fact it has an upper bee entrance to facilitate bee movement and vertical currents inside the hive during the summer.
The 8 frames are built from basswood and stainless 8 mm wire, with the interior size of 272 mm x 173 mm and a surface of 4.7 dm^2.
The following procedures were followed:
- The work done over the year on the four hive systems were identical to highlight the proposed parameters for the experiment;
- In the preparations for the winter, an equalization of the families was made (Hristea, 1976), by adding bees the classic

way (smell uniformization by adding flavoured tea with water and sugar 1:1);
- Protection of the hives was done according to the technology required for each hive type (adding thermo isolation diaphragms where needed);
- Widening the hive was made progressively, following each hive type instructions;
- The stimulation feedings were done during the winter with powdered sugar cakes and honey (Louveaux, 1987) (25% honey and 75% powdered sugar), and the beginning of the spring with powdered sugar cakes, honey and inactive yeast. (25% honey, 62.5% powdered sugar and 12.5% yeast);
- The treatments against Varroa were done with varachet, according to the treatment scheme: two in October-November (7 days apart) and two after the black locust (Istratie, 2010);
- The experiment was conducted over the course of one year (October 2013 – October 2014).

RESULTS AND DISCUSSIONS

To highlight the quantity evolution of the bee population, the research done on the four hive models took place over one year, starting in the period before the winter (October 2013) and ending with the last days of summer (September 2014). The results are presented in 1-5 tables, and concern the average bee quantities obtained using the same hive model. The standard quantity used was 2.2kg bees per family. Because the variation in bee mortality is greater in the winter even within the same hive model, we used the same quantity in all the hives so that de deviation could be kept to a minimum.

Table 1. Quantity evolution of bee families kept in Dadant hives in the winter

Month	Hive no 1			Hive no 2			Hive no 3			Mortality rate	
	Bee weight kg	Mortality		Bee weight kg	Mortality		Bee weight kg	Mortality		Kg	%
		Kg	%		Kg	%		Kg	%		
Oct	2.20	0	0	2.20	0	0	2.20	0	0	0	0
Mar	1.90	0.30	13.70	1.84	0.36	16.30	1.75	0.45	20.40	0.37	16.8

Table 2. Quantity evolution of bee families kept in Layens hives in the winter

Month	Hive no 1			Hive no 2			Hive no 3			Mortality rate	
	Bee weight kg	Mortality		Bee weight kg	Mortality		Bee weight kg	Mortality		Kg	%
		Kg	%		Kg	%		Kg	%		
Oct	2.20	0	0	2.20	0	0	2.20	0	0	0	0
Mar	2.09	0.11	5.20	2.11	0.09	4.20	2.07	0.13	6.20	0.11	5

Table 3. Quantity evolution of bee families kept in Warre hives in the winter

Month	Hive no 1			Hive no 2			Hive no 3			Mortality rate	
	Bee weight kg	Mortality		Bee weight kg	Mortality		Bee weight kg	Mortality		Kg	%
		Kg	%		Kg	%		Kg	%		
Oct	2.20	0	0	2.20	0	0	2.20	0	0	0	0
Mar	2.10	0.10	4.70	2.11	0.09	4.20	2.13	0.07	3.20	0.08	3.63

Table 4. Quantity evolution of bee families kept in Delon hives in the winter

Month	Hive no 1			Hive no 2			Hive no 3			Mortality rate	
	Bee weight kg	Mortality		Bee weight kg	Mortality		Bee weight kg	Mortality		Kg	%
		Kg	%		Kg	%		Kg	%		
Oct	2.20	0	0	2.20	0	0	2.20	0	0	0	0
Mar	2	0.20	10	2.14	0.06	2.80	2.12	0.08	3.70	0.11	5

Table 5. Quantity evolution comparison of bee families kept in the four hive models in the winter

Month	Hive Dadant			Hive Layens			Hive Warre			Hive Delon		
	Bee weight kg	Mortality kg	Mortality %	Bee weight kg	Mortality kg	Mortality %	Bee weight kg	Mortality kg	Mortality %	Bee weight kg	Mortality kg	Mortality %
Oct	2.20	0	0	2.20	0	0	2.20	0	0	2.20	0	0
Mar	1.80	0.40	16.80	2.10	0.10	5	2.10	0.10	3.63	2.08	0.12	5

If we follow the quantity evolution of the bee families, we notice that the Dadant hive model has suffered the biggest loss in the winter (16.8% average), the Layens and Delon hives have the same loss (5% average), while the Warre hive has the best percentage (3.63% average), thus the fewest losses.

