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Some Physiological Characteristics of Honeybee (*Apis mellifera* L.) Housed in Heated, Fan Wooden and Insulated Beehives

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Abstract: This study was conducted to investigate the effects of heating and ventilation devices mounted to insulated and wooden bee hives on some physiological characteristics of honeybees. The average number of frames in groups Control (C), Heated (H) and Heated-Fan (HF) were 15.14±4.73, 16.98±6.05 and 18.74±7.34 colony^{-1}, respectively. The average brood area for the colonies in groups C, H and HF were 4270.64±302.12, 4819.00±348.50, 5270.00±344.33 cm^2, respectively. The values of flying activity in groups were 74.79±19.80 in C, 85.36±27.34 in H and 101.43±16.78 in HF. Honey yields in groups C, H and HF were 14.61±1.71, 20.63±1.99 and 28.14±2.97 kg colony^{-1}, respectively.

Key words: Honey bee, heating, ventilation, honey yield, fan wooden, beehives

INTRODUCTION

Factors of external ambient and internal hive conditions are very important on the productivity of honey bees (Cetin, 2004). Beehives conditions can be more comfortable for honeybee colonies using devices such as fan and heating. Although, many studies have been studied on honey bees in the world, the numbers of conducted researches on the effects of factors such as internal hive temperature and humidity on honey bees are not quite extensive.

Temperature is one of the most important internal hive conditions. A high and constant brood temperature makes brood nest period shorter and reduces the rate of emergence in death or defective brood in social insects such as honeybee (*Apis mellifera*), vespa crabro (*Vespinae*) and bumble bee (*Bombus* sp.) (Seeley, 1985). During flight, the rather large flight muscles create heat, which must dissipate to brood area (Esch *et al*., 1991). The brood nest needs temperature of 30-36°C to develop the brood (Seeley and Heinrich, 1981). Nest heating has an energetic cost: when ambient temperature drops from 28-17°C, the metabolic rate of a bee colony rises from 7-19 watt kg^{-1} (Southwick, 1982). In order to minimize winter losses of bee colonies by improving hive microclimatic conditions, various trials were conducted in the United States (Owens, 1971; Detroy *et al*., 1982), Germany (Himmer, 1926), Norway (Villumstad, 1974) and in other countries. Researchers studied the effect of hive insulation on heat conservation inside the hive, reducing honey consumption from about 21-25% (Detroy *et al*., 1982), to up to 43% (Himmer, 1926).

Honeybees keep inside the hive atmosphere under livable conditions by fanning their wings. These behaviors of honey bees keep temperature and humidity within a certain limit. Bees consume honey to rise inside the hive temperature in winter (Hazelhoff, 1954).

In this research, we studied the impact of the internal hive temperature and humidity values of heating and ventilation devices mounted to beehives and their effects on physiological characteristics of honey bee colonies.

MATERIALS AND METHODS

A total of 42 Caucasian crossbreed honey bee colonies were used in the present study. Colonies were initially equalized to contain a similar amount of brood (five frames containing nest brood), adult bee population (ca. 9 frames covered with bees) and food stores. Colonies were divided into 6 groups as follows: (W-1) control group, (W-2) heated-wooden beehive adjusted to 21°C, (W-3) heated-fan wooden beehive adjusted to 21-34°C, (I-1) Control group in insulated beehives, (I-2) heated-insulated beehive adjusted to 21°C and (I-3) heated-fan insulated beehive adjusted to 21-34 °C (Table 1). In this way, application groups of W1-I1, W2-I2 and W3-I3 were consisted of control group, Heated (H) and Heated-Fan (H-F), respectively.

A 12 V, 0.68 A, 4 W and 8 cm diameter ventilation-fans were used to ventilate beehives. The spin speed of fans was set up as 2.5 km h^{-1} to provide air circulation. A 6 m resistance wires (220 V, 180 W), which was placed in

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Table 1: Experimental groups

Groups	Hive type	Temperature (°C)	Resistance	Ventilation	Groups	Applications
W-1	Wooden	-	-	-	Control (C)	W1-I1
W-2	Wooden	21	X	-	Heated (H)	W2-I2
W-3	Wooden	21-34	X	X	Heated-Fan (H-F)	W3-I3
I-1	Insulated	-	-	-	-	-
I-2	Insulated	21	X	-	-	-
I-3	Insulated	21-34	X	X	-	-

bottom of the hive, was covered with silicon to provide an isolation for heating of the hives. In order to eliminate the negative magnetic field effects on honey bees, the wires were covered with a thin sheet metal. A termohigrometre was used to determine daily maximum, minimum internal hive temperature and relative humidity in the bee yard.

