Thermotherapy 2015

Within testing of Thermosolar hives in the season of 2015, we focused particularly on the efficiency of thermotherapy compared to chemical drugs. In the second thermosolar treatment another group of colonies was included in the testing, which enabled us to compare the impact of long-term moderate heating of the brood chamber on the reproduction of the *Varroa* mite in Thermosolar hives. Thermotherapy was always carried out in accordance with the recommended methodology and the colonies permanently settled in Thermosolar hives throughout the year were also treated in accordance with this methodology. In 2015 these colonies were not treated against varroosis differently than using thermotherapy. Control groups of colonies were treated with an approved chemical preparation based on formic acid. It was the Formidol® product. Even in the case of this drug the application process strictly followed the recommended methodology. The progress of heating was also recorded during each thermotherapy.
Each treatment was performed in four Thermosolar hives and the control chemical treatment was always performed in 4 thin-walled hives. The size of all colonies was comparable.

Basic information about the Thermosolar Hive
The multiple-storey hive, which thanks to its special construction and active surfaces, can use sunlight to heat the hive space and increase the temperature of the brood chamber so that it kills the Varroa mite.
The hive must be placed on a sunlit spot in the exterior so that the entrance is turned to the southeast. Temperature sensors must be correctly placed in the center frame with the brood in the brood chamber; one of the sensors below the upper bar and the other one above the lower bar of the frame. During the treatment the queen excluder must not be used and the colonies must have enough honey (sugar) reserve. Thermotherapy always consists of two therapeutic heatings, the second heating is carried out 7 to 14 days after the first heating. For a 100% effect on mites in the sealed brood it is necessary to sustain temperature activity above 40 °C for 150 minutes. It is not recommended to exceed temperature of 47 °C. Thermotherapy can be performed with open and closed entrance. Recommended conditions for the treatment are at least 20 °C and cloud cover up to 20%.
In Central European conditions 1-2 thermotherapies per year are performed; the first treatment in the spring before stacking honey chambers (April) and the other one in the summer, after extracting the last honey before feeding for winter (August).
The Thermosolar hive is primarily intended to kill *Varroa destructor* in sealed brood. The observed efficiency is 100%.

Basic information about Formidol®
Preparation based on formic acid. A pad impregnated with formic acid (1 pad contains 40 ml of 85% of formic acid).

The pad is loosely inserted into the hive, on the upper frames, between supers or in the space between the hive bottom and the lower bars of frames. 48 hours after the insertion, the evaporation takes place only through the holes in the regulatory package of the pad. After that the packaging is removed and the evaporation takes place from the entire surface of the pad. It must not be used if the outside temperature exceeds 25 °C.
Formidol® kills *Varroa destructor* in sealed brood and even on adult bees. The stated effectiveness after the first use is about 50%.

Basic information about Varidol 125
A liquid drug, the active ingredient is amitraz (1 ml of solution contains 125 mg of the active ingredient). The drug is dripped onto the fumigation wick. It smolders after igniting and vaporizes the medicinal substance into the hive. Varidol 125 was included in the testing solely because of legislative regulation.
The reported effectiveness is > 95%, it kills mites on adult bees. Most of the mite population is killed 2 hours after application.

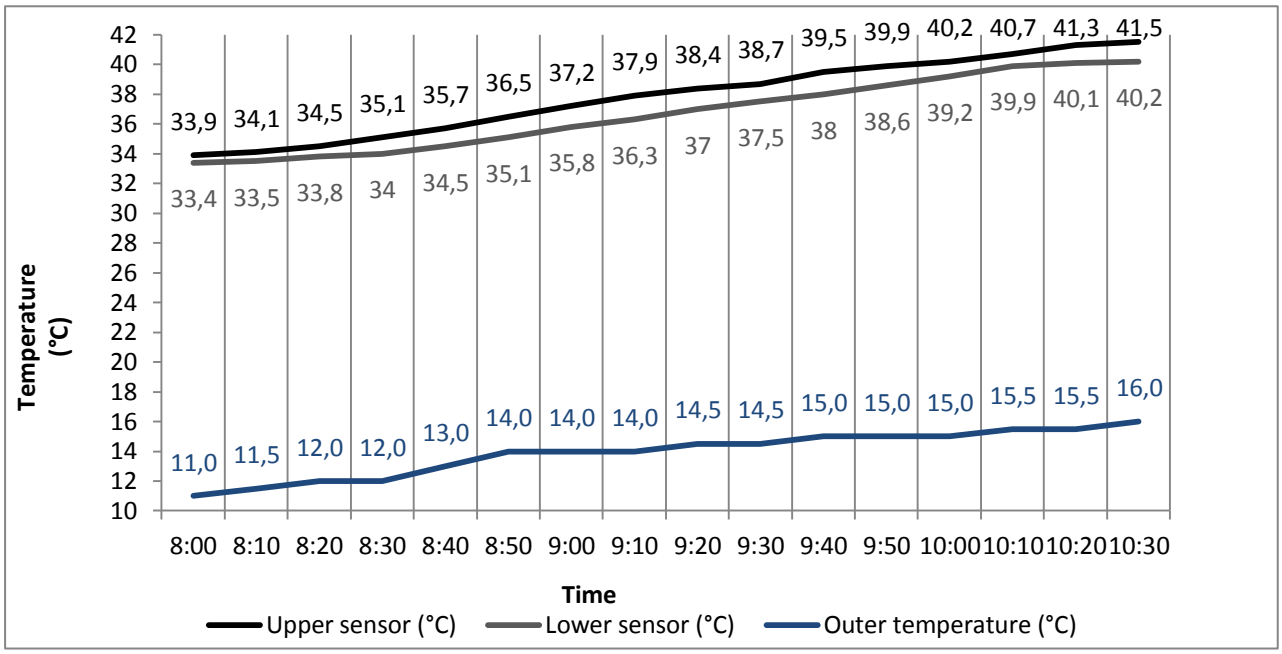
Spring thermotherapy

Spring thermotherapy took place in April. The entrances of the hives were closed during the entire treatment due to low outdoor temperature. Throughout the entire thermotherapy, bees could ventilate the interior of the hive through the holes on the rear side of the bottom, which are intended for this purpose.
48 hours before beginning the thermotherapy, colonies from regular thin-walled hives were transferred into 4 Thermosolar hives. These colonies were treated in 2014 in a standard way using permitted chemical drugs. In 2015, no treatment took place. Control colonies in thin-walled hives were in the previous season and in 2015 treated in the same way as the colonies transferred into Thermosolar hives.