Brood is an important factor in the development of bee families. The main factors that influence this are:

- Exterior temperature;
- Queen quality;
- Bee family power;
- Food supplies in nature and inside the hive;
- Hive model and quality.

To follow the development of the families we measured the brood honeycombs at different dates, 21 days apart, according to the development cycle of the working bee from egg to adult.

Table 6. Bee family growth dynamics between February 2014 and April 2014 in the four hive models

Hive model	Bee weight (Kg)	February 15 (dm^2)	March 7 (dm^2)	March 28 (dm^2)	April 18 (dm^2)	Brood (dm^2)	Brood (cell no)
Dadant 1	1.90	6.87	8.50	14.25	22.50	52.12	20 848
Dadant 2	1.84	5.62	7.50	13	22	48.12	19 248
Dadant 3	1.75	6.12	8	14	22.20	50.32	20 128
Dadant average	1.83	6.20	8	13.75	22.23	50.18	20072
Layens 1	2.09	9.10	12.50	18	29	68.60	27 440
Layens 2	2.11	10	12.80	18.20	30	71	28 400
Layens 3	2.07	9.80	12.80	18.20	30	70.80	28 320
Layens average	2.09	9.63	12.70	18.13	29.66	70.13	28 052
Warre 1	2.10	10.20	13	18.80	30	72	28 800
Warre 2	2.11	11	12.80	19	31	73.80	29 520
Warre 3	2.13	10.90	12	19	30	71.90	28 760
Warre average	2.11	10.70	12.60	18.93	30.33	72.56	29 026
Delon 1	2	10.20	13.50	19	31	73.70	29 480
Delon 2	2.14	10.80	14	20	32	76.80	30 720
Delon 3	2.12	11.50	14.80	21	32	79.30	31 720
Delon average	2.08	10.83	14.1	20	31.66	76.60	30 640

From the analysis of Table 6 we can observe that compared to the Dadant hive, the growth is bigger with:

- 39.75% inside the Layens hive;
- 44.60 % inside the Warre hive;
- 52.65 % inside the Delon hive.

This is due to the fact that the Dadant hive has a $0.050m^3$ and thus is very difficult to warm up, affecting the growth in the cold periods of spring. The best growth is in the Delon hive, with its narrow frame that allows the winter cluster to fill the entire space, preserving warmth and putting less stress on the bees.

Also to be noted is the fact that the brood frames are situated in the upper side of the hive where the conditions are best for development (in this model, the winter must be passed using 2 modules).

Compared to the Layens hive, the Delon hive had a 9.22% bigger growth, starting from identical conditions. The Delon had better results than the Warre hive also, with a 5.56% increase, leading us to the conclusion that it is the best hive model for the spring growth interval.

Another element to be considered is the honey production. This is different from hive to hive, being influenced by the following factors:

- Queen quality and egg-laying capacity;

- Brood quantity in the hive at the harvest time;
- Exterior temperature;
- Hive model used;
- Number of working bees;
- Distance to main harvest;
- Wind direction and speed;
- Rapeseed harvest began on 19th April 2014, and the honey extraction was made on 11th May 2014.

Looking at table 7 we can make some observations.

In the Dadant hives, the bee loss is the lowest during harvesting (7.9%), even though it is the hive model with the smallest bee quantity (2.91 kg average at the beginning). In the Delon hive, the bee loss is the highest (12.87%), even though it is the hive model with the biggest bee quantity (4.04 kg average at the beginning); The Layens hive has an almost equal loss with the Warre hive (11.5%).

