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Comparison of Plastic and Wooden Langstroth Hives in Terms of Some Traits*

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Abstract

This study was carried out to compare the number of honeycombs with full of bees (wax building activity) (frame count), survivability, swarm condition and honey yield for the thermo plastic (plastic) and wooden Langstroth honey bee hives. A total of 23 hives (10 plastic and 13 wooden hives) were used. The mean frame count for the plastic and wooden hives, respectively, were 13.25±0.28 and 14.77±0.48 (Z= -1.24, p=0.22). Survivability rates for the plastic and wooden hives, respectively, were 90.00% and 53.85% for at the end of first year (Fisher's exact test p=0.089) and 30.00% and 15.38% (Fisher's exact test, p=0.618) for at the end of the study. The plastic hives decreased the death incidence at the end of the study [relative risk ratio (RR)=0.82]. Swarm rates were 40.00% and 15.38% (Fisher's exact test p=0.341) for the plastic and wooden hives, respectively at the end of first year. Swarm condition increased about 3 times more in the plastic hives as compared to the wooden hives (RR=2.60). Mean honey yield per honeycomb was higher in the plastic hives (2264.65±182.39 g) than in the wooden hives (1634.20±191.08 g) (t=2.39, p=0.028). As a result, it was thought that thermo plastic hives can be efficiently and successfully used by bee keepers since they may increase survivability and honey yield and are easy to use.

Keywords: *Apis mellifera* L, Langstroth hive type, honey yield, survivability, swarm, relative risk.

INTRODUCTION

Beekeeping is a branch of production that has low investment costs and high income, can evaluate elderly, child and female labor force, can easily convert products and colony assets into money in situations of economic difficulties, provides easy production opportunities to producers of rural areas with limited income sources, and thus reduces unemployment and migration problems from village to city, contributes greatly to the economy of the country and the welfare of society (Doğaroğlu, 2004).

Turkey, which shows all kinds of changes from subtropical climate to desert climate and very harsh climate conditions, is considered the motherland of bee and beekeeping along with Africa and Europe with its rich and diverse plant flora. (Karacaoğlu and Fıratlı, 1998). Turkey, according to the Food and Agriculture Organization data for 2017, is third in the world with about 7.8 million hives and second with about 114 thousand tons of honey production, although ranked sixty sixth with 14.7 kg of honey production per hive (Anonymus, 2017). As can be understood from here, honey production per hive in Turkey is not at the desired level if Turkey's ecological situation and floral resources are considered, and it is not enough to benefit from the current beekeeping potential of the country.

The technical characteristics of the hive, in which the bee colony spends an entire life, are closely related to the efficiency of beekeeping. Technical beekeeping is only possible with modern hives. The most common modern hives in the world are Langstroth and Dadant (Doğaroğlu, 2004). Although many beekeepers in Turkey use Langstroth type hives, because these hives are made in different sizes, similar models to the Dadant type are also in the majority. Although an average of 4-5 kg of honey is taken in the old type hives, it is possible to take 40-50 kg of honey in the most appro priate conditions from modern hives and even in very good conditions to take 100 kg of honey from a hive is a common condition. (Doğaroğlu, 2004).

Research has shown that hive types have effects on the prevalence of honeybee diseases, brood and honey yield and honey quality. Racys (2000) tried four different hive types and found that bee output from brood was greater in high framed hives in the spring, but this difference decreased in the summer. In the same study, honeybee output from brood was found to be 36% higher than Dadant type hive in high framed and multi-storey hives, while the maximum honey harvest was obtained from improved Dadant type hive with 32.6 kg. Tucak et al. (2002) showed an association between beehive type and disease occurrence. Langstroth and Dadant-Blatt type hives were compared in terms of brood activity, colony population and honey production in a study (Doğaroğlu and Evren, 1993) conducted in Thrace region in Turkey. The difference between the two types of hives in terms of brood activity and honey production was insig- nificant. However, Langstroth hives were different in terms of frame surface and Dadant-Blatt hives were different in terms of frame surface for the comparison with respect to colony population. Birloiu et al. (2015) reported that Layens type hives were superior to Dadant type hives in terms of bee strength, reproductive ability and the amount of honey produced. Yeninar (2015) in his research on hives produced from different materials reported that the best performance in terms of life strength, wintering ability and weight change was in insulated plywood and the worst performance was in wooden hives. Paleolog and Jagiello (2001) reported that there were 22.50% fewer deaths in bees wintered in single box Wielkopolski hives, 44.00% more brooding areas were seen in early spring, while honey production was 9.60% more in Dadant type hives. However, the differences between these two hives were not statistically significant. Tucak et al. (2004) investigated the effects of hive types on honey quality and found that different types of hives used in bees affect honey quality. These investigations were generally carried out in wooden type hives. Plastic type hives have recently begun to be used. The comparison of plastic and wooden hives of the same type in terms of different characteristics was not observed and healthy data was not found in the literature survey, Therefore, this research was conducted to compare modern thermo plastic and wooden Langstroth hives in terms of frame count (the number of honeycombs with full of bees or wax building activity), survival strength, swarm status and honey yield.