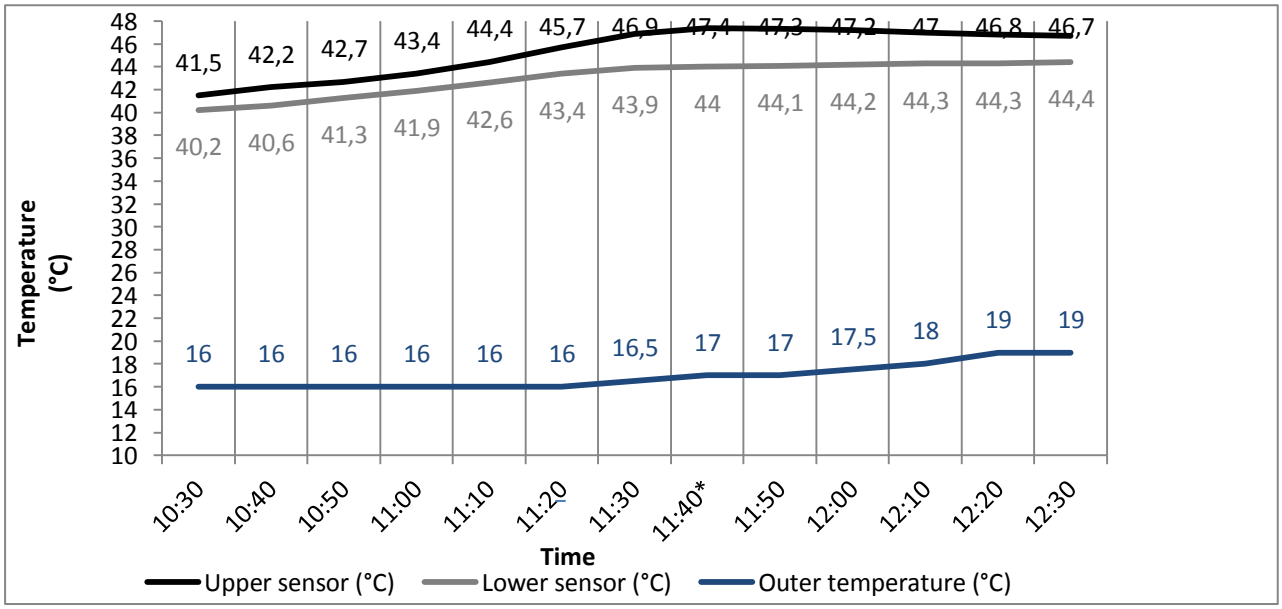
The first treatment
Thermotherapy was launched on 16 Apr 2015 at 8:00 a.m. All Thermosolar hives were placed in the same conditions in the same post and thermotherapy was launched at the same time. In the course of the treatment the cloud cover was 10 – 15% and there were windless conditions. Graph 1 shows the increase in temperature in the brood chamber in one of the Thermosolar hives. At 10:30 the required therapeutic temperatures were achieved in the entire brood chamber and the countdown of two-hour treatment interval began. Graph 2 shows sustaining therapeutic temperatures for 2 hours in the same Thermosolar hive. After reaching the maximal recommended temperature at 11:40, a roof was mounted, which completed the active heating of the brood chamber. Therapeutic temperatures were achieved in all 4 experimental Thermosolar hives during the first thermotherapy, the

required temperatures were sustained in the brood chamber of colonies for 2 hours. All hives were after 2 hours of exposure to therapeutic temperatures ventilated by opening the entrances and removing the ceiling. After thermotherapy, we did not register any taking out of dead brood or death of adult bees or the queen. Given the very similar temperature development in individual hives we present here only charts from one randomly selected tested Thermosolar hive.

Graph 1 - Achieving therapeutic temperatures during thermotherapy on 16 Apr 2015



Graph 2 - Sustaining therapeutic temperatures during thermotherapy on 16 Apr 2015



Simultaneously with the first thermotherapy, Formidol® pads were inserted into 4 control colonies in thin-walled hives in the same post. All monitored hives, Thermosolar and thin-walled, were provided with Varroa bottom board. The fallout of mites was checked and recorded every day, including the day of treatment. Chart 1 contains data on the amount of fallen mites in individual hives. Thermotherapy has a gradual effect and therefore the fallout takes more days. Formidol® is applied to hives for 4 days; in this case from 16 to 19 Apr 2015. After this time the pads were removed from the colonies. The number of killed mites is comparable in all hives.

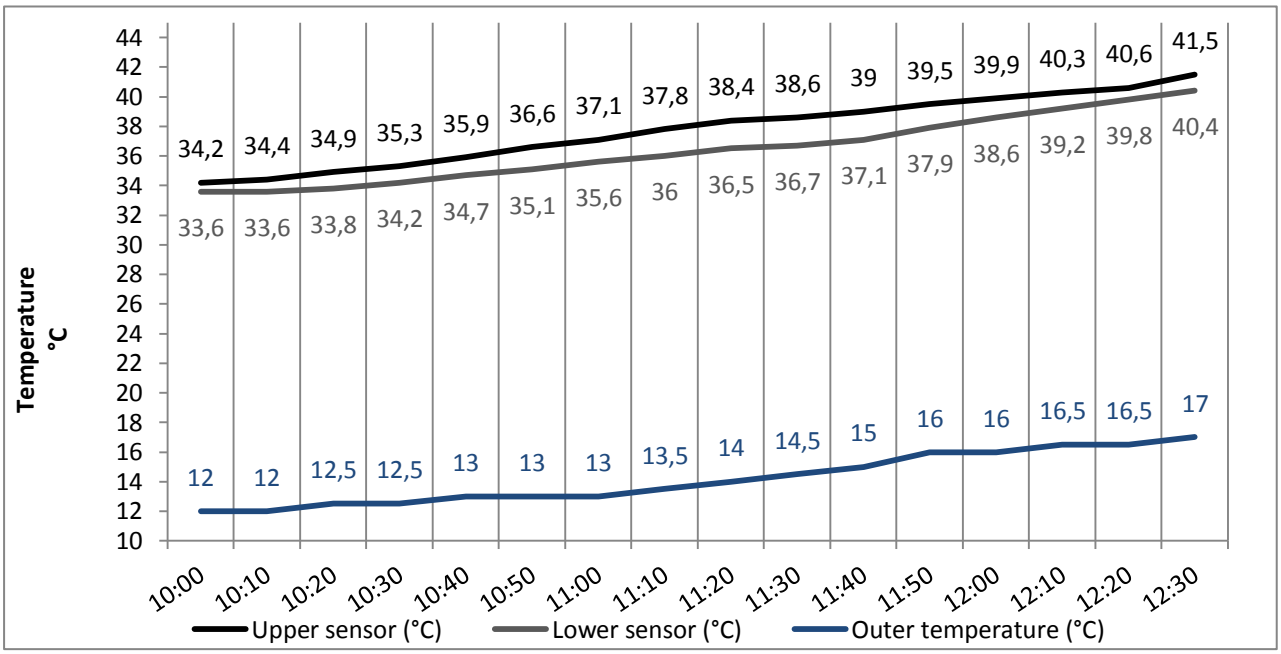
Chart 1 - Number of dead mites after the first spring treatment on 16 Apr 2015
(TSH = Thermosolar Hive, CH = Common hive)