Table 7. Honey production and bee weight evolution in the four hive models during rapeseed harvest 19th April 2014 to 11th May 2014

Hive model	Bee family weight		Bee quantity difference		Honey production	
	Before harvest (kg) 19.04.2014	After harvest (kg) 11.05.2014	kg	%	kg	kg of honey per kg of bees
Dadant 1	3.03	2.80	0.23	7.59	7.50	2.47
Dadant 2	2.84	2.62	0.22	7.74	7	2.46
Dadant 3	2.88	2.62	0.26	9.02	7.20	2.5
Dadant average	2.91	2.68	0.23	7.90	7.23	2.48
Layens 1	3.78	3.38	0.40	10.58	10	2.64
Layens 2	3.89	3.40	0.49	12.50	10.50	2.69
Layens 3	3.86	3.40	0.46	11.91	10.50	2.72
Layens average	3.84	3.39	0.45	11.71	10.33	2.69
Warre 1	3.93	3.50	0.43	10.94	10.80	2.74
Warre 2	3.89	3.44	0.45	11.56	10.50	2.69
Warre 3	3.93	3.46	0.47	11.95	11	2.79
Warre average	3.91	3.46	0.45	11.50	10.76	2.75
Delon 1	3.94	3.50	0.44	11.16	11	2.79
Delon 2	4.14	3.56	0.58	14	11.40	2.75
Delon 3	4.06	3.50	0.56	13.79	11	2.70
Delon average	4.04	3.52	0.52	12.87	11.13	2.75

We can conclude that if the bee family is strong, the work is taking its toll during harvest and bee losses are greater.

The honey production in the Delon hives (11.13 kg average) puts it in the lead; with 53.94% more than the Dadant hives (7.23 kg average). The difference between the Delon hive and other models is that it has an upper bee entrance that allows a better circulation and time saving with transporting nectar inside the hive. The Delon production is 3.43% larger compared to the Warre and 7.74% larger compared to the Layens.

Concerning the transformation of nectar to honey, Delon and Warre take the first place with 2.75 kg honey per kg of bees, followed by Layens with 2.69 kg honey per kg of bees and Dadant with 2.48 kg honey per kg of bees.

Acacia harvest due to adverse weather conditions could not be performed. The sunflower harvests a home in the 3rd of July 2014, while the honey extraction took place in the 5th of August 2014.

Looking at table 8 we can make some observations. In the Dadant hives, the bee loss is the highest during harvesting (31.16%), even though it is the hive model with the smallest bee quantity (3.53 kg average at the beginning).

In the Warre hive, the bee loss is the lowest (20.44%), even though it is the hive model with the second biggest bee quantity (4.06 kg average at the beginning). The Layens hive has a biggest loss (21.53%) than the Delon hive (20.44%).

Table 8. Honey production and bee weight evolution in the four hive models during sunflower harvest
3rd July 2014 to 5th August 2014

Hive model	Bee family weight		Bee quantity difference		Honey production	
	Before harvest (kg) 03.07.2014	After harvest (kg) 05.08.2014	kg	%	kg	kg of honey per kg of bees
Dadant 1	3.60	2.40	1.20	33.30	12.00	3.33
Dadant 2	3.50	2.40	1.10	31.42	12.00	3.42
Dadant 3	3.50	2.50	1.00	28.57	11.70	3.34
Dadant average	3.53	2.43	1.10	31.16	11.90	3.37
Layens 1	4.00	3.10	0.90	22.50	14.00	3.50
Layens 2	3.80	3.00	0.80	21.05	13.50	3.55
Layens 3	3.90	3.10	0.80	20.51	13.70	3.51
Layens average	3.90	3.06	0.84	21.53	13.73	3.52
Warre 1	3.90	3.10	0.80	20.51	13.00	3.33
Warre 2	4.20	3.50	0.70	16.66	13.20	3.14
Warre 3	4.10	3.10	1.00	24.39	13.10	3.19
Warre average	4.06	3.23	0.83	20.44	13.10	3.22
Delon 1	4.10	3.20	0.90	21.95	14.10	3.43
Delon 2	4.30	3.50	0.80	18.60	13.50	3.13
Delon 3	4.30	3.30	1.00	23.25	14.00	3.25
Delon average	4.23	3.33	0.90	21.27	13.86	3.27

We can conclude that due to the low temperatures during the night and the high air humidity, the stress is greater on the bees inside the Dadant hives due to the large volume.