MATERIALS AND METHODS

The hive material of the study was composed of 13 wooden (Figure 1) and 10 thermo hives (insulated) made of plastic suitable for the food codex (hereinafter referred to as "plastic hives") (Figure 2) Langstroth type hives with honey bees (Caucasian genotype; all queens with blue color code) (brood chamber and honey super together). The research pattern was first carried out in such a way as to have 10 wooden, 10 plastic bee hives and 3 spare hives (wooden). However, the company, from which the hives and honey bees were taken, brought 3 spare wooden hives with bees. Therefore, these 3 spare wooden hives were also included in the study. The study lasted 3 years. The hives, with honey bees of 5 frames, were brought to the organic agricultural land of Delice Vocational School (Delice / Kırıkkale) from Istanbul Silivri on 29 April of year 2010 (the first year). The hives were placed on stands to be 30-40 cm above the ground level, each hive was numbered separately, and all works, and observations were recorded in a registry book as data for the relevant hive. All works and observations on the hives were made at routine intervals even on some days of autumn and winter seasons. These processes have been seasonal maintenance and controls required by technical beekeeping. During the controls, it was attempted to determine the number of frames with honey bees and the areas with eggs, larvae and capped cells on the frames, the frames with honey and pollen and the status of the queen. The honey bees were artificially fed in the spring until the start of nectar flow, and in the autumn before they entered overwintering. In artificial feed- ing, the honey bees in each hive were given cooled sherbet (prepared from 1 part of sugar and 1 part of hot water) in equal amounts (1-2 liters) during each control. Commercial vitamin mixture of 2 teaspoons per 5 liters was also added to the sherbet. In addition, commercial bee cake (about 1 kg per hive) was given to the hives along with honey left in brood chamber before wintering. The addition of empty frames to the hives was made in the form of commercial basic honeycomb fitted frames.

Honey was harvested in August when 2/3 of the honey in the frames is cured and capped with bee wax. The collected frames were weighed and the bee wax on the frames were stripped off with a knife. Then the frames were rotated manually in the honey extractor. Finally, the honey was removed, and the empty frames weighed again. Honey harvesting was done only in the frames of honey super. After the honey harvest was completed, the autumn maintenance of the hives was made, and the hives were allowed to rest for the winter as the weather started to cool down. The same procedure was repeated in the following season.

