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ENGINEERING STUDIES ON HONEYBEE HIVES

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ABSTRACT: **The present work was carried out in a private apiary located at El-Tamaneen locality, Abou-Hammad, Sharkia during 2004-2005 to evaluate the suitability of three engineering modifications carried out on Langstroth hive to optimize the microclimate of the colonies.**

Flight activity of honeybee colonies housed in the modified hives, expressed as the number of incoming foragers with or without pollen loads during the four seasons i.e. spring, summer, autumn and winter was assessed.

Records of brood nest temperature, hive temperature and hive relative humidity cleared that the most suitable model was the completely isolated (model, A) during autumn and winter and the completely isolated with two ventilating openings (model, B) during spring and summer. Data revealed percent increases ranges of 60.10 – 110.80, 22.00 – 134.80 and 19.77 – 42.10 % for incoming unloaded foragers, and 28.92 – 179.20, 14.78 – 163.10 and 16.94 – 72.49 % for incoming pollen loaded foragers were recorded in this parameter for the colonies housed in hive models A, B and C (semi-isolated), respectively over that of the control colonies.

Increases of 30.38 – 41.97 % were recorded in the total honey yield of the isolated colonies over that of the control colonies. Accordingly, the financial evaluation indicated that the return per colony ranged between 30.90 – 44.93 LE/colony, and the return per pound ranged from 7.54 – 18.47 LE/colony in the year of running this investigation according to the isolating system.

Key words: Honeybee hives, thermoregulation, ventilating openings, fabricating costs, thermo isolation, return per colony.

INTRODUCTION

Honeybees are cold-blooded animals living in general outdoors. So, they are greatly affected by the changes in the climate because they are obligated to adapt their microclimate, which becomes ever changing, to be suitable for them and their blood. Therefore, the microclimate of honeybee colonies is still in need for more and more studies to assess the effect of the ever changing environmental factors on their microclimate, and to investigate whatever the subsequent effects of these changes on biological, morphometerical, physiological, behavioral and productivity aspects of the individual worker bee and colony (Komisar, 1991; Southwick, 1991; Chuda Mickiewicz *et al.,* 1995, and Dodologlu *et al.*, 2004).

One of the main purposes of the behavioral and microclimatic studies for honeybee colonies inside and outside the hive is to determine the most suitable habitat for honeybees to survive and reproduce to maintain their kind.

From this standpoint, the present work was designed to investigate the influence of housing honeybee colonies in different isolating systems (completely isolated hive with or without ventilating openings and semi isolated hive) on the aforementioned aspects during the year of 2004-2005.

MATERIALS AND METHODS

The present investigation was carried out during 2004-2005. Fabricating the test hives was carried out in a private carpenter workshop at El-Salhia, Facous, Sharkia. However, evaluating suitability of the fabricated hives for inhabiting honeybee colonies and their effect on colony productivity were investigated in a private apiary located at El-Tamaneen, Abou-Hammad, Sharkia.

Materials

Wood

Two types of wood of different thicknesses were used in the experiment, the first one was white wood (k = 0.12 $W.m^{-1}.K^{-1}$, cp = 1.380 $J.kg^{-1}.k^{-1}$) of 1cm thickness used for fabricating the walls of the hive and the cover rim. The second one was plywood (k = 0.12 $W.m^{-1}.K^{-1}$, cp = 1.215 $J.kg^{-1}.k^{-1}$) of 3mm thickness used for fabricating the cover and the base of the hive.

Isolating material

Foam sheets of a thermal conductivity (0.038 Wm^{-1} K^{-1}) and 1cm thickness were used as a thermal isolator.

Measuring devices

Thermometer

A total of 33 Celsius thermometers were used for measuring temperature outside hives, inside hives within brood nest and in the empty part. These thermometers act by ether liquid, and their length are 30 cm and have 5 mm diameter.

Hygrometer

A total of 17 hygrometers were used for measuring the relative humidity directly inside (in the empty part) and outside the hive.

Test honeybee hives

Engineering modifications were carried out on the wooden Langstroth bee hive in order to make a complete or partial thermal isolation for the hive, (Fig. 1) as follows:

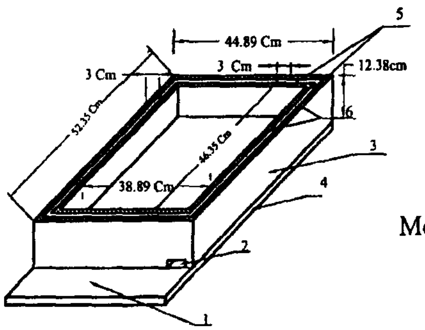
Type (A): In this type the walls of the four sides of Langstroth hive were made of three layers as follows: the outer and the inner layers were from wood sheets of 1 cm thickness, whereas the median layer was a sheet of foam 1 cm thickness. Moreover, a sheet of foam was placed between two plates of plywood of 3mm thickness under the metal layer (zinc lid) of the outer cover of the hive.