A digital thermostat which is connected to double contactors and attached to the sensor probe was used to observe brood nest temperature. When, the thermostat reached at adjusted low temperature (21°C), the heater resistance started to run but it was turned off when it was just 21°C. When internal hive temperature rose to excessive levels (34°C), inside the hives was ventilated by fans and when it dropped to certain temperature the fan was turned off. The resistance was activated or inactivated by thermostats with a single contactor used in groups W-2 and I-2.

On 5th June 2007, colonies were equalized for 9 frames covered with bees and 5 combs of brood/colony to observe adult bee development. From this equalization till honey harvest (25 August), the number of frames covered with bees was determined 30 days interval as a measurement of adult bee development. In the same period, measurements of worker brood area were determined by measuring capped brood to the nearest cm^2 using PUCHTA method at the beginning of every month (Fresnaye and Lensky, 1961).

In order to determine weight gain during nectar flow, all colonies were weighed at the beginning (June 20) and end of nectar flow (August 5). A flight activity was determined in one colony randomly selected from experimental colonies. For this, number of flying bees was observed for 60 sec running, 7 times 10 days interval before noon at 10:00 am (Genc *et al*., 1999).

Honey was harvested from only supers of each colony. All combs were marked with its own hive number during the harvest. All combs were weighed before and after honey extraction and the difference in between were recorded as honey yield (Genc and Aksoy, 1993).

The present study was designed with 3-way repeated measures and 7 honey bee colonies in each repeated measures (Gorgulu and Sahinler, 2006). SPSS version 13 packet program was used to do statistical analysis. Duncan (1955) test was used to determine the significant differences between group means in an analysis of variance setting.

RESULTS AND DISCUSSION

The average maximum and minimum internal hive temperature and humidity values were given in Table 2. The average maximum and minimum temperature and humidity in wooden and insulated hives was recorded as 37.09±3.42°C, 22.00±2.07°C, 61.97±10.65%, 24.83±3.54% and 35.98±2.78°C, 22.74±2.03°C, 64.18±10.18%, 25.00±4.19%, respectively. The best results were obtained in group H-F with regard to maximum and minimum internal hive temperatures. This result indicate that internal hive temperature is not allowed to go over and under a certain limit by fan that is mounted on the top of hive and resistance wires placed in bottom of the hive.

Studies have shown that the temperature inside uninsulated wooden beehives differs little from ambient temperature (Owens, 1971). Heinrich (1993) reported that there are some temperature effects on honey bees and the bees' activities to control temperature in a beehive that does not have apparatus designed to cool the beehive artificially in hot weather.

Experimental colonies in the current study reached to highest level towards to end of nectar flow by exposing a regular improvement with regard to adult bee population. The best results in adult bee population were obtained in H-F. The average adult bee population with regard to hive types was 17.46±6.59 in insulated beehives and 16.44±5.96 in wooden beehives (Table 3). The results of adult bee population in group H-F was found higher than previous trials carried out by different researchers (Guler, 2000; Sahinler and Kaya, 2001; Dodologlu and Genc, 2002; Dodologlu *et al*., 2004).

The brood area growth and flight activity was higher in group H-F than those of other groups. Brood area growth and flight activity in insulated hives was found higher than wooden beehives. According to results, obtained in the present study, the best period in brood growth was during nectar flow session. This result is

Table 2: Maximum and minimum internal hive temperature and humidity

		$\bar{x}\pm S\bar{x}$			
Groups	n	Maximum temperature (°C)	Minimum temperature (°C)	Maximum humidity (%)	Minimum humidity (%)
W-1	81	38.99±2.81	20.53±2.09	67.39±10.70	25.05±4.77
W-2	81	36.95±2.63	22.79±1.69	61.88±9.830	24.77±2.80
W-3	81	35.33±2.68	22.69±1.53	56.66±8.590	24.67±2.68
Average	243	37.09±3.42	22.00±2.07	61.97±10.65	24.83±3.54
I-1	81	37.67±3.09	21.48±1.99	70.53±9.080	24.53±2.45
I-2	81	36.06±2.37	22.78±1.66	63.59±9.390	25.09±3.30
I-3	81	34.20±1.48	24.08±1.51	58.48±8.250	25.38±6.00
Average	243	35.98±2.78	22.74±2.03	64.18±10.18	25.00±4.19
Hive type					
Wooden	243	37.09±3.42	22.00±2.07	61.97±10.65	24.83±3.54
Insulated	243	35.98±2.78	22.74±2.03	64.18±10.18	25.00±4.19
Average	486	36.53±3.17	22.37±2.06	63.08±10.44	24.91±3.87
Applications					
C	162	38.34±3.88[a]	21.00±2.0.9[a]	68.96±9.980[a]	24.79±3.79[a]
H	162	36.50±2.48[b]	22.72±1.69[b]	62.71±9.620[b]	24.93±3.05[a]
H-F	162	34.77±1.60[c]	23.38±1.67[c]	57.57±8.440[c]	25.02±4.65[a]
Average	486	36.53±3.17	22.37±2.07	63.15±10.47	24.91±3.87