The number of honeycombs with full of bees (wax building activity) (hereinafter referred to as "frame count"), survivability, swarm condition and honey yield for the thermo plastic (plastic) and wooden Langstroth bee hives were considered for analysis and the results were presented in tables. For the survivability rate calculation, the number of collapsed (dead) hives at the end of each year and trial was determined and the survivability rate (SR) was calculated as: SR = (number of live hives at the end of the trial or year / number of hives at the beginning of the trial or year) x 100 (Doğaroğlu, 1981). Since parametric test assumptions were not met, Mann Whitney U test was used for the comparison of two hive types in terms of the number of frames. In initial analysis, Chi-square test was used for the analysis of the relationship of the number of collapsed and live hives with the hive types as well as the relationship of the number of swarmed and not swarmed hives with the hive types. But, because the expected numbers in all 2x2 cross tables fell below 5 in at least one cell, Fisher's exact test was used instead (Özdemir, 2005). In addition, relative risk ratio (RR) was calculated. RR is calculated as the ratio of the frequency of the event when the risk factor exists and not exist (Özdemir, 2005). RR for the hive type and status of bees was calculated as: RR= [(number of collapsed or dead plastic hives / total number of plastic hives)] / [(number of collapsed or dead wooden hives / total number of wooden hives)]. Thus, it was examined whether the incidence of bee death increased with hive type. Similarly, at the end of first year, RR for the hive type and status of swarm was calculated as: RR= [(number of swarmed plastic hives / total number of plastic hives)] / [(number of swarmed wooden hives / total number of wood- en hives)]. Thus, it was examined whether the incidence of swarm increased with hive type. The last year and the honey yield per frame, instead of honey yield per hive, were considered for honey yield analysis of two hive types due to poor data. For this purpose, honey frames were randomly selected from 3 plastic and 2 wooden hive types that remained alive in the last year (10 frames from plastic hive and 10 frames from wooden hive) for honey yield analysis. In the analysis of honey yield per frame, the difference between the weights of the frames (before and after honey extraction) was used instead of the honey that was extracted. Since parametric test assumptions were met, Student-t test was performed in the analysis of honey yield per frame according to hive type. In the statistical evaluation, $p \leq 0.05$ was considered statistically significant. Statistical analysis of the data was performed with SPSS v15.0 package program (SPSS, Inc., Chicago, Illinois, USA).

Figure 1.Wooden Langstroth hives

Figure 2. Plastic Langstroth hives

RESULTS

The average frame count is given in Tables 1, 2 and 3 by years and in Table 4 by all years. In both the plastic and wooden hives, frame count increased continuously in parallel for both hives until August and frame count decreased at the same rate after the honey harvest (Table 1). At the end of the first year, no statistically significant difference was found between the average frame counts (12.78 for the plastic hives and 11.95 for the wooden hives) ($Z = -1.63$, $p = 0.103$) (Table 1). At the beginning of the second year after wintering, most of the wooden hives lost their bees (due to the winter losses and swarm). Frame count increased in favor of the wooden hives by the end of the second year due to the relatively strong bees of the remaining wooden hives (5 hives at the beginning of the year and 2 hives later) (Table 2). At the end of the second year, the difference between the average frame counts (14.11 for the plastic hives and 17.67 for the wooden hives) was not statistically significant ($Z=1.73$, $p = 0.084$) (Table 2). At the beginning of the third year, there were also bee losses in the plastic hives (due to the winter losses and swarm) and the number of the plastic hives with live bees decreased to 3. The bees of the 2 wooden hives remaining from the previous year were alive. Frame counts and control dates for this year are given in Table 3. In the remaining wooden hive bees, the swarm was not seen in previous years and these hives' bees were found to be more aggressive. When the average frame counts in the remaining hives (13.23 for the plastic hives and 22.45 for the wooden hives) was analyzed, a significant difference was found according to hive type ($Z = -6.65$, $p < 0.0001$). However, this difference is thought to be due to the fact that the bees of the last two wooden hives were very strong and did not have any swarm. When all the years were considered together (Table 4), the difference between the average frame counts (13.25 for the plastic hives and 14.77 for the wooden hives) was not statistically significant ($Z = -1.24$, $p = 0.22$).

Table 1. Mean frame count (honeycombs with full of bees -wax building activity) per hive in the first year.

Control date	Hive type	n	Mean frame count/hive±SE*	Median	% 95 CI†
May 26	Plastic	10	7.60±0.27	8,00	7.00-8,00
	Wooden	13	6.54±0.27	6.00	5.95-7.12
June 04	Plastic	10	9.60±0.16	10.00	9.23-9.97
	Wooden	13	8.15±0.27	8.00	7.56-8.75
June 09	Plastic	10	12.60±0.31	12.00	11.91-13.29
	Wooden	13	10.00±0.18	9.00	8.95-11.05
June 18	Plastic	10	13.90±0.43	14.50	12.92-14.88
	Wooden	13	11.92±0.63	13.00	10.56-13.28
June 21	Plastic	10	14.90±0.66	15.50	13.41-16.39
	Wooden	13	13.85±0.65	14.00	12.46-15.26
July 01	Plastic	10	14.80±1.11	15.50	12.28-17.32
	Wooden	13	14.77±0.62	15.00	13.41-16.12
July 14	Plastic	10	16.50±1.39	18.00	13.35-19.65
	Wooden	13	16.54±0.84	17.00	14.70-18.38
August 10	Plastic	10	16.20±1.35	17.50	13.15-19.25
	Wooden	13	16.54±0.90	17.00	14.59-18.49
October 24	Plastic	9	10.78±0.52	10.00	9.58-11.98
	Wooden	11	10.18±1.00	10.00	7.96-12.41
December 30	Plastic	9	10.44±0.44	10.00	9.42-11.47
	Wooden	11	10.55±0.55	10.00	9.33-11.76
General	Plastic	98	12.78±0.38	12.00	12.02-13.53
Z= -1.63, p=0.103	Wooden	126	11.95±0.36	10.00	11.25-12.66

