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Research Article
Impact of Arid Land Conditions on Biological Activities of Honeybee Colonies

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Abstract

Background: The study carried out to evaluate the biological activities of three honeybee races namely: *Apis mellifera lamarckii* (indigenous race), *Apis mellifera carnica* (Carniolan race) and *Apis mellifera ligustica* (Italian race) under the environmental conditions of arid lands. **Material and Methods:** Three colonies of each race kept at the experimental farm of arid lands Cultivation Research Institute, city for Scientific Research and Technology Applications, New Borg El-Arab city, Alexandria, Egypt, from March, 2012 to April, 2013. **Results:** Number of frames covered with bees showed highly significant differences between tested honeybee races ($F = 9.00$, $p<0.0009$). Obtained results showed no significant differences for sealed worker brood, stored honey and stored pollen. *Apis mellifera lamarckii* produced the highest sealed drone brood (8.08 ± 2.79 inch^2), number of queen cups (7.39 ± 2.21) and number of queen cells (6.06 ± 2.07). Generally, stored honey and stored pollen had positive significantly correlations with sealed worker brood and number of frames covered with bees ($r = 0.88$, $p = 0.000$; $r = 0.66$, $p = 0.004$) and ($r = 0.92$, $p = 0.000$; $r = 0.64$, $p = 0.005$), respectively. **Conclusion:** Under the arid land conditions, there are positive correlations between stored honey area and stored pollen area and temperature. Therefore, beekeepers can wintering their colonies in arid land and managed them for the next foraging season.

Key words: Honeybees, *Apis mellifera*, carniolian and Italian bees, *Apis mellifera lamarckii*

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Honeybees (*Apis mellifera* L.) are important to both agriculture environment and human society that because much of the plant biodiversity depends on their activity at pollination. The development of colony reproductive and food reserves are the major criteria for honeybee colony to success in surviving in different regions[1]. The biological activities of honeybee colonies are affecting by weather conditions at any region in the world. The air temperature has direct effects on the gathering food, brood rearing, colony population and the tendency of colony to swarming[2]. One of the management considerations in beekeeping is selecting the apiary locality, quality of honeybee genotype and fulfilling seasonal management requirements[3,4]. The temperature and relative humidity, in particularly, have great effect on survival, physiology, behavior, distribution and productions yield of honeybee colonies[5-7]. However, Do Nascimento and Nascimento[8] mentioned that the seasonal variation strongly affected internal and external biological activities and the forging activities decrease from dry to rainy season but the temperature and humidity affected on forging behavior.

Under harsh environment conditions in desert and arid regions, the flora is decreasing at summer season and the honeybee colonies gradually consume stored food in their nest. Also, the queen stops laying egg and the colony population decline[9-11]. Thus, honeybee need to forage for nectar and pollen throughout the year in arid lands, where the food is available to be strong. However, the foraging for pollen, nectar affected by weather conditions and the availability of flora[12]. Under desert condition, forging activity of honeybee is fluctuating during the day and greatly impacted by the region[13]. Also, Abou-Shaara *et al.*[14] observed that Yemeni honeybees (*Apis mellifera jemenitica*) showed higher tolerance to harsh conditions than Carniolan honeybees (*Apis mellifera carnica*).

The strength of a colony was directly proportional to the queen quality and the brood rearing[15,16]. Rangel *et al.*[17] revered that honeybee colonies that headed by high quality queens had significantly more sealed worker and drone brood, stored more pollen and honey and grew larger than colonies headed by low quality queens. A similar pattern of an increase in larvae found when the temperature increased and food became more available[18]. Furthermore, honey production is often difficult because, in addition to honeybee genotypes, an important effect on this trait is of other factors such as environmental conditions, vegetation area, the colony population, status of worker bees and brood quantity[19]. However, Jevtic *et al.*[20] found that genetics alone do not play a decisive role when came to production traits of honeybee colony. Regardless of the genetic determination of individual productive traits, it needed many environmental factors to fit together.

Vegetation area, as sources of food for honeybee, is critical for honeybee life and considered as a major variable for beekeeping[21]. Therefore, the aim of this study was to evaluate the biological activities of three honeybee genotypes under environmental conditions of arid lands.

MATERIALS AND METHODS

This work carried out at the experimental farm at City for Scientific Research and Technology Applications, New Borg El-Arab City, Alexandria, Egypt, from March, 2012 to April, 2013.