Type (B): As in (A) in addition to two ventilating openings (5x10 cm) each mostly made in the middle of the fore and back walls of the hive. Each opening was covered with a wire screen mesh to prevent bees inside from getting outside and to prevent the entry of honeybee pests inside the hive.

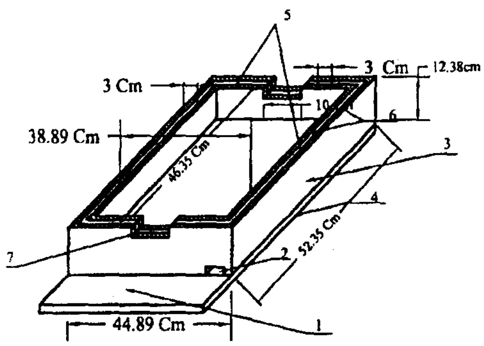
A plug of wood of 5x10 cm was made for each opening to close it during cold and rainy season.

Type (C): In this type foam sheets were put in the two sides and the outer cover only with no ventilating openings.

Type (D): A normal common Langstroth hive without any modifications was used as a control. Two holes were made in the mid back wall of all hives of the four types, the two holes are of a suitable diameter to enable the insertion of a thermometer.

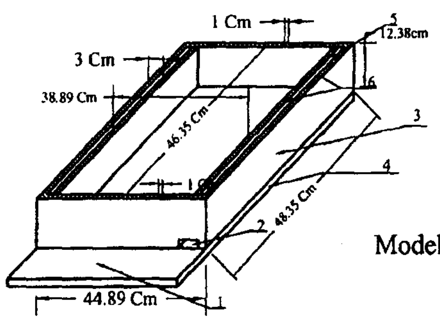


Model (A): Completely isolated hive.



1- Flying board
2- Hive entrance
3- Hive walls
4- Hive base
5- Isolating material
6- Wood
7- Ventilating opening

Model (B): Completely isolated hive with two ventilating openings.



Model (C): Semi-isolated hive.

Fig. 1. Isolating systems models A, B and C.

The first hole lies between the 3rd and the 4th combs to measure the temperature inside the core of brood nest, the second hole lies between the 9th and the 10th combs to be in the empty space out of the combs place.

Honeybee colonies

A total of sixteen honeybee (*Apis mellifera* L.) colonies of 8 combs covered with bees were established during February, 2004 and nearly all were equal in strength. The established colonies were headed by mated young Carniolan sister queens (previously mated in a mating nuclei). The test colonies were divided randomly into four groups of four colonies each. The colonies of each group were housed in one of the above mentioned hive types.

Methods

Environmental Studies

Measuring of temperature

The measurements of temperature inside the core of brood nest, inside the hives (outside the brood nest) and outside the hives were taken at two hour intervals a day, weekly starting from 8 a.m. and lasted to 4 p.m., allover the experimental period from May 7, 2004 to February 25, 2005.

Air temperature outside the hives was read by a thermometer placed in the shade in the apiary.

Measuring of relative humidity

Relative humidity was measured using common hygrometers outside and inside the hive (in the empty place) housed by the experimental colonies. The readings were taken at two hour intervals a day, weekly starting from 8 a.m. and lasted to 4 p.m., during the period from May 7, 2004 to February 25, 2005.

Behavioral and Productivity Studies

Evaluating flight activity

Number of incoming (loaded and unloaded with pollen) bees of each test colony were counted during 1 minute periodically every 2-hour intervals a day, weekly, starting from 8 a.m. to 4 p.m. allover the experimental period extended from May 7, 2004 to February 25, 2005.

Estimating honey production

Citrus honey yield

Citrus flowering started from the 3rd week of March and lasted to the second week of April, when the honey yield was estimated for each experimental colony individually as follows:

On April 7, 2005, the surplus honey combs were taken from their respective colonies and marked with paint, the bees covering them were shaken off. Thereafter, honey yield was estimated for each colony separately (in kg/colony) by calculating the difference between the weight of honey combs before and after honey extraction.

Clover honey yield

After citrus honey extraction, the experimental colonies were fed twice on sucrose syrup (1:1) to protect bee colonies from starvation and to prepare such colonies for clover flow season.

Clover flow started at the beginning of May and lasted to the first week of June, when the honey yield was estimated for each experimental colony individually on June 6, 2005, following the same technique applied to harvest citrus honey yield.