*SE: Standard error, †CI: Confidence interval

Table 2. Mean frame count (honeycombs with full of bees -wax building activity) per hive in the second year.

Control date	Hive type	n	Mean frame count/hive±SE*	Median	% 95 CI†
January 14	Plastic	8	10.50±0.50	10.00	9.32-11.68
	Wooden	5	11.20±1.20	10.00	7.87-14.53
March 31	Plastic	6	10.17±0.17	10.00	9.74-10.60
	Wooden	2	13.00±3.00	13.00	0.00-51.12
May 10	Plastic	6	12.67±1.67	10.50	8.38-16.95
	Wooden	2	15.00±5.00	15.00	0.00-78.53
June 02	Plastic	6	14.83±1.78	14.00	10.26-19.40
	Wooden	2	15.00±5.00	15.00	0.00-78.53
June 09	Plastic	6	16.00±2.63	14.00	9.23-22.77
	Wooden	2	22.00±8.00	22.00	0.00-123.65
June 23	Plastic	6	16.33±2.63	15.00	9.58-23.09
	Wooden	2	22.00±8.00	22.00	0.00-123.65
July 04	Plastic	6	17.83±2.44	18.50	11.56-24.11
	Wooden	2	23.00±7.00	23.00	0.00-111.94
July 14	Plastic	6	17.83±1.64	20.00	13.61-22.05
	Wooden	2	25.00±5.00	25.00	0.00-88.53
July 28	Plastic	6	12.00±1.63	10.00	7.80-16.20
	Wooden	2	23.50±3.50	23.50	0.00-67.97
General Z= -1.73, p=0.084	Plastic	56	14.11±0.68	11.00	12.75-15.46
	Wooden	21	17.76±1.67	16.00	14.29-21.23

*SE: Standard error, †CI: Confidence interval

Table 3. Mean frame count (honeycombs with full of bees -wax building activity) per hive in the third year.

Control date	Hive type	n	Mean frame count/hive±SE*	Median	% 95 CI†
March 28	Plastic	3	13.33±3.33	10.00	0.00-27.68
	Wooden	2	18.50±8.50	18.50	0.00-126.50
April 18	Plastic	3	13.33±3.33	10.00	0.00-27.68
	Wooden	2	18.50±8.50	18.50	0.00-126.50
April 25	Plastic	3	11.67±3.28	10.00	0.00-25.79
	Wooden	2	18.50±8.50	18.50	0.00-126.50
May 02	Plastic	3	12.67±3.18	13.00	0.00-26.35
	Wooden	2	21.00±6.00	21.00	0.00-97.24
May 16	Plastic	3	14.00±3.46	14.00	0.00-28.90
	Wooden	2	18.50±1.50	18.50	0.00-37.56
May 23	Plastic	3	14.00±3.46	14.00	0.00-28.90
	Wooden	2	18.50±0.50	18.50	12.15-24.85
May 30	Plastic	3	15.33±2.40	14.00	4.99-25.68
	Wooden	2	21.00±2.00	21.00	0.00-46.41
June 06	Plastic	3	11.67±1.20	11.00	6.50-16.84
	Wooden	2	21.00±2.00	21.00	0.00-46.41
June 13	Plastic	3	13.00±1.53	14.00	6.43-19.57
	Wooden	2	22.50±3.50	22.50	0.00-66.97
June 22	Plastic	3	13.67±1.45	14.00	7.42-19.92
	Wooden	2	26.50±3.50	26.50	0.00-70.97
June 28	Plastic	3	13.67±1.45	14.00	7.42-19.92
	Wooden	2	26.50±3.50	26.50	0.00-70.97
July 06	Plastic	3	13.67±1.45	14.00	7.42-19.92
	Wooden	2	26.50±3.50	26.50	0.00-70.97
July 13	Plastic	3	13.33±1.45	13.00	7.08-19.58
	Wooden	2	26.50±3.50	26.50	0.00-70.97
July 18	Plastic	3	13.33±1.45	13.00	7.08-19.58
	Wooden	2	26.50±3.50	26.50	0.00-70.97
September 19	Plastic	3	13.67±0.88	14.00	9.87-17.46
	Wooden	2	26.50±3.50	26.50	0.00-70.97
October 05	Plastic	3	12.67±0.33	13.00	11.23-14.10
	Wooden	2	26.50±3.50	26.50	0.00-70.97
October 19	Plastic	3	12.00±0.58	12.00	9.52-14.48
	Wooden	2	21.00±2.00	21.00	0.00-46.41
November 02	Plastic	3	16.00±1.53	17.00	9.43-22.57
	Wooden	2	21.00±2.00	21.00	0.00-46.41
November 23	Plastic	3	10.33±2.33	8.00	0.29-20.37
	Wooden	2	21.00±2.00	21.00	0.00-46.41
General Z= -6.65, p<0.0001	Plastic	57	13.23±0.46	13.00	12.31-14.14
	Wooden	38	22.45±0.91	23.00	20.61-24.29