Experimental colonies: Nine honeybee colonies of three races, three colonies of Carniolian bees *Apis mellifera carnica* three colonies of Italian bees *Apis mellifera ligustica* and three colonies of Egyptian bees *Apis mellifera lamarckii* reared under arid land conditions. Each colony cultured in langstroth hive body and was at the same strength (5 combs). All the tested colonies left to rear queens naturally during swarm season to replace the old queens with young ones. Tested colonies examined daily at the same time of the day to count queen cups and queen cells. The date of construction for each cup and cell recorded. For queen cells the age of larvae in it estimated and on subsequent examinations, any changes in cup or cell were recorded[22]. Twelve days after queen laying eggs in the queen cells, the length of the queen cells measured and then the queen cells caged until the queen emerged. Newly emerged queens weighed, using an analytical scale, to nearest 0.001 mg within 10-15 min of emergence.

Biological activities: Three virgin sister queens at 3 days old of each genotype introduced to queen less colonies. The introduced queens selected from the heaviest weight. All queenless colonies were of similar size three combs (one comb of honey and pollens, one comb of uncapped brood and one comb of capped brood). Virgin queens were caged and released after 48 h[4]. After virgin queens mating, every 3 colonies of the same genotype were headed by

young open-mated sister queens. Then, the colonies controlled to be at the same size (5 combs), where about three combs were covered with bees.

The area of stored honey, stored pollen, the sealed brood workers and drones were measured (inch^2) twice at 21 days intervals[23] using an empty standard frame divided into inch^2 [11]. Number of combs covered with bees/colony recorded to determine the colony population size[24,25]. Also, the queen cups and queen cells were recorded[25]. Frames were individually numbered and inspected for queen cups and queen cells and then returned to its original position. All examinations made as carefully as possible to minimize colony disturbance.

Statistical analysis: The experimental design was Randomized Complete Block Design (RCBD). The data subjected to analysis of variance using SAS computer software[26] v.9.1.3 SP4, 2003. The mean values compared with the least significant difference test according to Snedecor and Cochran[27].

RESULTS

Results showed that, the honeybee genotypes were significantly affected length of queen cells and weight at emergence of virgin queen that reared naturally ($p<0.000$, $F = 26.05$ and $p<0.000$, $F = 15.44$, respectively) (Table 1). Local Italian bees *Apis mellifera ligustica* had significantly the longest queen cells and the heaviest queen weight (1.75±0.04 cm) and (173.25±4 mg) than *Apis mellifera carnica* and *Apis mellifera lamarckii*, respectively. However, the native race *Apis mellifera lamarckii* produced the highest number of queen cup, queen cell and largest drone sealed brood area (7.39, 6.06 cm and 8.08 inch^2) than the other races, respectively (Table 2).

Table 3 indicated that the honeybee races did not significantly affected stored honey area, stored pollen area and worker sealed brood ($p = 0.54$, $F = 0.62$; $p = 0.28$, $F = 1.31$ and $p = 0.31$, $F = 1.20$, respectively). On the other hand, honey bee races affected significantly number of frame covered with bees ($p<0.009$, $F = 9.002$, respectively). Furthermore, data showed significant differences between season, stored honey area, stored pollen area, worker sealed brood and number of frame covered with bees (Table 3).

Correlation between temperature, relative humidity and its effect on biological activities of *Apis mellifera carnica*, *Apis mellifera lamarckii* and *Apis mellifera ligustica* colonies at different seasons was presented at Fig. 1-3, respectively. All tested colony stored more honey and pollen during spring than the other seasons (Fig. 1-3). However, Carniolan honeybee colonies produced more worker brood during spring (420.4 inch^2) than other seasons (Fig. 1). Moreover, Egyptian and Italian honeybee colonies produced more worker brood during spring and winter than summer and autumn, respectively (Fig. 2 and 3). Carniolan and Egyptian honeybee colonies recorded the highest number of frames covered with bees during summer (5.7 and 4.6 frame per colony, respectively) (Fig. 4).

Generally, a positive significant correlation found between workers sealed brood; number of frames covered with bees, stored honey area and stored pollen area. Although, there was positive correlation between temperature, stored honey area and stored pollen area (Table 4-6).