[a,b,c]Means in each column followed by the same letter are significantly different ($p<0.05$)

Table 3: Brood area growth and the number frames covered with bees

		$\bar{x}\pm S\bar{x}$*			
Groups	n	June	July	August	Mean
Applications					
C	14	9	16.43±1.28[a]	20.00±1.71[a]	15.14±4.73
H	14	9	18.86±1.70[b]	23.07±1.77[b]	16.98±6.05
H-F	14	9	20.93±1.44[c]	26.29±1.77[c]	18.74±7.34
Average	42	9	18.74±2.36[b]	23.12±3.11[c]	16.95±6.31
Wooden beehives					
W-1	7	9	15.57±1.13	18.86±1.35	14.48±4.20
W-2	7	9	18.29±1.38	22.86±1.57	16.71±5.87
W-3	7	9	20.00±1.41	25.43±1.33	18.14±6.90
Average	21	9	18.15±2.11	22.65±2.87	16.44±5.96
Insulated beehives					
I-1	7	9	17.28±0.76	21.14±1.21	15.81±5.12
I-2	7	9	19.43±1.90	23.29±2.05	17.24±6.22
I-3	7	9	21.86±0.69	27.14±1.95	19.33±7.70
Average	21	9	19.52±2.25	23.86±3.05	17.46±6.59

*Means in each column followed by the same letter are significantly different ($p<0.05$)

Table 4: The results of weight gain during nectar period (kg colony^{-1}), number of foraging honeybees and honey yield (kg colony^{-1})

Factors	n	Weight gain $\bar{x}\pm S\bar{x}$*	Number of foragers $\bar{x}\pm S\bar{x}$	Honey yield $\bar{x}\pm S\bar{x}$
Hive types				
Wooden	21	40.89±11.00	84.00±23.96	20.30±5.48
Insulated	21	45.69±13.84	90.38±24.09	21.96±6.56
Average	42	43.29±12.59	87.19±23.95	21.13±6.02
Applications				
C	14	29.51±4.07[a]	74.79±19.80[a]	14.61±1.71[a]
H	14	42.81±3.37[b]	85.36±27.34[bc]	20.63±1.99[b]
H-F	14	57.54±6.95[c]	101.43±16.78[c]	28.14±2.97[c]
Average	42	43.29±12.59	87.19±23.95	21.13±6.02
Wooden beehives				
W-1	7	28.64±3.38	71.00±20.89	14.24±1.77
W-2	7	40.66±2.78	82.14±29.84	20.57±1.49
W-3	7	53.37±5.24	98.86±11.31	26.59±2.42
Average	21	40.89±3.80	84.00±23.96	20.46±1.89
Insulated beehives				
I-1	7	30.39±4.76	78.57±19.48	14.99±1.70
I-2	7	44.96±2.47	88.57±26.55	21.20±2.37
I-3	7	61.71±6.05	104.00±21.60	29.70±2.75
Average	21	43.29±12.59	90.38±24.09	21.13±6.02

*Means in each column followed by the same letter are significantly different ($p<0.05$)

similar to the results obtained by Genc *et al*. (1999). The results of average brood activities in current study are higher than the results reported by numerous researchers (Guler and Kaftanoglu, 1999; Karacaoglu *et al*., 2003). Regarding to flight activity, the results obtained in the present study was higher the findings recorded by Dodologlu *et al.* (2004) but lower than those reported by Dodologlu and Genc (2002). The highest weight gain during nectar flow period was recorded also in H-F. On the other hand, the highest and lowest weight gain during nectar flow was obtained in I-3 and W-1, respectively (Table 4). However, these findings are lower than the results obtained by Dodologlu and Genc (2002) and Dodologlu *et al.* (2004).

Since, internal hive temperature and humidity was suitable, honeybees housed in HF had many foragers and they carried more water and nectar compared to other colony groups. Likewise, the highest honey yield (28.14±2.97) was recorded in group H-F and there was a significant difference ($p<0.05$) between application groups

(C, H and H-F). Among hive types, the highest honey yield was obtained in insulated hives and this result was higher than a previous study reported by Chaudhary (2001) and lower than the findings by Wineman *et al.* (2003).

CONCLUSION

Consequently, there are little technologic researches about internal hive comfort. In the current study, significant differences were found between applications and control groups in favor of applications. Internal hive temperature and humidity and ventilation of the hive plays very important role on honey bee behaviors. We think that the results contained in the present study could give fundamental information to beekeepers and technologic researches in beekeeping in the future.