*SE: Standard error, †CI: Confidence interval

Table 4. Mean frame count (honeycombs with full of bees -wax building activity) per hive in all years.

Hive type	n	Mean frame count/hive±SE*	Median	% 95 CI†
Plastic	211	13.25±0.28	12.00	12.70-13.81
Wooden	185	14.77±0.48	14.00	13.83-15.71
Z= -1.24, p=0.22				

*SE: Standard error, †CI: Confidence interval

Table 5 shows the viability of two hive bees by the end of the first year. At the end of the first year only one (10.00%) of the plastic hives' bees died, while this number was six (46.15%) for the wooden hives. Although there was no relationship between hive type and the status of bees (dead and alive), the analysis showed that this relationship tended to occur (Fisher exact test p=0.089). The relative risk ratio (RR) was 0.22 at the end of the first year. Since this number is less than one, it is understood that the plastic hives reduced the incidence of death at the end of the first year (Table 5). Tables 6 and 7 show the status of bees (dead and alive) of the two hives in their second and third years. In these years, a similar situation to the first year was observed and it was determined that there was no relationship between the hive type and the status of bees (Fisher exact test p=0.315 and p=0.464, respectively). RR values have also been below 1 in the last two years (0.46 and 0.00, respectively), and the plastic hives also reduced the incidence of death in the second and third years (Tables 6 and 7). At the end of the trial, only 2 (15.38%) of the wooden hives remained alive, while 3 (30.00%) of the plastic hives remained alive (Table 8). However, no relationship between the hive type and the status of bees was found again (Fisher exact test p=0.618). The RR was 0.82 at the end of the trial and the ratio below 1 showed that the plastic hives reduced the incidence of bee death at the end of the trial (Table 8).

Table 5. Honey bee status in the plastic and wooden hives at the end of the first year

			Hive bee status		
			Collapsed (dead)	Live	Total
Hive type	Plastic	Number	1	9	10
		Within hive type %	% 10.00	% 90.00	% 100.00
		Within hive bee status %	% 14.29	% 56.25	% 43.48
		Total %	% 4.35	% 39.13	% 43.48
	Wooden	Number	6	7	13
		Within hive type %	% 46.15	% 53.85	% 100.00
		Within hive bee stat. %	% 85.71	% 43.75	% 56.52
		Total %	% 26.09	% 30.43	% 56.52
Total		Number	7	16	23
		Within hive type %	% 30.43	% 69.57	% 100.00
		Within hive bee stat. %	% 100.00	% 100.00	% 100.00
		Total %	% 30.43	% 69.57	% 100.00

Fisher exact test p value=0.089. Relative risk (RR) = 0.22

Table 6. Honey bee status in the plastic and wooden hives at the end of the second year