Financial Evaluation (Feasibility Study)

The economic feasibility was evaluated for each isolated hive model separately, based on the outcomes and incomes according to the actual price.

Production costs (outcome)

The manufacturing costs of each isolating system were evaluated by calculating the costs of the materials used in manufacturing the hives as well as the manufacturing fees, it is taken in consideration discounting all the production costs as it is the same for all colonies housed in the modified and Langstroth hives.

Return (income)

Calculating of returns for each modified and Langstroth hives depends on citrus and clover honey yield. Returns from total honey yield were evaluated for all models A, B, C and D during the two studied production seasons (citrus and clover honey yield).

The financial evaluation of the tested hive models of the two studied production seasons was achieved by calculating the following measures according to Gittinger (1972) and Hassan (1997).

Net profit = *Total income - Total outcome*

$$\text{Benefit / cost ratio} = \frac{\text{Total income}}{\text{Total outcome}}$$

$$\text{Return per colony} = \frac{\text{Net profit}}{\text{No. of colonies}}$$

$$\text{Return per pound} = \frac{\text{Net profit}}{\text{Total outcome}}$$

RESULTS AND DISCUSSION

Obtained results will be discussed under the following items:

Effect of Isolating Models on Colony Microclimate

The effect on colony temperature

Spring season

Brood nest temperature

The mean of brood nest temperature during spring attained 34.01, 33.90, 35.62 and 36.44 °C for the colonies housed in the completely isolated hive model (A), completely isolated hive with two ventilating openings model (B), semi isolated hive model (C) and control model (D), respectively compared to the ambient temperature that was 27.52 °C, these increases may be due to breathing of the honeybee individuals (Table 1). Significant positive correlations were found between the ambient temperature and the brood nest temperature in models A and C and negative in models B and D.

Hive temperature (empty part)

The mean of hive temperature recorded 29.96, 29.09, 31.50 and 33.40 °C for hive models A, B, C and D housed with honeybee colonies, respectively compared to 27.52 °C as ambient temperature (Table 1). The (r) values between ambient (external) temperature and hive temperature recorded 0.740, 0.802*, 0.843* and 0.808* for the test hives, respectively.

Summer season

Brood nest temperature

The brood nest temperature during summer season averaged 34.98, 34.34, 36.24 and 36.43 °C for the colonies housed in the hive models A, B, C and D (Langstroth), respectively compared to 28.28 °C recorded for external temperature (Table 1). Brood nest temperature was significantly and highly significantly positively correlated to ambient temperature for colonies housed in hives models B, C and D recording 0.697**, 0.616* and 0.561*, respectively.

Table 1. Mean of brood nest temperature (B. N. temp.), hive temperature and hive RH % of the test isolating models as seasonal average during the year 2004-2005.

Season	Internal microclimate	A			B			C			D			External temperature	External RH %
		B. N. temp.	Hive temp.	Hive RH %	B. N. temp.	Hive temp.	Hive RH %	B. N. temp.	Hive temp.	Hive RH %	B. N. temp.	Hive temp.	Hive RH %		
Spring	Internal microclimate	34.01	29.96	60.07	33.90	29.09	58.81	35.62	31.50	61.33	36.44	33.40	62.40	27.52	56.64
	%± as control	- 6.69	- 10.28	- 3.74	- 6.98	- 12.9	- 5.76	- 2.25	- 5.68	- 1.72	0.00	0.00	0.00		
	r values *	0.829*	0.740	0.945**	- 0.623*	0.802*	0.979**	0.950**	0.843*	0.880**	- 0.363	0.808*	0.833*		
Summer	Internal microclimate	34.98	30.76	78.76	34.34	29.36	73.83	36.24	31.57	79.74	36.43	32.97	82.85	28.28	74.42
	%± as control	- 3.98	- 6.71	- 4.94	- 5.74	- 10.94	- 10.89	- 0.52	- 4.25	- 3.76	0.00	0.00	0.00		
	r values	0.385	0.923**	0.319	0.697**	0.951**	0.596*	0.616*	0.915**	0.020	0.561*	0.840**	0.207		
Autumn	Internal microclimate	35.77	25.81	82.84	34.21	24.84	77.62	36.79	26.82	83.69	35.86	27.66	85.20	24.04	78.38
	%± as control	- 0.22	- 6.69	- 2.77	- 4.60	- 10.18	- 8.89	+2.59	- 3.04	- 1.83	0.00	0.00	0.00		
	r values	- 0.660*	0.832**	0.774**	0.698**	0.992**	0.913**	0.283	0.990**	0.749**	0.608*	0.996**	0.897**		
Winter	Internal microclimate	38.74	23.04	85.96	35.97	19.59	80.28	37.89	21.88	91.76	36.45	20.96	93.76	18.11	80.95
	%± as control	+ 6.27	+ 9.91	- 8.32	- 1.34	- 6.55	- 14.38	+ 2.35	+ 4.39	- 2.13	0.00	0.00	0.00		
	r values	- 0.085	0.948**	0.953**	-0.059	0.883**	0.952**	0.105	0.947**	0.901**	0.069	0.900**	0.893**		