	16.4.	17.4.	18.4.	19.4.	20.4.	21.4.	22.4.	Total
TSH 1		1	1			1		**3**
TSH 2	1	1		1	1			**4**
TSH 3	1	2	2		1			**6**
TSH 4	2	1	2	1				**6**
CH 1	1	1	3	1				**6**
CH 2	2	1	3	1				**7**
CH 3	1	1	4					**6**
CH 4	1	1	2					**4**

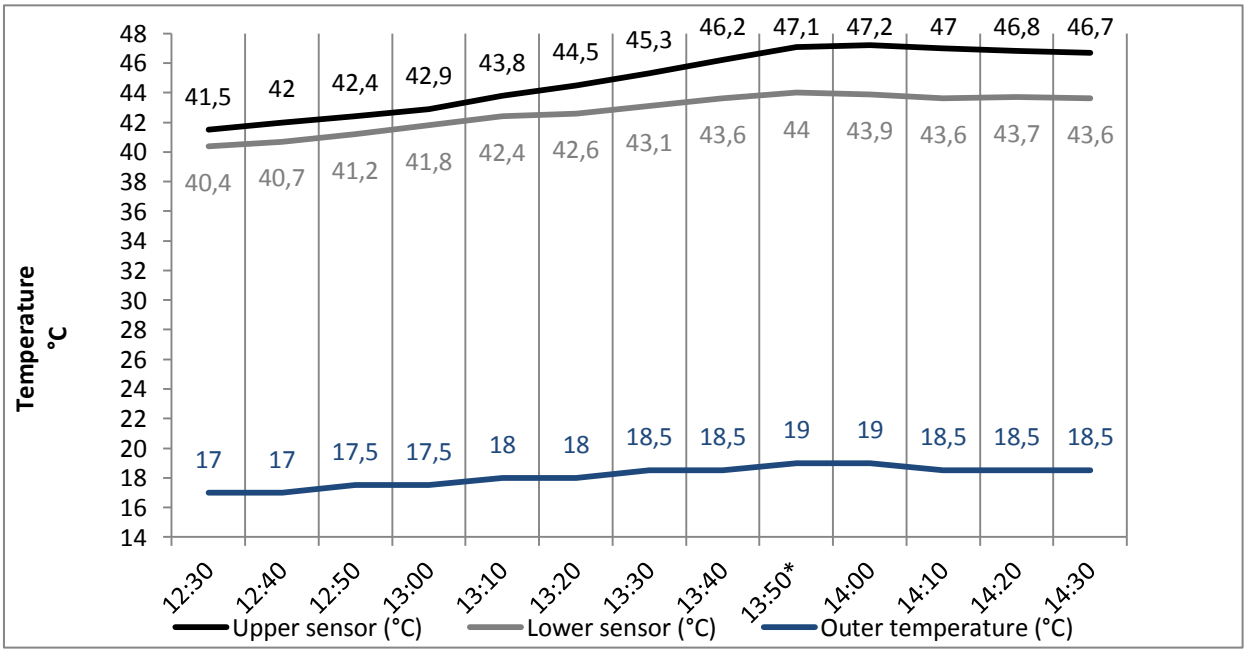
The second treatment

In accordance with the methodology, the second thermotherapy was carried out in monitored hives on 23 Apr 2015. The entire treatment was again performed with closed entrances. The treatment was launched at 10:00 a.m. The cloud cover at the beginning of thermotherapy was about 30%, followed by 0-10%. Graph 3 shows the achievement of therapeutic temperatures in one of the Thermosolar hives and Graph 4 shows sustaining of therapeutic temperature for the desired period of 2 hours. At 1:50 p.m. a roof was mounted on the monitored hive, thus completing the active heating. Required therapeutic temperatures were achieved in all 4 tested Thermosolar hives. The graphs clearly show that heating of the brood chamber is smooth and gradual. Due to the closure of the entrance the temperature differences between the upper and lower part of the brood chamber are not particularly significant.

Graph 3 - Achieving therapeutic temperatures during thermotherapy on 23 Apr 2015



Graph 4 - Sustaining therapeutic temperatures during thermotherapy on 23 Apr 2015



After the second thermotherapy, the fallout was monitored in the same way as after the first treatment. The counting of killed mites was carried out 12 days after treatment. During this time all brood that underwent thermotherapy hatched and therefore all dead mites killed by elevated temperature fell out of the cells. Formidol® pad was removed from colonies on 19 Apr 2015, that is 4 days after application. This medical procedure was fully in line with the official methodology.

The fallout from the two tested groups of hives was comparable, bee colonies thus showed a similar rate of Varroa infestation. The observed infestation in this period is considered standard, the tested colonies therefore showed no abnormalities even in the level of infestation. The charts show that most of the *Varroa* mite population was killed already during the first heating.

Chart 2 – Number of dead mites after the second spring treatment on 23 Apr 2015
(TSH = Thermosolar Hive, CH = Common hive)

	23.4.	25.4.	26.4.	27.4.	28.4.	29.4.	30.4.	1.5.	2.5.	3.5.	4.5.	5.5.	Total
TSH 1		1											**1**
TSH 2													**0**
TSH 3													**0**
TSH 4	1												**1**
CH 1													**0**
CH 2													**0**
CH 3													**0**
CH 4													**0**

Chart 3 - Total number of dead mites after spring treatment of 2015
(TSH = Thermosolar Hive, CH = Common hive)

	TSH 1	TSH 2	TSH 3	TSH 4	CH 1	CH 2	CH 3	CH 4
1.treatment	3	4	6	6	6	7	6	4
2.treatment	1	0	0	1	0	0	0	0
Total	4	4	6	7	6	7	6	4

Summer thermotherapy

Four colonies, which were transferred into the tested Thermosolar hives for the purposes of spring thermotherapy, were kept there after the treatment. The same four colonies located in the thin-walled hives in the same post were used as a control group again. We included a third group of hives into the test for the summer thermotherapy. These were another four Thermosolar hives, into which colonies from thin-walled hives had been transferred 48 hours before beginning the first thermotherapy. These hives were treated in spring with Formidol® preparation. The inclusion of this group of tested hives enabled us to determine the effect of long-term moderate heating of the *Varroa* mite population by comparing the fallout from both groups of Thermosolar hives.

Summer thermotherapy took place in August, due to the outdoor temperature, the entrances were left open during all treatments in all Thermosolar hives. To facilitate the heating, the entrances were only narrowed, adult bees could nevertheless fly out of the hive throughout the treatment.

The control group of thin-walled hives was again treated with Formidol® preparation. The subsequent counting of dead mites was carried out in the same way as in the spring treatment.