			Hive bee status		
			Collapsed (dead)	Live	Total
Hive type	Plastic	Number	3	6	9
		Within hive type %	% 33.33	% 66.67	% 100.00
		Within hive bee status %	% 37.50	% 75.00	% 75.00
		Total %	% 18.75	% 37.50	% 75.00
	Wooden	Number	5	2	7
		Within hive type %	% 71.43	% 28.57	% 100.00
		Within hive bee status %	% 62.50	% 25.00	% 43.75
		Total %	% 31.25	% 12.50	% 43.75
Total		Number	8	8	16
		Within hive type %	% 50.00	% 50.00	% 100.00
		Within hive bee status %	% 100.00	% 100.00	% 100.00
		Total %	% 50.00	% 50.00	% 100.00

Fisher exact test p value=0.315. Relative risk (RR) =0.46

Table 7. Honey bee status in the plastic and wooden hives at the end of the third year

			Hive bee status		
			Collapsed (dead)	Live	Total
Hive type	Plastic	Number	3	3	6
		Within hive type %	% 50.00	% 50.00	% 100.00
		Within hive bee status %	% 100.00	% 60.00	% 75.00
		Total %	% 37.50	% 37.50	% 75.00
	Wooden	Number	0	2	2
		Within hive type %	% 0.00	% 100.00	% 100.00
		Within hive bee status %	% 0.00	% 40.00	% 25.00
		Total %	% 0.00	% 25.00	% 25.00
Total		Number	3	5	8
		Within hive type %	% 37.50	% 62.50	% 100.00
		Within hive bee status %	% 100.00	% 100.00	% 100.00
		Total %	% 37.50	% 62.50	% 100.00

Fisher exact test p value=0.464. Relative risk (RR) = 0.00

Table 8. Honey bee status in the plastic and wooden hives at the end of the trial

			Hive bee status		
			Collapsed (dead)	Live	Total
Hive type	Plastic	Number	7	3	10
		Within hive type %	% 70.00	% 30.00	% 100.00
		Within hive bee status %	% 38.89	% 60.00	% 43.48
		Total %	% 30.43	% 13.04	% 43.48
	Wooden	Number	11	2	13
		Within hive type %	% 84.62	% 15.38	% 100.00
		Within hive bee status %	% 61.11	% 40.00	% 56.52
		Total %	% 47.83	% 8.70	% 56.52
Total		Number	18	5	23
		Within hive type %	% 78.26	% 21.74	% 100.00
		Within hive bee status %	% 100.00	% 100.00	% 100.00
		Total %	% 78.26	% 21.74	% 100.00

Fisher exact test p value=0.618. Relative risk (RR) = 0.82

Table 9. Hive swarm status in the plastic and wooden hives at the end of the first year

			Hive swarm status		
			Swarmed	Not swarmed	Total
Hive type	Plastic	Number	4	6	10
		Within hive type %	% 40.00	% 60.00	% 100.00
		Within hive swarm status %	% 67.67	% 35.29	% 43.48
		Total %	% 17.39	% 26.09	% 43.48
	Wooden	Number	2	11	13
		Within hive type %	% 15.38	% 84.62	% 100.00
		Within hive swarm status %	% 33.33	% 64.71	% 56.52
		Total %	% 8.70	% 47.83	% 56.52
Total		Number	6	17	23
		Within hive type %	% 26.09	% 73.91	% 100.00
		Within hive swarm status %	% 100.00	% 100.00	% 100.00
		Total %	% 26.09	% 73.91	% 100.00

Fisher exact test p value=0.341. Relative risk (RR) = 2.60

Table 9 shows the relationship between hive type and swarm status (swarmed and not swarmed) in the first year. Although the percentage of swarm in the plastic hives (40.00%) was higher than the percentage of swarm in the wooden hives (15.38%), it was found that there was no relationship between the hive type and the swarm status (Fisher exact test p=0.341). RR was calculated as 2.60 and it was seen that the plastic hives tend to give about 3 times more swarm than the wooden hives (Table 9).

Table 10 shows honey yield per frame according to hive types. The honey yield per frame in the plastic hives (2264.65 g) was significantly higher than the honey yield per frame in the wooden hives (1634.20 g) (t=2.39, p=0.028).