*** Correlation coefficient values between each of brood nest temperature, hive temperature, hive RH % and the ambient temperature and ambient RH %.**

Hive temperature (empty part)

The mean of temperature in the empty part of the hive housed by test colonies averaged 30.76, 29.36, 31.57 and 32.97 °C for models A, B, C and D hives, respectively compared to 28.28 °C recorded for external temperature (Table 1). Highly significant positive correlation was detected between ambient temperature and hive temperature in all models as it recorded 0.923**, 0.951**, 0.915** and 0.840**, for hive models A, B, C and D housed with honeybee colonies, respectively. However, hive models A, B and C decreased hive temperature by 6.71, 10.94 and 4.25 % as compared to that of the control (D), respectively.

Autumn season

Brood nest temperature

The mean of brood nest temperature in the colonies housed in the hive models A, B, C and D (control) attained 35.77, 34.21, 36.79 and 35.86 °C, respectively compared to 24.04 °C recorded for external temperature (Table 1). The (r) values between ambient (external) temperature and brood nest temperature recorded -0.660*, 0.698**, 0.283 and 0.608* for the test hives, respectively.

Hive temperature (empty part)

The mean of temperature in the empty part of the hive housed by test colonies was 25.81, 24.84, 26.82 and 27.66 °C for models A, B, C and D, respectively compared to 24.04 °C recorded for external temperature. Highly significant positive correlation was detected between ambient temperature and hive temperature in all models recording 0.832**, 0.992**, 0.990** and 0.996**, for colonies housed in the hive models A, B, C and D (Langstroth), respectively.

Winter season

Brood nest temperature

The brood nest temperature during winter season averaged 38.74, 35.97, 37.89 and 36.45 °C for the colonies housed in the hive models A, B, C and D (Langstroth), respectively compared to 18.11 °C recorded for external temperature. Insignificant and negative correlation coefficient values were detected between the ambient temperature and the brood nest temperature in all hive models.

Hive temperature (empty part)

The mean temperature in the empty part of the test hives housed by honeybee colonies averaged

23.04, 19.59, 21.88 and 20.96 °C for models A, B, C and D hives, respectively compared to 18.11 °C recorded for external temperature (Table 1). Hive temperature was highly significant positively correlated to ambient temperature in models A, B, C and D as it recorded 0.948**, 0.883**, 0.947** and 0.900**, respectively. However, hive models A and C increased hive temperature by 9.91 and 4.39 % as compared to that of the control (D), respectively.

The effect on colony relative humidity

Spring season

Data obtained and presented in Table 1 clear that the mean relative humidity inside the hive during spring attained 60.07, 58.81, 61.33 and 62.40 % in the hive models A, B, C and D, respectively compared to 56.64 % the ambient RH %. Mostly highly significant positive correlation coefficient values were detected between the ambient relative humidity and relative humidity inside the hive in all models A, B, C and D as it recorded 0.945**, 0.979**, 0.880** and 0.833*, respectively.

Summer season

The mean hive relative humidity recorded 78.76, 73.83, 79.74 and 82.85 % for hive models A, B, C and D housed with honeybee colonies, respectively compared to 74.42 % as ambient relative humidity Table, 1. The (r) values between ambient (external) RH % and hive relative humidity recorded 0.319, 0.596*, 0.020 and 0.207 for the test hives A, B, C and D, respectively.

Autumn season

The mean hive relative humidity averaged 82.84, 77.62, 83.69 and 85.20 % in models A, B, C and D, respectively compared to 78.38 % recorded for external relative humidity (Table 1). Highly significant positive correlation was detected between the ambient relative humidity and relative humidity inside the hive in all models recording 774**, 0.913**, 0.749** and 0.897**, for models A, B, C and D, respectively. However, hives models A, B and C decreased hive relative humidity by 2.77, 8.89 and 1.83 % as compared to that of the control (D), respectively.

Winter season

The mean hive relative humidity during winter attained 85.96, 80.28, 91.76 and 93.76 % in the hive models A, B, C and D, respectively compared to 80.95 % (the ambient RH %), (Table 1). Highly significant positive correlation coefficient values were detected between the ambient relative humidity and relative humidity inside the hive in models A, B, C and D, recording 0.953**, 0.952**, 0.901** and 0.893**, respectively.