REFERENCES

Cetin, U., 2004. The effects of temperature changes to bee losts. Uludag Bee J., 4 (4): 171-174.

Chaudhary, O.P., 2001. Performance and prospects of *Apis mellifera* L. in South Western Hayrana. Haryana Agric. Univ. J. Res., 30 (3-4): 89-97.

Detroy, B.F., E.H. Erickson and K. Diehnelt, 1982. Plastic hive covers for outdoor wintering of honey bees. Am. Bee J., 122: 583-587.

Dodologlu, A. and F. Genc, 2002. Some physiological characteristics of Caucasian and Anatolian Honeybee (*Apis mellifera* L.) races and their crossbreeds. Turk. J. Vet. Anim. Sci., 26: 715-722.

Dodologlu, A., C. Dulger and F. Genc, 2004. Colony condition and bee behavior in honey bees (*Apis mellifera* L.) housed in wooden or polystyrene hives and fed 'bee cake' or syrup. J. Apicult. Res., 43 (1): 3-8.

Duncan, D.B., 1995. Multiple range and multiple F-tests. Biometrics, 11: 1-42.

Esch, H.E., F. Goller and B. Heinrich, 1991. How do bees shiver? Naturwissenschaften, 78: 325-328.

Fresnaye, J. and Y. Lensky, 1961. Methods 'Appreciation des Surfaces de vain Dans les colonies Abeilles. Ann. Abeille, 4: 369-376.

Genc, F. and A. Aksoy, 1993. Some of the correlations betwen the colony development and honey production on the honeybee (*Apis mellifera* L.) colonies. Apiacta, 28: 33-41.

Genc, F., C. Dulger, S. Kutluca and A. Dodologlu, 1999. Comparison of behavior features of Caucasian, Middle Anatolia and Erzurum Honeybee (*Apis mellifera* L.) genotypes in Erzurum conditions. Turk. J. Vet. Anim. Sci., 23 (4): 651-656.

Gorgulu, O. and N. Sahinler, 2006. Repeated measures analysis and some experimental design considerations in animal sciences. Kirgizistan-Turkiye Manas Universitesi Fen Bilimleri Dergisi, 7: 77-97.

Guler, A. and O. Kaftanoglu, 1999. Morphological characters of some important races and ecotypes of Turkish honeybees (*Apis mellifera* L.) -I. Turk. J. Vet. Anim. Sci., 23 (3): 565-570.

Guler, A., 2000. The effects of narrowed area and additional feeding on some physiological characteristics of honey bee (*Apis mellifera L.*) colonies. Turk. J. Vet. Anim. Sci., 42 (1): 1-6.

Hazelhoff, E.H., 1954. Ventilation in a bee-hive during summer. Physiologia Comparata et Oecologi, 3: 343-364.

Heinrich, B., 1993. Comfort in a Hive: Heads you're hot, tails you're cold. Natural History, 102 (8): 53-54.

Himmer, A., 1926. Der soziale Wärmehaushalt der Honigbiene. I. Die Wärme in nicht-brütenden Wintervolk. Erlanger Jahrbuch für Bienenkunde, 4: 1-51.

Karacaoglu, M., H.V. Gencer and A.U. Koc, 2003. Effects of supplemental feeding on brood production and honey yield of honey bee (*Apis mellifera* L.) colonies in the Aegean Region. J. Anim. Prod., 44 (2): 47-54.

Owens, C.D., 1971. The thermology of wintering honey bee colonies. USDA Technol. Bull. No. 1429, pp: 1- 32.

Sahinler, N. and S. Kaya, 2001. The effects of supplementary feeding on honeybee (*Apis mellifera* L.) colony performance. Ziraat Fakultesi Dergisi, Mustafa Kemal Universitesi, 6 (1-2): 83-92.

Seeley, T.D. and B. Heinrich, 1981. Regulation of Temperature in the Nests of Social Insects. In: Heinrich, B. (Ed.). Insect Thermoregulation New York, pp: 159-234.

Seeley, T.D., 1985. Honeybee ecology: A study of adaptation in social life. Princeton University Press. Princeton. N.J, pp: 31-36.

Southwick, E.E., 1982. Metabolic energy of intact honeybee colonies. Comparative Biochem. Physiol., 71: 277-281.

Villumstad, E., 1974. Importance of hive insulation for wintering. development and honey yield in Norway. Apiacta, 9: 116-118.

Wineman, E., Y. Lenski and Y. Mahrer, 2003. Solar heating of honey bee colonies (*Apis mellifera* L.) during the subtropical winter and its impact on hive temperature. worker population and honey production. Am. Bee J., 143: 565-570.