Table 10. Average honey yield per frame (gram)

Hive type	n	Mean±SE*	Minimum	Maximum	% 95 CI†
Plastic	10	2264.65±182.39	1367	3013	1852.05-2677.25
Wooden	10	1634.20±191.08	924	2730	1201.95-2066.45
t=2.39, p=0.028					

*SE: Standard error, †CI: Confidence interval

In addition, no disease was found in both hive types and bee deaths were determined to be due to winter losses.

DISCUSSION

Erdogan et al. (2009) reported that the number of bee frames in wooden and insulated hives was 16.44 and 17.46 per hive, respectively, and found no statistically significant difference. Likewise, Yeninar et al. (2010) found that the number of bee frames was 15.60 and 12.00 per hive, respectively, for the hive types where the frames were placed horizontally and vertically relative to the entrance hole In the present study, when all the years are taken into account, frame count was lower than the first study mentioned above, but they were similar in terms of statistical difference, and it was partially similar to the second study in terms of frame count. Akyol et al. (2005) found wax building activities of four genotypes or the average number of bee frames per hive for pure Caucasian genotype as 13.50 in their trial on classic wooden Langstroth hives. This number was similar to the average frame counts determined for the plastic hive in this study, but it was lower than the average frame counts for the wooden hive. On the other hand, Güler and Kaftanoğlu (1999) reported an average of 1.50 of frame count (wax building activity) per hive for the Caucasian genotype, which is considerably lower than other studies and the number reported in this study. Akyol et al. (2005) reported the tendency of swarms to be 10% and the survival rate of 90.90% for pure Caucasian bees. In this study, the rate of swarming was higher for both the plastic and wooden hives for the first year. The first year survival rates in this study were low for the wooden hives compared to the above study, but similar for the plastic hives. Yeninar (2015) reported that the survival rates for wooden (85.00%) and insulated plywood hives (100.00%) was higher than the survival rates for the wooden and the plastic hives reported for the first year in this study. On the other hand, Dülger (1997) reported the survival rates as 70.00%, 78.80% and 90.00% for the Caucasian, Anatolian and Erzurum group bees during production period. Dodoloğlu et al. (2004) examined the colony status and behavior of honey bees fed with bee cake and syrup and housed in two different hives (wooden and polystyrene). In contrast to the present study, winter losses, the survival rate after wintering and brood activity in the wooden hives were found to be better than those of polystyrene hives. However, in the same study, colony weight gain in polystyrene hives was found to be higher during nectar [i]flow period. In this study, the average honey yield was given per frame and not per hive or colony and was different from other studies. The average honey yields for Caucasian and Caucasian cross bees per hive or colony were reported as 20.46 and 21.13 kg for wooden and insulated hives, respectively (Erdoğan et al., 2009), 26.56 kg (Güler and Kaftanoğlu, 1999) and 30.62 kg (Dülger, 1997) for wooden hives Assuming that honey yields in these studies were taken from only ten frames in honey super, it can be said that average honey yields per frame were 2046, 2113, 2656 and 3062 grams Therefore, it can be said that the average honey yield per frame for the plastic hives in this study was similar to the honey yield per frame in the above studies, but the average honey yield per frame for the wooden hives in this study was lower than the honey yield per frame in the above studies.

In this study, it was observed that the plastic and wooden hives had no difference in terms of the frame counts, and although it was not statistically significant, the bees found in the plastic hives at the end of the first year had a better winter and their winter losses were less than those of the wooden hives. This can be attributed to the fact that the plastic hives are thermo hives, the presence of insulating material and the ventilation holes underneath the plastic hive provide better ventilation and thus less moisture Swarming was more common in the plastic hives. One of the reasons for swarming was that the rapidly growing bees were in search of new nests. The observations showed that bees within the plastic hives reproduce more rapidly which might have an effect on increasing the swarm in the plastic hives. Average honey yield per frame was also found to be statistically higher in the plastic hives. No bee diseases were found in both hive types. As a result, it was concluded that the thermo plastic hives can reduce winter deaths and increase the survival rate, affect the honey yield positively and can be used more effectively and successfully by bee keepers because of its easy use.

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REFERENCES

Akyol E, Özkök D, Öztürk C, Bayram A. 2005. Bazı saf ve melez bal arısı (*Apis mellifera L.*) kolonilerinin oğul eğilimi, yaşama gücü, kışlama yeteneği ve petek işleme etkinliklerinin belirlenmesi üzerine bir araştırma. Uludağ Arıcılık Dergisi, 5(4): 162-166.