Obtained results are supported by Zhadanova (1969) who mentioned that during spring the average temperature of the center of the hive was 33 °C, and of the periphery about 2°C lower. During the main flow there was a temperature gradient from top to bottom of the hive. The author stated also that most wax was produced at 35-36°C then the temperature fell to 33-34°C lower than for brood. Similarly, Johansson and Johansson (1979) said that in summer the brood nest of the colony was maintained at 34-35°C with as little variation as 0.2-0.4°C. Even when external temperatures were 40.5°C there was a variation of only 1.5-3°C. Also, Chuda Mickiewicz *et al.* (1995) stated that the environmental temperature modifies the thermal conditions of the nest and affects the contractions of bees in the winter cluster. They added that the increase of environmental temperature by 1°C in the positive temperature period (up to +6.8°C) caused an increase of temperature of the nest by 0.31°C.

Effect of Isolating Models on Flight Activity and Honey Production

The effect on flight activity

Flight activity was recorded by counting the number of incoming foragers unloaded and loaded with pollen to each test hive during one minute at 2-hour intervals a day weekly during the four seasons of the study (Table 2).

Spring season

Incoming unloaded foragers

Data presented in Table 2 revealed that the mean seasonal number was 27.58, 34.81, 21.88 and 17.03 bees/min/colony for the colonies housed in the hive models A, B, C and D (control), respectively. The increase in this parameter attained 61.95, 104.4 and 28.46 % for colonies housed in models A, B and C over that of the control colony (D).

Table 2. Mean number of incoming foragers without (N) and with (P) pollen loads per minute at 2 hour intervals a day weekly during the four seasons.

Season		Isolating models											
		A			B			C			D		
		N	P	Total	N	P	Total	N	P	Total	N	P	Total
Spring	Average	27.58	3.33	30.91	34.81	4.80	39.61	21.88	2.37	24.25	17.03	1.82	18.85
	%± as Control	61.95	82.31	63.98	104.40	163.10	101.00	28.46	30.20	28.64	0.00	0.00	0.00
Summer	Average	56.18	21.56	77.74	81.82	20.25	102.07	44.51	15.71	60.22	34.84	9.11	43.95
	%± as Control	61.23	136.70	76.88	134.80	122.40	132.20	27.75	72.49	34.01	0.00	0.00	0.00
Autumn	Average	41.53	7.06	48.59	46.26	6.28	52.54	31.06	6.40	37.46	25.94	5.47	31.41
	%± as Control	60.10	28.92	54.69	78.35	14.78	67.27	19.77	16.94	19.26	0.00	0.00	0.00
Winter	Average	60.11	13.30	73.41	34.78	5.83	40.61	40.52	7.59	48.11	28.51	4.76	33.27
	%± as Control	110.80	179.20	120.60	22.00	22.50	22.06	42.10	59.32	44.60	0.00	0.00	0.00

Incoming loaded foragers

The mean seasonal number of incoming loaded foragers during spring season was 3.33, 4.80 and 2.37 bees/min/colony for the colonies hived in hive models A, B and C, respectively compared to 1.82 bees/min/colony recorded for Langstroth hive (D) (Table 2). The respective increases in this parameter attained 82.31, 163.1 and 30.2 % over that of the control colonies.

Summer season

Incoming unloaded foragers

The mean seasonal number of incoming unloaded foragers recorded 56.18, 81.82 and 44.51 bees/min/colony for the modified hive models A, B and C, respectively compared to 34.84 bees/min/colony (control). Modified hive models A, B and C recorded increases reached 61.23, 134.8 and 27.75 %, respectively in this parameter as compared to that of the control colonies (Langstroth hives).

Incoming loaded foragers

The mean seasonal number of incoming loaded foragers during summer reached 21.56, 20.25 and 15.71 bees/min/colony for the modified hive models A, B and C, respectively compared to 9.11 foragers/min/control colony (D). The corresponding increase in this parameter attained 136.7, 122.4 and 72.49 % over that of the control colonies (Table 2).

Autumn season

Incoming unloaded foragers

The mean seasonal number of incoming unloaded foragers recorded 41.53, 46.26 and 31.06 bees/min/colony for the colonies housed in the isolated models A, B and C, respectively compared to 25.94 bees/min/colony recorded for the control colony (D). However, modified hives showed obvious increases in number of incoming unloaded foragers of 60.1, 78.35 and 19.77 % for colonies housed in the modified hive models A, B and C, respectively over that of the control colonies (D). Data are shown in (Table 2).

Incoming loaded foragers

The mean seasonal number of incoming pollen loaded foragers recorded 7.06, 6.28, 6.4 and 5.47 bees/min/colony for colonies housed in test hive models A, B, C and D, respectively (Table 2). Increases of 28.92, 14.78 and 16.94 % were recorded for modified hive models A, B and C, respectively over that of the control colonies model (D).