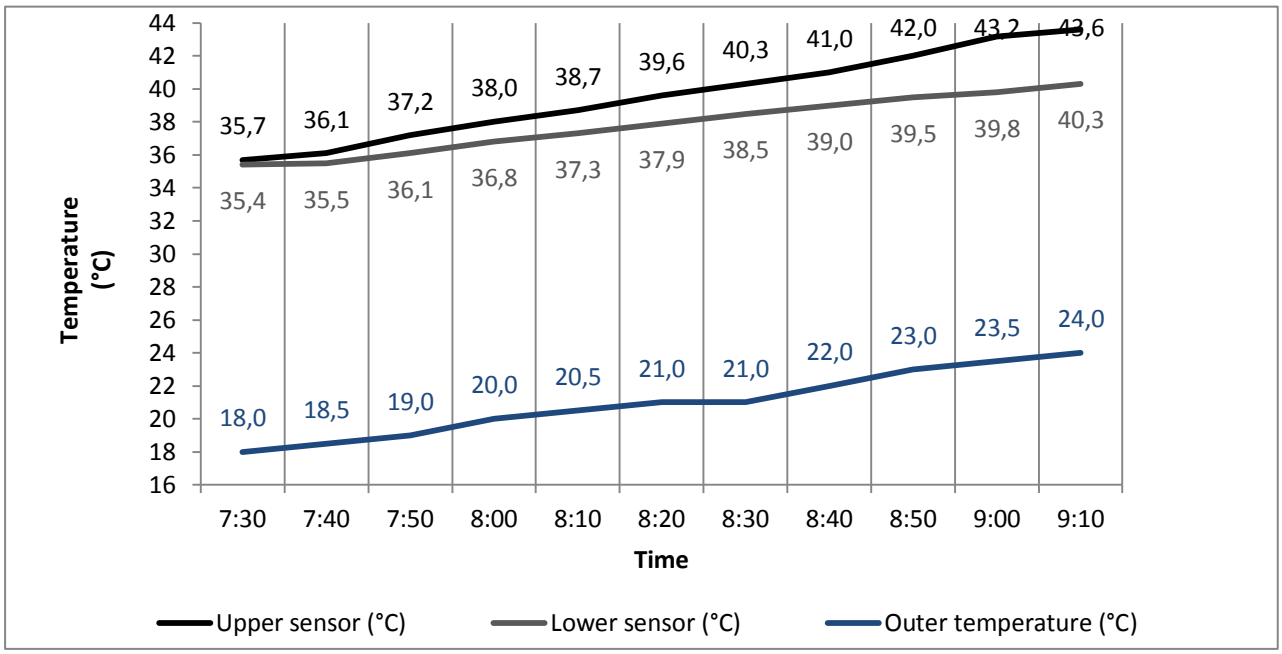
The first treatment

In accordance with the methodology of the Thermosolar hive, the summer thermotherapy was carried out after extracting the last flow and the removal of honey chambers. Colonies in Thermosolar hives were fed before the treatment so that there were 6-8 kg of supplies in the brood chamber.

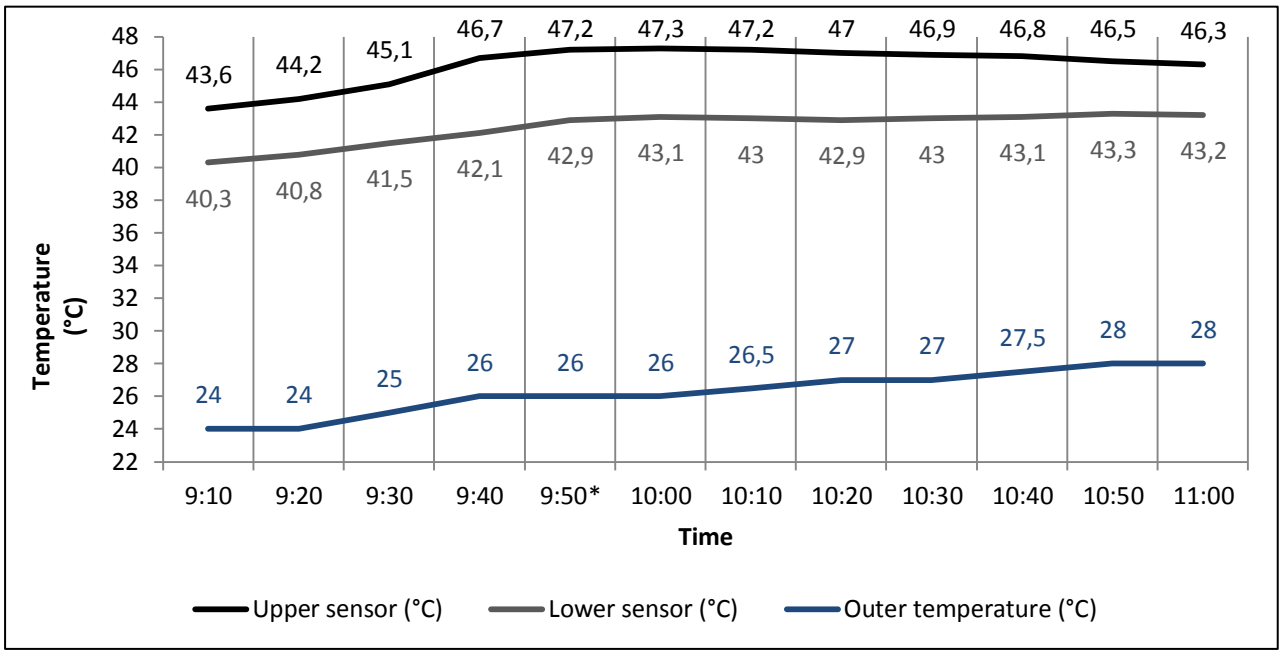
Thermotherapy took place on 17 Jul 2015, the treatment was initiated at 7:30 a.m. The cloud cover was ca 10% throughout the whole treatment. Graph 5 and 7 illustrate achieving the therapeutic temperatures in Thermosolar hives. Graph 5 features a hive occupied by a colony since spring, Graph 7 a colony transferred into the Thermosolar hive before the treatment. Thanks to open entrances, it is evident that there is a bigger difference in temperature between the upper and lower parts of the brood chamber during heating (see Graphs 5 and 7), which is caused by ventilation of bees on the entrance. When reaching the maximum allowed temperature (at 9:50 in Graph 6 and at 9:40 in Graph 8) and mounting a roof, one can observe from Graphs 6 and 8 a gradual slow reduction in the temperature in the upper part of the brood chamber and a slight increase in the temperature in the bottom part of the brood chamber. The heat from the upper part of the brood chamber spontaneously passes into the lower, cooler part of the brood chamber, and this leads to gradual temperature compensation. After the two-hour interval of effect of the therapeutic temperature, the warmth was ventilated from Thermosolar hives by opening the ceilings.