Anonymous. 2017. Food and Agriculture Organization of United Nations. http://www.fao.org/faostat/en/#data (Access date:30.06.2019).

Birloiu GD, Diaconescu Ş, Nicolae CM. 2015. Study on the maintenance of bee families into vertical hives on Dadant and Layens frames. Scientific Papers. Series D. Animal Sciences, 58: 239-246.

Dodoloğlu A, Dulger C, Genc F. 2004. Colony condition and bee behaviour in honeybee (*Apis Mellifera*) housed in wooden or polystyrene hives and fed bee cake or syrup. Journal of Apicultural Research, 43 (1): 3-8.

Doğaroğlu M. 2004. Modern Arıcılık Teknikleri. 2. Baskı. Doğa Arıcılık Ticaret, Tekirdağ, Türkiye.

Doğaroğlu M. 1981. Türkiye' de yetiştirilen önemli arı ırk ve tiplerinin "Çukurova Bölgesi" koşullarında performanslarının karşılaştırılması. Doktora tezi. Çukurova Üniversitesi, Fen Bilimleri Enstitüsü, Adana.

Doğaroğlu M, Evren HS. 1993. Trakya Bölgesi'nde Langstroth ve Dadan-Blatt kovan tiplerinin bal verimi ve koloni gelişimi üzerine etkileri. T.Ü. Tekirdağ Ziraat Fak. Dergisi, 2(1): 77-91.

Dülger C. 1997. Kafkas, Anadolu ve Erzurum balarısı (*Apis mellifera* L.) genotiplerinin Erzurum koşullarındaki performanslarının belirlenmesi ve morfolojik özellikleri. Doktora Tezi. Atatürk Üniversitesi, Fen Bilimleri Enstitüsü, Erzurum.

Erdoğan Y, Dodoloğlu A, Emsen B. 2009. Some physiological characteristics of honeybee (*Apis mellifera* L.) housed in heated, fan wooden and insulated beehives. Journal of Animal and Veterinary Advances, 8 (8): 1516-1519.

Güler A, Kaftanoglu O. 1999. Determination of performances of some important races and ecotypes of Turkish honeybees (*Apis mellifera* L.) under migratory beekeeping condition. Turkish Journal of Veterinary and Animal Sciences, 23(3):577–581.

Karacaoğlu M, Fıratlı Ç. 1998. Bazı Anadolu Bal Arısı Ekotipleri (Apis mellifera anatoliaca) ve Melezlerinin Özellikleri.I. Morfolojik Özellikler. Turkish Journal of Veterinary and Animal Sciences, 22 (1):17-21.

Özdemir O. 2005. Medikal İstatistik (Medical Statistics). 1.Baskı. İstanbul Medikal Yayıncılık, İstanbul.

Paleolog J, Jagiello R. 2001. Comparisons of overwintering, spring build up and honey yield in honeybee colonies kept in wielkopolski and Dadant hives. Annales Universitatis Mariae Curie-Sklodowska, Sectio EE Zootechnica, 19: 333-340.

Racys J. 2000. Suitability of various hive types for Lithuania. Zemdirbyste, Mokslo Darbai,72: 268-280.

Tucak Z, Periskic M, Beslo D, Tucak I. 2004. Influence of the beehive type on the quality of honey. Collegium Antropologicum, 28 (1): 463-467.

Tucak Z, Periskic M, Krznaric M, Feher-Belaj V, Ozimec S, Tucak I. 2002. Influence of the beehive types on the development of some diseases at apiaries. Acta Agraria Kaposvariensis, 6 (2): 93-96.

Yeninar H. 2015. Ülkemizde farklı materyallerden üretilmiş kovanlarda barındırılan bal arısı (*Apis mellifera* L) kolonilerinin Doğu Akdeniz sahil şeridinde kışlama özellikleri. Uludağ Arıcılık Dergisi, 15(1): 1-9.

Yeninar H, Akyol E, Şahinler N. 2010. The effects of hive types (shield and sword) on wintering ability, survival rates and strength of honeybee colonies (*A.mellifera* L.) in spring season. Trop Anim Health Prod, 42:425-429.