Winter season

Incoming unloaded foragers

The mean seasonal number of incoming unloaded foragers recorded 60.11, 34.78 and 40.52 bees/min/colony for the modified hive models A, B and C, respectively compared to 28.51 bees/min/colony recorded for the control colonies (D). The respective increases in this parameter attained 110.8, 22.0 and 42.1 % over that of the control colony, (Table 2).

Incoming loaded foragers

The mean seasonal number of incoming pollen loaded foragers recorded 13.3, 5.83 and 7.59 bees/min/colony for honeybee colonies housed in the hive models A, B and C, respectively compared to 4.76 bees/min/colony for control hives (Table 2). The corresponding increases in this parameter attained 179.2, 22.5 and 59.32 % over that of the control colony.

Generally, during spring season, the correlation coefficient values (r) between foraging activity (number of incoming pollen loaded and unloaded workers) and brood nest and inside hive temperature was mostly insignificant in all isolating models. On the other hand, this activity was mostly positively significant and highly significant with RH % (Table 3). During summer season the inverse is true. in addition, during autumn season the correlation between the two weather factors and flight activity was insignificant although it varied between negative (specially with brood nest temperature) and positive relationship. During winter season this relationship was mostly negative significant with brood nest temperature especially in the completely isolated model being weak insignificant in case of control hives and rarely negatively significant with relative humidity (Table 3).

In this respect, Whang and Chaol (1988) mentioned that foraging activity was correlated with temperature, relative humidity, and solar radiation intensity, but not with wind velocity in a very hot period in May in Korea Republic. Moreover, Kaur and Sihag (1994) determined the foraging activity in 9 *Apis mellifera* colonies and also ambient temperature and relative humidity, every 2 h per day each

Table 3. Correlation coefficient values (r) between each of brood nest temperature, temperature inside the hive (empty place), RH % inside the hive and flight activity (pollen loaded and unloaded) of test models A, B and C and control D during the four seasons of 2004/2005

Isolating models	Seasonal flight activity	Spring			Summer			Autumn			Winter		
		Brood nest temp.	Inside hive temp.	hive RH %	Brood nest temp.	Inside hive temp.	hive RH %	Brood nest temp.	Inside hive temp.	hive RH %	Brood nest temp.	Inside hive temp.	hive RH %
(A)	With pollen loads	0.026	-0.265	0.933**	0.160	0.560*	-0.348	0.029	-0.358	0.282	-0.792**	0.247	0.237
	Without pollen loads	0.142	0.007	0.419	0.391	0.724*	-0.090	-0.346	0.040	0.011	-0.441	0.301	-0.352
	Total	0.141	-0.052	0.604*	0.347	0.754**	-0.210	-0.293	-0.116	0.129	-0.725*	0.329	-0.089
(B)	With pollen loads	0.329	0.112	0.861**	0.766**	0.485	-0.112	-0.029	-0.358	0.005	-0.196	0.062	-0.202
	Without pollen loads	0.080	0.175	0.481	0.764**	0.667*	-0.019	-0.145	0.161	-0.205	0.746*	-0.109	-0.252
	Total	0.161	0.197	0.682*	0.841**	0.684*	-0.047	-0.159	0.043	-0.209	0.576	-0.074	-0.278
(C)	With pollen loads	0.256	0.201	0.794**	0.275	0.588*	-0.315	-0.330	-0.254	0.240	-0.652*	0.590	-0.085
	Without pollen loads	0.009	0.041	0.735*	0.402	0.700*	-0.387	-.509	0.054	-0.088	-0.341	0.389	-0.605*
	Total	0.086	0.096	0.854**	0.382	0.709**	-0.388	-0.526	-0.053	0.022	-0.497	0.512	-.0497
(D)	With pollen loads	0.625*	0.340	0.469	0.751**	0.495	-0.140	-0.260	0.032	0.233	0.271	0.057	0.029
	Without pollen loads	0.187	-0.114	0.616	0.582*	0.501	-0.046	0.206	0.488	-0.086	0.202	-0.317	-0.162
	Total	0.290	-0.020	0.610	0.690*	0.540	-0.083	0.020	0.404	0.061	0.245	-0.252	-0.129

week. They found that total number of foraging (F) and number of pollen foragers (P) was each positively and highly significantly correlated with temperature and negatively and highly significant with relative humidity. The number of nectar foragers (N) showed a similar correlation with relative humidity. P was negatively correlated with N and also with F, the correlation between N and F was positive and highly significant.

The effect on honey production

Honey production was detected by calculating the difference between weight of honey combs before and after extraction process (Table 4).