Table 1: Effect of honeybee races on the mean length of queen cells (cm) and weight at emergence of virgin queen (mg)

Honeybee races	Length of queen cell (cm)	Weight of queen (mg)
Apis mellifera ligustica	1.75±0.27^a	173.25±18.23^a
Apis mellifera carnica	1.63±0.23^a	165.90±21.02^a
Apis mellifera lamarckii	1.40±0.22^b	150.44±22.33^b
F	26.05**	15.44**
P	0.000	0.000

Means within columns bearing different subscripts are significantly different (p = 0.05), **Significant

Table 2: Effect of honeybee races on the mean number of queen cups, queen cells and sealed drones brood (inch^2)

Honeybee races	No. of queen cups	No. of queen cells	Drone sealed brood (inch^2)
Apis mellifera ligustica	3.19	5.28	4.56
SE	1.20	1.62	1.70
Apis mellifera carnica	6.33	2.06	6.39
SE	1.64	0.83	2.27
Apis mellifera lamarckii	7.39	6.06	8.08
SE	2.21	2.07	2.79

Table 3: Analysis of variance of honeybee races and seasons on stored honey area, stored pollen area, worker sealed brood (inch^2) and number of frames covered with bees

Parameters	Length of queen cell (cm)	Weight of queen (mg)	Stored honey area (inch^2)	Stored pollen area (inch^2)	Worker sealed brood area (inch^2)	No. of frame covered with bees
Honeybee races	**	**	ns	ns	ns	**
Season	ns	ns	**	**	**	**

**Significant, ns: Non-significant

Table 4: Correlation coefficients for stored honey area, stored pollen area, worker sealed brood, number of frames covered with bees, temperature and relative humidity for *Apis mellifera ligustica*

Parameters	Temperature	Relative humidity	Stored honey area (inch²)	Stored pollen area (inch²)	Worker sealed brood area (inch²)	No. of frame covered with bees
Relative humidity	-0.34					
Stored honey area	0.90	-0.10				
Stored pollen area	0.19	-0.11	0.89**			
Worker sealed brood area	0.24	0.05	0.88**	0.92**		
No. of frame covered with bees	0.24	-0.07	0.66**	0.64**	0.79**	

**Significant

Table 5: Correlation coefficients for stored honey area, stored pollen area, worker sealed brood, number of frames covered with bees, temperature and relative humidity for *Apis mellifera carnica*

Parameters	Temperature	Relative humidity	Stored honey area (inch²)	Stored pollen area (inch²)	Worker sealed brood area (inch²)	No of frame covered with bees
Relative humidity	-0.34					
Stored honey area	0.22	-0.10				
Stored pollen area	0.23	-0.40	0.67**			
Worker sealed brood area	0.31	-0.16	0.78**	0.61**		
No of frame covered with bees	0.59**	-0.30	0.42	0.16	0.56**	

**Significant

Table 6: Correlation coefficients for stored honey area, stored pollen area, worker sealed brood, number of frames covered with bees, temperature and relative humidity for *Apis mellifera lamarckii*

Parameters	Temperature	Relative humidity	Stored honey area (inch²)	Stored pollen area (inch²)	Worker sealed brood area (inch²)	No. of frame covered with bees
Relative humidity	-0.34					
Stored honey area	0.05	-0.18				
Stored pollen area	0.08	-0.22	0.86**			
Worker sealed brood area	0.18	-0.01	0.75**	0.82**		
No of frame covered with bees	0.34	-0.28	0.53**	0.57**	0.69**	

**Significant

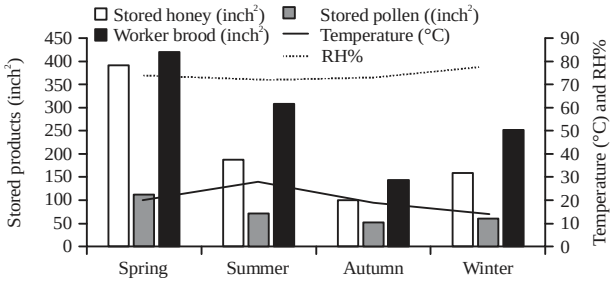

Fig. 1: Biological activities of *Apis mellifera carnica* colonies and their correlation with temperature and relative humidity (RH%) during different seasons

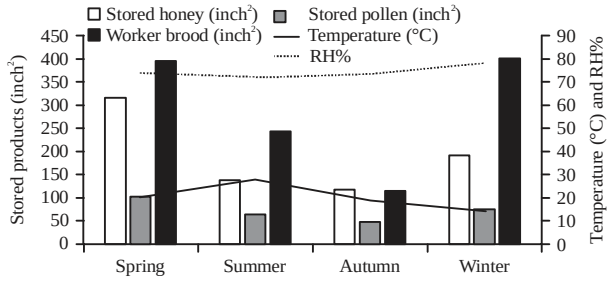

Fig. 2: Biological activities of *Apis mellifera lamarckii* colonies and their correlation with temperature and relative humidity (RH%) during different seasons