In parallel with the first thermotherapy, Formidol® pads were inserted into control colonies in thin-walled hives. The amount and method of insertion of the drug fully complied with the official methodology.

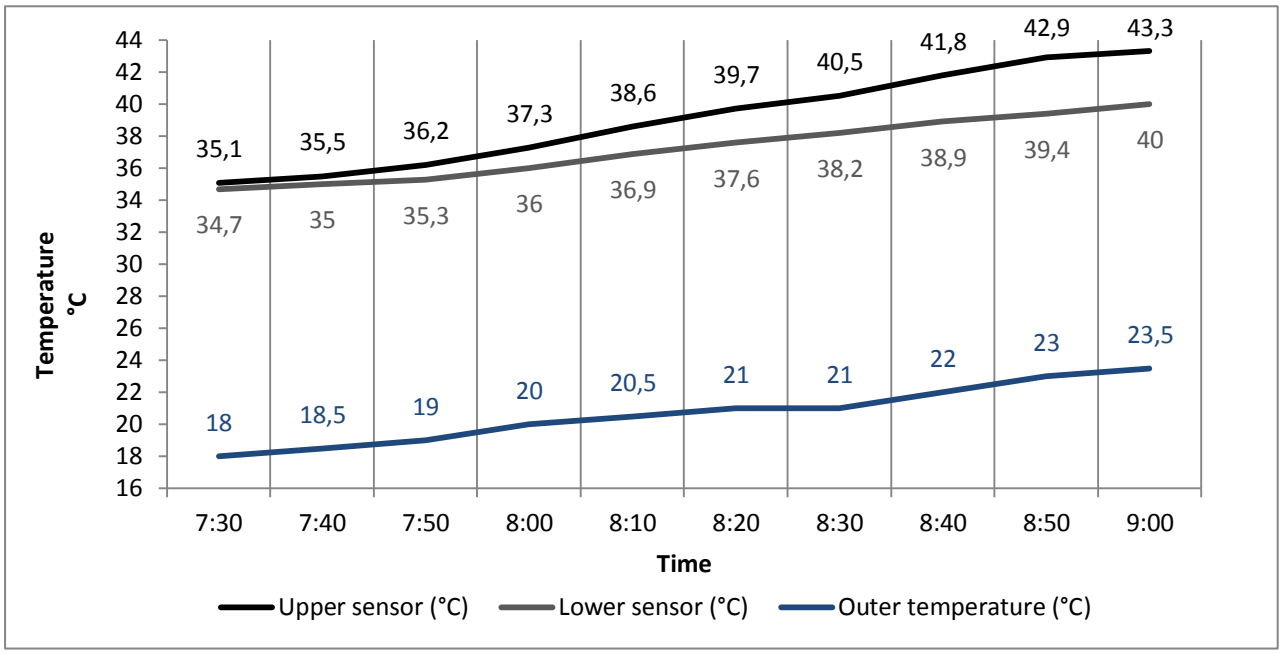
Graph 5 - Achieving therapeutic temperatures of permanently occupied TSH on 17 Jul 2015



Graph 6 - Maintaining therapeutic temperatures of permanently occupied TSH on 17 Jul 2015



Graph 7 - Achieving therapeutic temperatures of the newly occupied TSH on 17 Jul 2015



Graph 8 - Maintaining therapeutic temperatures of the newly occupied TSH on 17 Jul 2015

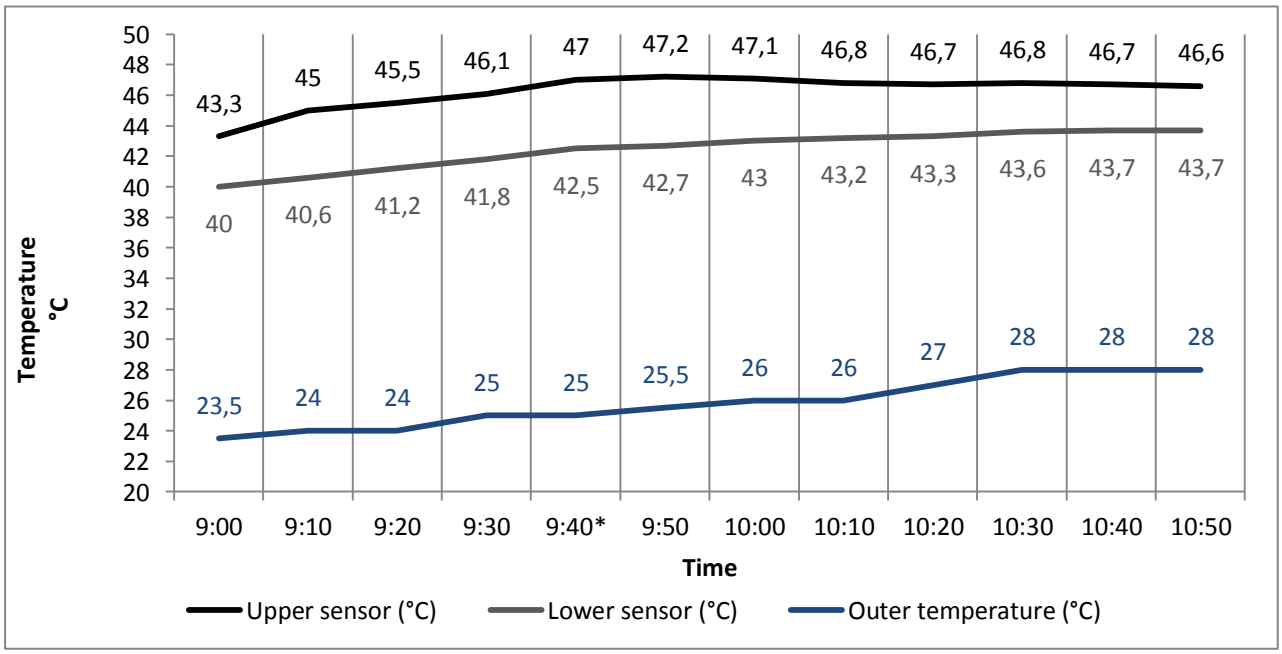


Chart 4 – Number of dead mites after the first summer treatment on 17 Jul 2015

(TSH = Thermosolar Hive, CH = Common hive)

	17.7.	18.7.	19.7.	20.7.	21.7.	22.7.	23.7.	24.7.	25.7.	26.7.	28.7.	28.7.	29.7.	Total
TSH 1	1	2		1		1		1		1				7
TSH 2	2	2	1	1			1		1					8
TSH 3	1	1	2		1									5
TSH 4	2	1	2	1		1		1	1					9
TSH 5	11	21	14	25	21	13	9	4	3	1	1			128
TSH 6	8	20	20	23	28	18	10	9	4	1	2	1		144
TSH 7	5	10	15	11	17	7	3	5	2	1				75
TSH 8	7	15	16	17	18	11	6	3	1	1	1			96
CH 1	7	8	35	6										56
CH 2	8	9	33	8										58
CH 3	5	8	40	7										60
CH 4	9	8	29	5										51

Chart 4 shows the fallouts of the *Varroa* mites after the first summer thermotherapy of all tested groups of Thermosolar hives. Colonies located in Thermosolar hives from the spring thermotherapy are labeled TSH 1 to TSH 4. TSH 5 to TSH 8 indicates colonies transferred into Thermosolar hives 48 hours before beginning the summer thermotherapy. A common hive 1-4 indicates colonies in thin-walled hives treated with Formidol® on 17 Jul 2015.