Citrus honey yield

The mean yield of citrus honey weighed 4.025, 3.008 and 3.708 kg/colony for the colonies housed in hive models A, B and C, respectively compared to 2.816 kg/colony recorded for control colony (D). The respective increases in this parameter attained 42.93, 6.82 and 31.67 % over that of the control colonies. Statistical analysis in this parameter showed that the L.S.D. value was 1.111, (Table 4).

Clover honey yield

The mean weight of clover honey yield recorded 2.517, 3.000, 2.442 and 1.792 kg/colony for the colonies housed in the test hive models A, B, C and D, respectively. Increases of 40.46, 67.41 and 36.27 % were recorded in the clover honey yield of the colonies housed in the isolated hive models A, B and C, respectively (Table 4).

The total annual honey yield attained 6.542, 6.008 and 6.150 kg/colony for colonies housed in the modified hives A, B and C, respectively compared to 4.608 kg/colony recorded for control colony. The respective increases in favour of the isolated hives reached 41.97, 30.38 and 33.46 % over that of the control colony; these increases were detected because of optimization of hive microclimate as it possible and its suitability for living of colony individuals allover the year (Table 4).

In this respect, Dodologlu *et al.* (2004) reported that colonies housed in wooden hives achieved

superior performance over polystyrene hives as measured by overwintering colony survival, winter population loss, brood area,

Table 4. Honey yield (Kg) and percentage of increase in the yield during 2005 based on control as 100 %.

Kind of honey	Isolating models								
	A		B		C		D		
	Kg	% ±*	Kg	% ±	Kg	% ±	Kg	% ±	L.S.D.
Citrus honey	4.025	+ 42.93	3.008	+ 6.82	3.708	+ 31.67	2.816	0.00	1.111
Clover honey	2.517	+ 40.46	3.000	+ 67.41	2.442	+ 36.27	1.792	0.00	N.S.
Total honey yield	6.542	+ 41.97	6.008	+ 30.38	6.150	+ 33.46	4.608	0.00	1.200

% ±* increase as compared to that of control.

number of frames of bees and low defensiveness. Although, Kleinschmidt (1993) disagreed with the obtained results as he stated that hive design had no effect on honey production.

Financial Evaluation

Regarding the financial evaluation, data presented in (Table 5) cleared that the mean manufacturing costs of the esigned hive models recorded 109.25, 116.00 and 94.75 LE for hive models A, B and C, respectively compared to 75 LE as the market price of Langstroth hive (control).

Calculating the return per colony and per pound basing upon the increase in the fabricating costs over the control and the increase as compared to that of the control colonies cleared that the return per colony attained 44.93, 30.90 and 36.58 LE for the hive models A, B and C, respectively. The corresponding return per pound attained 13.10, 7.54 and 18.47 LE for the hive models A, B and C, respectively.

Conclusion

It is obvious that the completely isolated hives proved to be more suitable model for cold months as it enabled honeybee colonies thermoregulate their habitat that positively affected the flight activity; moreover, they recorded the highest productivity of citrus honey yield. Whereas, the

Table 5. Financial evaluation for fabricating of isolated hive models during the year 2004-2005.

Isolating models	Outcomes								Incomes				Benefits		
	Materials					Fabricating costs (LE)	Total costs (LE)	Costs increase over the control (LE)	Hive annual consumption (10%) (LE)	Annual honey yield (Kg)	Increase in honey yield over the control (Kg)	Price of increased honey yield (LE) [P]	Benefit / cost ratio	Return per colony (LE)	Return per pound (LE)
	Wood	Plywood	Isolating material	Zinc plate	Wire screen mesh										
A	46.50	17.25	9.00	10.50	----	26.00	109.25	34.25	3.43	6.542	1.934	48.35	14.12	44.93	13.10
B	46.50	17.25	9.00	10.50	1.75	31.00	116.00	41.00	4.10	6.008	1.400	35.00	8.54	30.90	7.54
C	42.75	17.25	7.25	10.50	----	17.00	94.75	19.75	1.98	6.150	1.542	38.55	19.52	36.58	18.47
D							75.00	0.00	0.00	4.608	0.000	0.00	0.00	0.00	0.00

- Discounting all the production costs as it is the same for all colonies housed in the modified and Langstroth hives except that of the materials used in manufacturing the hives as well as the manufacturing fees.

[P] Price of (1 kg) pure honey is calculated as (25 LE) depending upon the market price, in the year of running this investigation.

completely isolated hives with two ventilating openings indicated the best thermoregulation during hot months where the fore and back openings helped in reducing high temperature inside the hives and within brood nest and also succeeded in reducing moisture inside the hives to avoid microbial infections and to be more suitable for honeybee, so they recorded the highest flight activity and realized the best productivity of clover honey yield.