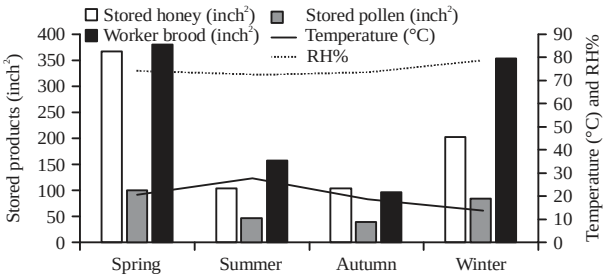

Fig. 3: Biological activities of *Apis mellifera ligustica* colonies and their correlation with temperature and relative humidity (RH%) during different seasons

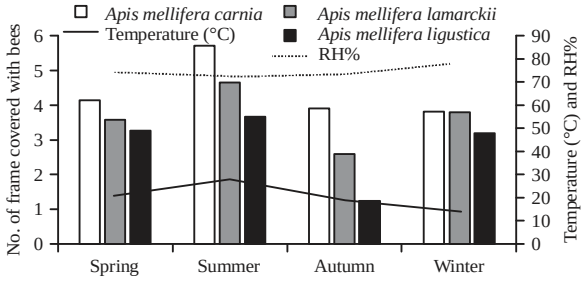

Fig. 4: Number of frame covered with bees of races colonies and their correlation with temperature and relative humidity (RH%) during different seasons

DISCUSSION

Arid lands at the North coast of Egypt had high temperature and dry weather under same condition bees cannot survive. The obtained results showed that the tested honeybee races native race *Apis mellifera lamarckii*, local *Apis mellifera carnica* and *Apis mellifera ligustica* were active under arid land conditions at different seasons. *Apis mellifera ligustica* produced the heaviest queen (173.25±4 mg) in spring during swarm season. High quality queen depends on her genotype and the environment where it reared. The first step for selecting high quality naturally queen is to select longest queen cell and heaviest queen weight[28]. However, *Apis mellifera ligustica* built longest queen cells than Carniolian and Egyptian bees. This finding is in contrast with Krol[29] and Masry *et al.*[28] who recorded that Carniolan bees built longest queen cells than Italian and Caucasian bees. In addition, the results agreed with both Koç and Karacaoglu[30] and Jevtic *et al.*[20] who found that honeybee races effect on the queen rearing conditions. However, Morais *et al.*[31], Gebreagziabher *et al.*[3] and Gemeda[32] found that the colony production differed according to the queen races. Quality of honeybee queen influenced the productivity and production of its colony[33]. Moreover, they stated that colonies headed by high quality queens showed some performance characters such as high brood production, high population of bees and high pollen and honey yield. Furthermore, the queen genotype and body weight significantly affected the brood area and honey production[34,35]. The seasons were significantly affected honeybee biological activities (Table 3). Also, the correlation coefficient between tested activities showed that worker sealed brood area of *Apis mellifera ligustica* and *Apis mellifera lamarckii* colonies is extremely had positive significantly effect on stored honey (r = 0.88 and 0.75) and pollen (r = 0.92 and 0.82), respectively (Table 4 and 6). Taha and Al-Kahtani[11] and Jevtic *et al.*[36,37] revealed that collected pollen was highly affected by colony population. Furthermore, the quantity of worker brood area and the quantity of bee population are in the positive correlation with the colony productivity[19].

Abou-Shaara[14] and Delgado *et al.*[38] found that the temperature and relative humidity effects of climatic changes on honeybees and ultimately the essential services that they provide to us. The represented results showed low positive correlation coefficient between biological activities of tested honeybee colonies and temperature. However, the relative humidity was negatively correlated with biological activities of tested honeybee colonies (Table 4-6). Colony productions, mainly honey production is in the core interest of beekeepers, when they evaluate the quality of their queens.

Climate and environmental conditions differ among regions, thus it is difficult to compare honey production between seasons or apiaries[33].

CONCLUSION

Under the arid land conditions, there are positive correlations between stored honey area and stored pollen area and temperature. Egyptian and Italian honeybee colonies produced more worker brood during spring and winter. Therefore, beekeepers can wintering their colonies in arid land and managed them for the next foraging season.

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