Already after the first treatment, it is clear that the fallouts from TSH 5 - TSH 8 are significantly higher than those from TSH 1 - TSH 4. A very low population of the *Varroa* mite in colonies that were located in Thermosolar hives throughout the whole season is determined by long-term mild increasing of the temperature in the brood chamber. Thanks to Thermosolar windows in the supers, the Thermosolar hive can raise the temperature of the brood chamber by several degrees Celsius above the normal temperature of the brood chamber even without the intervention of a beekeeper. In the case of clear and sunny days, the temperature in the brood chamber can be increased even for several hours. This slight increase in temperature is neither harmful to bees, nor does it cause the bees any stress. But the *Varroa* mite can no longer reproduce at temperatures above 35.5 ° C, and its population cannot develop in the Thermosolar hive, and cannot survive over a longer period either.

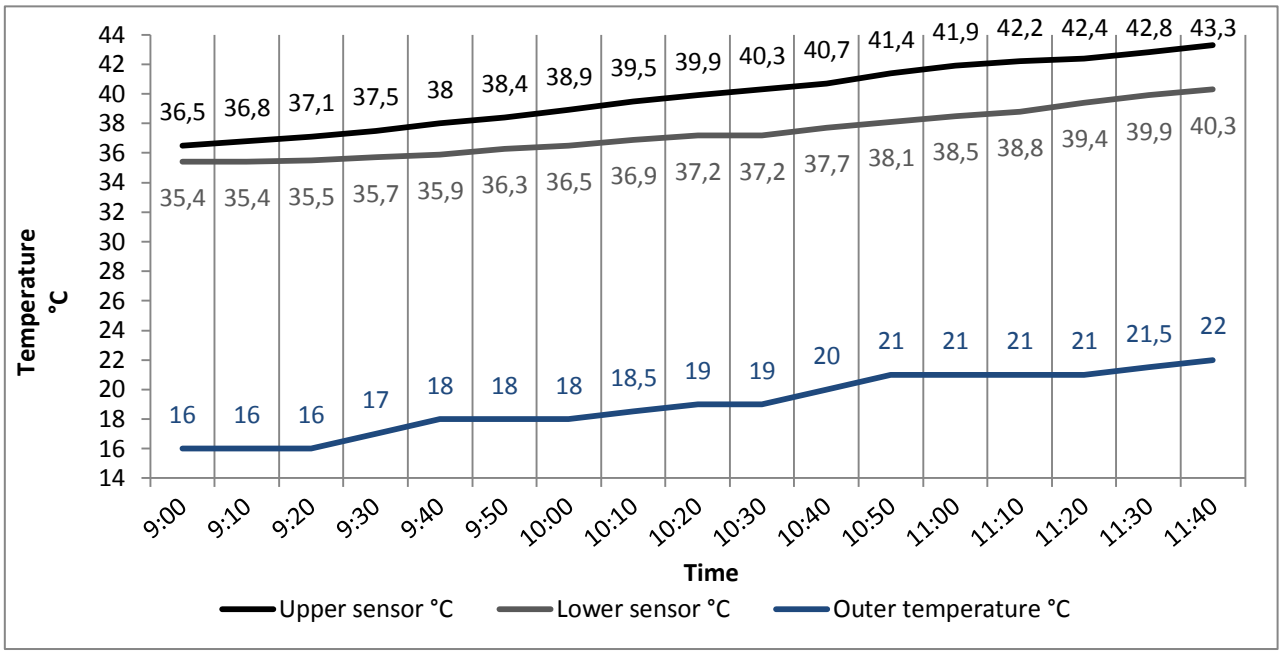
Formidol pads were again inserted into thin-walled hives for 4 days, namely from 17 Jul 2015 till 20 Jul 2015. The highest fallout was recorded on the third day. According to the methodology, the protective cover of the pad was removed and there was an increased evaporation of the drug. This led to a higher fallout.

The second treatment

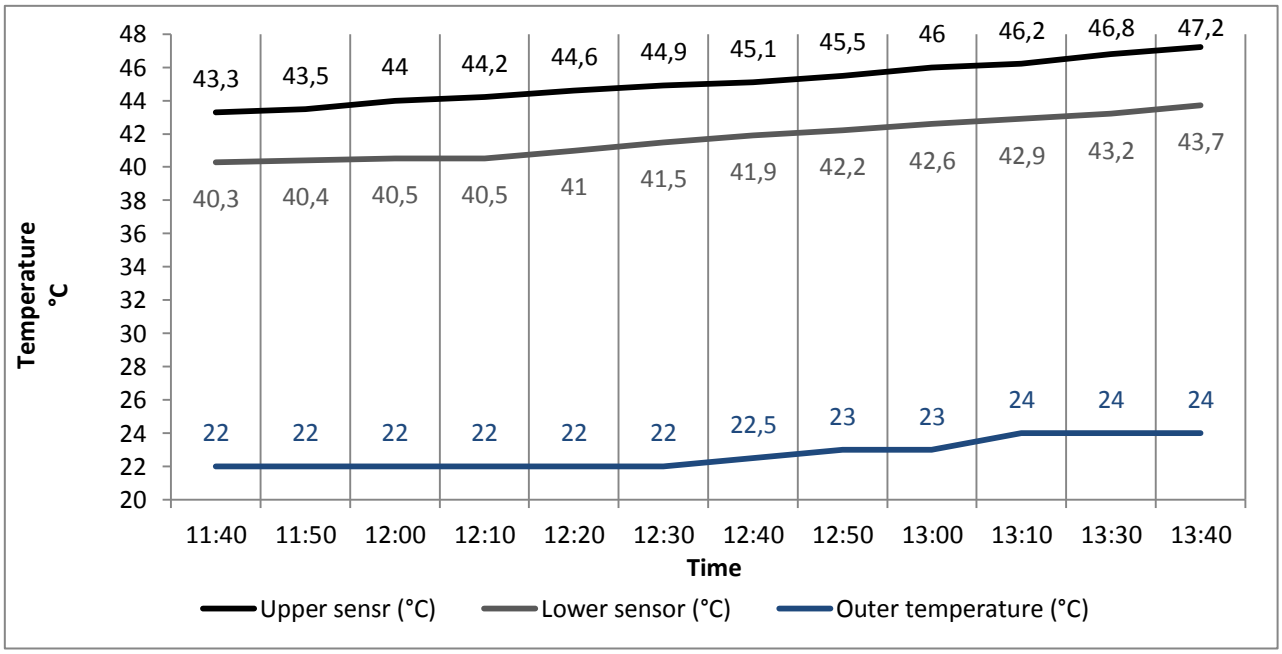
The second thermotherapy took place on 30 Jul 2015. The experimental sets of hives remained the same as in the case of the first thermotherapy. At 9:00, the roofs of all eight tested Thermosolar hives were removed, thus starting the active heating of the brood chamber. The thermotherapy in all hives took place with open, only narrowed entrances for the whole time. All Thermosolar hives managed to achieve therapeutic temperatures above 40 °C and maintained them for the desired period of 2 hours.
Formidol® pads were again inserted into the control group of thin-walled hives. The subsequent fallout from all hives was counted 12 days after thermotherapy. During this time, all sealed brood treated with thermotherapy already hatched and all killed mites fell out of the cells.