Therefore, it is advisable to utilize of the completely isolated hives with two ventilating openings during the warmer periods and to plug the ventilating openings during cold months to protect the colonies from cold streams.

REFERENCES

Chuda Mickiewicz, B.; Prabucki,J. and Kostrzewa, Z. 1995. Response of a honeybee colony (*Apis mellifera*) to environmental temperature variation. *Pszczelnicze Zeszyty Naukowe.; 37: 51 – 63.*

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

Gittinger, J.P. 1972. Economic analysis of agricultural projects. *A world Bank Publication, Washington.*

Hassan, A.R. 1997. Studies on division and package production in honey bee. *M. Sc. Thesis, Fac. Agric., Zagazig Univ., Zagazig, Egypt.*

Johansson, T.S.K. and M.F. Johansson 1979. The honeybee colony in summer. *Bee world, 60 (4) : 155-170.*

Kaur, G. and Sihag, R.C. (1994). Effect of weather factors on the colony foraging of honeybee (*Apis mellifera* L.). *Indian bee J. 56 (3/4) : 158- 162.*

Kleinschmidt, G. 1993. Influence of hive design & hive position on pallet on honey production on the Atherton Tableland. *Australian Beekeeper.; 95 (3) : 111 - 113, 115.*

Komisar, A. 1991. The temperature preference of honeybees in a winter cluster. *Vestnik Zodogii. No. 4, 64-69. (AA 912/94)*

Kaviany, M. 2002. Principles of Heat Transfer. *Dept. Michanical Engineering, Univ. Michigan,* *Ann Arbor. 916 - 937.*

Southwick, E.E. 1991. The colony as a thermoregulating super organism. *Royal Entomological Society of London and the International Bee Research Association, 28-47. ISBN 0-85198-7214.*

Whang, S.M. and Chaol, S.Y. 1988. Relationship between honeybee foraging activity on *Cercis chinensis* and weather conditions. *Korean J. of Apic. 3 (2) : 7-10.*

Zhadanova, T.S. 1969. Optimal conditions for artificial queen rearing. Trudytatar Respub. Gos. Sel : Khoz. Opyt. Sta. (2) : 476-484. In Russian. Apic. Abst. 698 – 23/1972.

دراسات هندسية على خلايا نحل العسل

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تم إجراء هذا البحث بمنحل خاص بناحية التمانين مركز أبو حماد محافظة الشرقية خلال ٢٠٠٤ – ٢٠٠٥. بغرض تقييم ملائمة ثلاث تحورات هندسية أجريت على خلية لانجستروث القياسية لتوفير بيئة ملائمة لطائفة نحل العسل.

قدر نشاط الطيران لطوائف نحل العسل المسكنة في الخلايا المعدلة على أساس عدد الشغالات العائدة (محملة وغير محملة بحبوب اللقاح) خلال فصول السنة الأربعة (الربيع والصيف والخريف والشتاء).

وقد أظهرت درجة الحرارة داخل عش الحضنة وداخل الخلية والرطوبة النسبية داخل الخلية أن أفضل نظام عزل كان العزل الكامل خلال فصلي الخريف والشتاء بينما العزل الكامل والمزود بفتحتي تهويه كان الأنسب لفصلي الربيع والصيف. وقد أوضحت النتائج زيادة في نشاط الطيران تراوحت بين ٦٠,١٠ – ١١٠,٨٠ ، ٢٢,٠٠ – ١٣٤,٨٠ ، ١٩,٧٧ – ٤٢,١٠ % للشغالات غير المحملة بحبوب اللقاح و٢٨,٩٢ – ١٧٩,٢٠ ، ١٤,٧٨ – ١٦٣,١٠ ، ١٦,٩٤ – ٧٢,٤٩% لجامعات حبوب اللقاح تم تسجيلها في هذا المؤشر لطوائف نحل العسل المسكنة في الخلايا طرز AوB وC على الترتيب، عن الخلية المقارنة.

كما قدرت الزيادة في الإنتاج السنوي من العسل بنسبة تراوحت بين ٣٠,٣٨ – ٤١,٩٧ % لطوائف نحل العسل المسكنة في الخلايا المعدلة وذلك عن الخلية المقارنة (لانجستروث). وفقاً لذلك فقد اتضح من التقييم المالي أن العائد على الطائفة قد تراوح من ٣٠,٩٠ – ٤٤,٩٣ جنيه مصري، كما تراوح العائد على الجنيه بين ٧,٥٤ – ١٨,٤٧ جنيه مصري وذلك خلال عام الدراسة على حسب نظام العزل للخلايا.