The honey production in the Delon hives (13.86 kg average) puts it in the lead, with 16.4% more than the Dadant hives (11.9 kg average).

The Delon production almost the same with Layens hives (13.73 kg average) and Warre hives (13.1 kg average). The difference between the Dadant hive and the other models is that the frame surface and lengths is larger and thus the bees work more and spend more energy. The Delon production is 5.8% larger than Warre's and 0.94% larger than Layens.

Concerning the transformation of nectar to honey, Layens hives take the first place with 3.52 kg honey per kg of bees, followed by Dadant with 3.37 kg honey per kg of bees, Delon with 3.27 kg honey per kg of bees and Warre with 3.22 kg honey per kg of bees.

CONCLUSIONS

After analyzing all the date, we have reached a number of conclusions.

The bee family quantity evolution during the winter is very different depending on the hive model used. In Layens and Warre hives, the mortality is at 5.2%, in Delon hives at 5.7% and in Dadant hives at 20.3%. The explanation in the fact that Layens hives, Warre and Delon has the same internal dimensions of the ball size of the wintering area and therefore losses are small, while Dadant hives have grater inner dimension 100-150 mm than the ball it does not form on the center of the frame so that, the bees will fall laterally for food and bee losses are high.

There are great differences in the bee family growth dynamic in the spring. In Layens hives there is 39.75% more brood than in Dadant hives, in Warre there is 44.60 % more brood and in Delon there is 52.65% more brood than in Dadant hives. Because of the rate of 100-150mm higher, Dadant hives updrafts form internal cooling leading to the family nest of bees and queen laying eggs correlates with the ability to heat the family nest. On Delon hives, Alpine frame is reduced to the use of free space inside the hive, the nest is very well protected and the capacity of the queen is the best.

The Dadant hives have the smallest bee loss rate during rapeseed harvest (7.9%), Delon has the biggest bee loss rate (12.87%), Layens (11.71%) is close to Warre (11.5%). Bee loss is correlated with the strength of the bee family. The Dadant hives where bee families are still growing, the quantity of bee forage is lower, resulting lower losses, many of them being nurse bees.

Concerning rapeseed harvest, the nectar to honey transformation rate is the best in Warre and Delon with 2.75 kg of honey per kg of bees, followed by Layens with 2.69 kg of honey per kg of bees and Dadant with 2.48 kg of honey per kg of bees. The quantity of the nectar bought to the hive is directly proportional to the strength of the bee family.

During sunflower harvest, when the difference between day and night temperatures is big, the Dadant hives suffer the greatest loss (31.16%), Warre the smallest one (20.44%), Layens (21.53%) nearly the same as Delon (21.27%). Being the last great harvest of the year, forcing the bees gathering nectar and quantity bought in to the hive is relatively equal, but in Dadant hives, bees wear out quickly being forced to work harder at night to maintain the indoor temperature.

Concerning sunflower harvest, the nectar to honey transformation rate is best in Layens hives with 3.52 kg of honey per kg of bees, followed by Dadant with 3.37 kg of honey per kg of bees, Delon with 3.27 kg of honey per kg of bees and Warre with 3.22 kg of honey per kg of bees. The parameter shows no large differences between the four models of hives, but we can see that Dadant hives are not good enough at this respect.

It is clear that in the current pedoclimatic conditions of Romania the use of the Dadant hive model is no longer justifiable, considering that it has the largest mortality rate during winter, the slowest growth during spring, the smallest nectar to honey rate during the first harvest, the largest mortality rate during summer and a low nectar to honey rate during spring.

Layens, Delon and Warre hive models are showing differences between the parameters taken into account, but each beekeeper, depending on the purpose it pursues in beekeeping can choose one of the other models.

The overall conclusion is that the Layens frame with the interior size of 310 mm x 370 mm and a total surface of 11.47 dm^2 is best fitted for winter beekeeping and good growth in the spring. The technology must be adapted by adding a second module under the main one in the spring and by using the upper bee entrance during the summer. It remains however to solve the problem of obtaining flower honeys because of the large dimension of the frame.

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