Graphs 9 and 10 show the temperature development in the brood chamber during thermotherapy in a randomly selected Thermosolar hive, which was already occupied by a colony from the spring therapy. Given the less favorable temperature conditions, it was not necessary to end the active heating during the treatment by mounting the roof. High cloud cover, which reduced the intensity of sunlight, caused a slower rise in temperatures in Thermosolar hives. In some cases the maximum recommended temperature was not achieved. The same thing can be seen in Graphs 11 and 12, which monitor the temperature development in one of the Thermosolar hives occupied by a colony before the first thermotherapy. The influence of bees ventilating on the entrance is evident from the graphs as well, because the temperatures between the upper and lower parts of the brood chamber differ by a few degrees Celsius. During this thermotherapy, the required therapeutic temperatures were achieved in all monitored Thermosolar hives and therapeutic temperatures were maintained in all hives for the desired period of 2 hours.

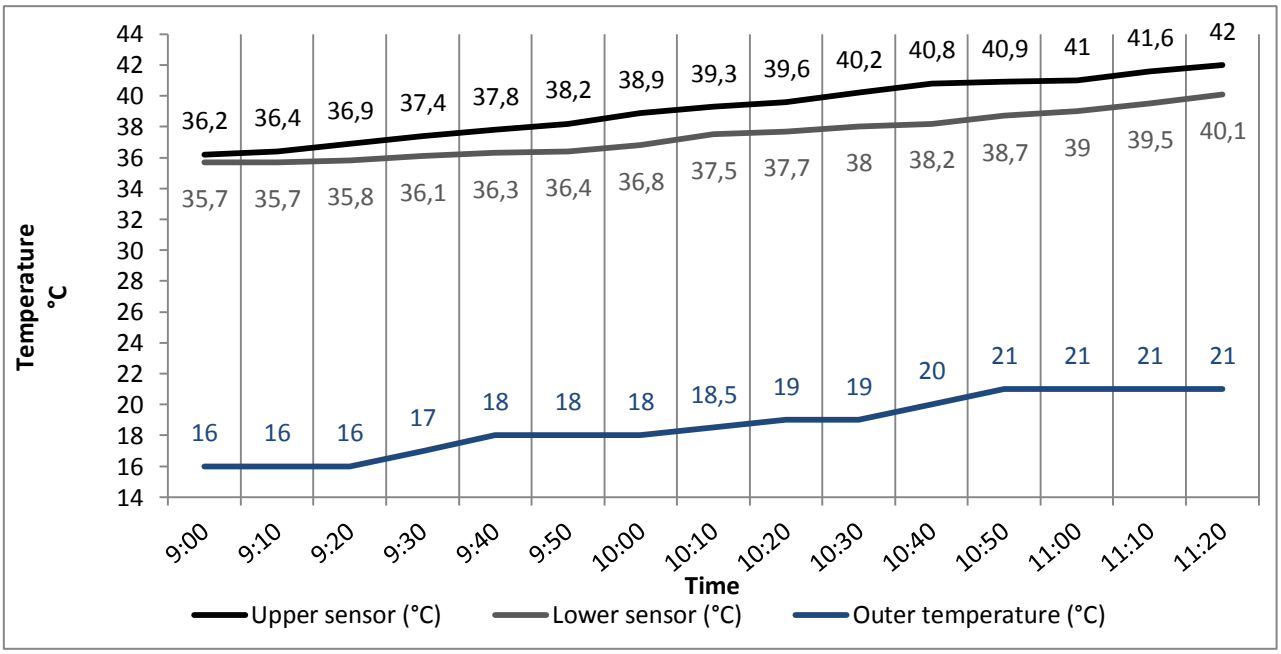
Graph 9 - Achieving therapeutic temperatures in permanently occupied Thermosolar hive on 30 Jul 2015



Graph 10 - Maintaining therapeutic temperatures in permanently occupied Thermosolar hive on 30 Jul 2015



Graph 11 - Achieving therapeutic temperatures in newly occupied Thermosolar hive on 30 Jul 2015



Graph 12 - Maintaining therapeutic temperatures in newly occupied Thermosolar hive on 30 Jul 2015

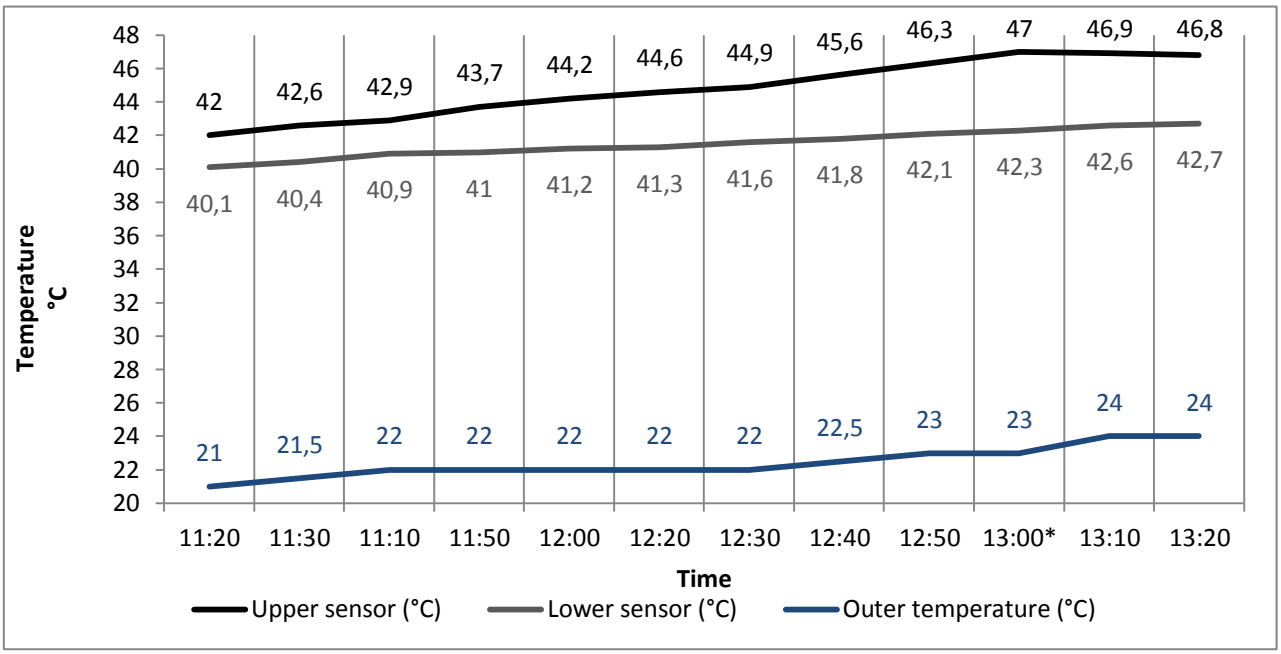


Chart 5 - The number of dead mites after the second summer treatment
(TSH = Thermosolar Hive, CH = Common hive)

	30.7.	31.7.	1.8.	2.8.	3.8.	4.8.	5.8.	6.8.	7.8.	8.8.	9.8.	10.8.	Total
TSH 1													0
TSH 2													0
TSH 3	1												1
TSH 4		1											1
TSH 5	1	1											2
TSH 6	1	2	1			1							5
TSH 7		2	1										3
TSH 8	2	1											3
CH 1	4	4	13	1									22
CH 2	2	3	20	2									27
CH 3	3	5	19	1									28
CH 4	4	6	21	3									34

Chart 6 - Total number of dead mites after the summer treatment
(TSH = Thermosolar Hive, CH = Common hive)

	TSH 1	TSH 2	TSH 3	TSH 4	TSH 5	TSH 6	TSH 7	TSH 8	CH 1	CH 2	CH 3	CH 4
1.treatment	7	8	5	9	128	144	75	96	56	58	43	38
2.treatment	0	0	1	1	2	5	3	3	22	27	28	34
Total	7	8	6	10	130	149	78	99	78	85	61	72

Chart 5 shows the fallout of mites counted from the second thermotherapy dated 30 Jul 2015 during further 12 days until 10 Aug 2015. The amount of fallout in TSH 1 – TSH 4 and TSH 4 - TSH 8 clearly proves that the majority of the *Varroa* mite population was killed already during the first heating. Some mites found after the second thermotherapy could have been killed by the first heating and could have fallen out of the cell together with a hatched house bee only during the second counting of the fallout. The total number of *Varroa* mites in colonies that were placed in Thermosolar hives during the whole season is significantly lower than the fallout from the other tested groups. Permanently low infestation of colonies in TSH 1 - TSH 4 is determined by repetitive slight increase in temperature in the brood chamber to values preventing the reproduction of the *Varroa* mite. Colonies in TSH 5 - TSH 8 were treated in spring with Formidol® product as well as test colonies in thin-walled hives. High summer fallouts prove a high reproductive ability of the *Varroa* mite. The mite is able to multiply its population in a short time and therefore the treatment with a short-term effect is only a short-term solution to varroosis. After the effect of the drug wears off, surviving mites or mites from reinvasion in a colony again rapidly multiply. The total fallout from the control group of colonies in thin-walled hives treated again with Formidol® preparation is lower than that from group TSH 5 - TSH 8. These colonies were treated in the same way throughout the season and were located in the same post. This difference could have been caused by a lower level of infestation of colonies in ordinary hives, or by lower efficiency of the chemical drug.

After completion of thermotherapy and counting of fallen mites, the colonies TSH 5 - TSH 8 were put back to the thin-walled hives.

Winter treatment with Varidol 125

All beekeepers in the Czech Republic are bound by law to treat colonies in winter with this medicament. The active ingredient Amitraz belongs to hard chemicals, its undeniable advantage, however, is high and immediate effectiveness. The reported effectiveness is > 95%. The fallout of the *Varroa* mite after application of Varidol 125 was monitored in three test groups. TSH 1 – TSH 4 indicate colonies, which were during the whole 2015 season placed in Thermosolar hives and were treated only with thermotherapy. TSH 5 – TSH 8 are colonies, which were transferred to Thermosolar hives for the summer thermotherapy, and after treatment and counting of the fallout were again returned to the thin-walled hives. Colonies in the four monitored ordinary thin-walled hives were treated with Formidol® in the spring and summer. The application of Varidol 125 was carried out on 15 Nov 2015 in full accordance with the recommended methodology and the fallout in the test groups of hives was counted three days after application. Given the date of treatment, the whole population of mites was located on adult bees.

Chart 7 – Fallout of *Varroa* after application of Varidol 125 on 15 Nov 2015
(TSH = Thermosolar Hive, CH = Common hive)

	TSH 1	TSH 2	TSH 3	TSH 4	TSH 5	TSH 6	TSH 7	TSH 8	CH 1	CH 2	CH 3	CH 4
1. day	2	7		6	261	186	254	216	445	297	353	389
2. day		1		1	16	12	15	19	26	12	14	15
3. day					1		2	1	2	2		1
Total	2	8	0	7	278	198	271	236	473	311	367	405

Chart 7 shows totals of fallouts of the *Varroa* mite after the application of Varidol 125. The large span of mites found in individual hives is due to several factors. The group of colonies TSH 1 - TSH 4 was placed in Thermosolar hives from spring thermotherapy and was not treated differently than using heat. Performed thermotherapies always killed the population of mites, which was found in the hive. Long-term moderate heating through thermosolar windows prevented the reproduction of the mite in the hives and protected colonies even from the reproduction of the mite from late summer reinvasions. High fallout from the control group TSH 5 - TSH 8 was caused by these very reinvasions. This group was treated with Formidol® during the spring treatment and for the purposes of summer treatment these colonies were transferred to Thermosolar hives, where the thermotherapy was conducted. Following that, this group was again returned to the thin-walled hives. Thermotherapy with almost 100% efficiency killed mites that were found in colonies during thermotherapy. After being transferred back into the thin-walled hives, nothing prevented mite infestation and reinvasions. Mite population in the colonies in the second half of August and early September reproduced to

observed values. The third control group, which consisted of common thin-walled hives, was treated in summer with Formidol® in two consecutive treatments. As with the group TSH 5 – TSH 8, there was a repeated importation and reproduction of mites after the performed treatment. Relatively higher values of the fallout compared with the group TSH 5 – TSH 8 may be due to a higher reinvasion or lower efficiency of the chemical drug, which did not kill the entire population of the mite, thus causing its quicker repeated reproduction.