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Behavior of rearing and distribution of drone brood in different parts of colony combs during various seasons under sub-tropical climate

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ABSTRACT

This study was carried out during the period from February to September of 2015 to study the production and distribution of drone brood within honeybee colonies. The large percentage of drone brood was reared in the centre of brood nest (44.8%) then followed by the left outer area (36.1%), and finally in the right outer area (19.1%). The percentage of capped drone brood that reared in the upper area of comb was highly significant (60.7%) than those reared in the lower ones (39.3%). On the same trend, the results showed that the percentage of drone brood which reared in peripheral position was significant higher (54.1%) than those reared in the centre position (45.9%). There is a highly significant interaction between the position in brood nest and time of year. During spring the colonies primarily reared drone brood in the central brood nest. However, the higher rate of drone rearing was concentrated in the left outer brood nest during summer. These rates of drone rearing were retarded again to the centre area during autumn.

Keywords: Honeybee drone – Distribution and behavior of drone brood rearing.

INTRODUCTION

Under sub-tropical climate, the drones of honeybee, (*Apis mellifera* L.) are appeared in colonies from January until the end of September and disappeared from October to December, (Khattap, 1976; El-Dakhakhni, 1980; Abou El-Enin, 1992; Zeedan, 2002 and Marzouk, 2009).

A honeybee colony consists of a multiple-mated queen, several thousands to about thirty thousand workers and numbers of drones don't proceed 10% of the adult population, (Abou-Korah, 1972; Ghoniemy, 1984 and Czekonska *et al*., 2015). However, Free & Williams (1974) found a large percentage of eggs were sometimes laid in drones cells before the end of April, but few were reared. Also, Page & Metcalf (1984), mentioned that drone brood represented 14-15% of the total brood and reached 24% of that for workers, as reported by Rowland and Mclellan (1987).

It would be desirable to increase drone brood and adult drone population for some of the following reasons: to saturate the area with drones of known genetic origin for controlled mating of queens, (Hellmich, 1991 and Hellmich *et al*., 1993), to use capped drone brood removal for controlling *Varroa destructor*, (Szabo, 1994), to build combs for wax production, (Szabo, 1994) and to rear drone brood for human consumption, (Abd Al-Fattah *et al*., 2010 and Nour El-Deen, 2013).

Temperature degrees in the brood area, especially during spring season in Egypt, are not uniform. The central brood nest temperature is the warmest and most stables, which ranged from 33.9°C - 34.5°C than other positions in the hive, which more variable and ranged from 30.2°C – 32.4°C. In reverse, the central and outer brood nest temperatures are approximately similar, (34.8°C & 34.4°C, respectively) during summer season, (Fathy, 1980 and El-Dakhakhni, 1980).

Free (1967) shown that drone cells don't always build at the periphery or on outside combs, but Taber & Owens (1970), found that as the worker population increased, the quantity of drone comb increased and this occurred closer to the centre of the brood nest. On the other hand, Owens & Taber (1973) reported that drone cells and drone brood are normally found at the periphery of the brood nest. So, Levin & Collison (1990) found that drone brood temperatures were significantly lower than those of workers in the upper, lower and peripheral octads of the comb, while not significantly different in the central octads.

Due to the outer regions of the brood area are often used for drone production, this study was carried out to investigate the distribution pattern of drone brood rearing in Giza region during the active season of honeybee colonies from February to September of 2015.

MATERIALS AND METHODS

The production and distribution of drone brood was carried out in overwintered honeybee, *Apis mellifera* L. colonies during the period from February to September of 2015 at the apiary of Agricultural Experimental Station, Faculty of Agriculture, Cairo University, Egypt. Three honeybee colonies of the F1 Carniolan hybrid similar in their strength, (four brood combs, three food combs and two empty combs) were chosen for this study. Colonies were weekly provided with sugar syrup (1:1 w/w) to stimulate queen in egg-laying and encouraging workers to build and repair the wax combs. The hives were facing south and the combs were assigned numbers 1-9, from left to right when stopped behind the hive.

The direction and position of the combs within brood chamber don't change or alternate throughout the experiment. According to Levin & Collison (1990), the two comb sides were divided into equal eight portions through delineating by placing on octads ploxi glass grid over each comb side. Octads of comb side (A) were numbered from left to right; 1-4, and 5-8, in the upper and lower horizontal sections, respectively. The opposite comb side (B) was numbered similarly, except that numbering went from right to left. The number of capped drone areas (in cm^2) per colony, comb side (A or B), and comb octad were recorded at 15 days intervals from, February 13 to September, 26. The obtained data were transformed to a number of drone cells through multiplied by 2.48 (which equal the number of drone cells in square centimeter). The means of drone cells / colony/month were took in consider for data analysis by MSTAT program, (Version 2.1) to determine the preferred position and location within brood nest to rear drone brood. The means of various treatments were compared by Duncan's Multiple Range Test (1955).

RESULTS AND DISCUSSION

The obtained results of capped drone brood showed that the distribution was varied with brood nest position and time of year. The mean percentages of the capped drone brood cells in the centre were 44.8% while it was 36.1% in the left outer brood nest which was not significantly differed. However, the lowest percentages of capped drone brood cells was found in the right outer brood nest area, (19.1%), which significantly less than the other two preceding positions, (Table1 & Figure1).

The interaction between the position in brood nest and time of year was highly significant for the recorded results. During February, (late winter), the experimental colonies primarily reared drone brood in the central brood nest with a percentage of 51.6%. The same pattern was followed by colonies in rearing drone brood during spring season, (March, 45.6%, April, 50.2% and May, 45.8%). During summer months, the higher drone rearing rate was concentrated in the left outer brood nest (combs No. 1,2 and 3 against the hive entrance), where the percentages were 49.1%, 47.0% and 52.6% for June, July and August, respectively. In the early autumn, (September), the drone rearing was mainly retarded and concentrated in the central brood nest, (combs No. 4,5 and 6) where the percentage of capped brood cells reached to 56.6%, (Table 1& Figure1).

The mean percentage of capped drone brood that reared in the upper octads of combs, (octads from 1-4) was significantly higher, (60.7%) than those reared in the lower (39.3%) octads, (from 5-8), when combs were divided horizontally. (Table 2 & Figure2). The only exception was induced in March, where the lower octads of combs had significantly more drone brood cells (14%) than the upper ones.

When combs were divided vertically, the drone pupae were significantly higher, (54.1%) in the peripheral octads of combs, (1, 4, 5 & 8) than those presented in the central, (45.9%) ones, (2, 3, 6 & 7) as shown in Table (3). Also, there are interaction for drone brood distribution between time of year and peripheral or central positions of combs within brood nest. The percentages of drone brood production were significantly higher in the central octads than those reared in the peripheral ones during late winter, (February) and early autumn, (September). These percentages were 56.6% and 66.0% for the two previous months, respectively. During spring season, drone brood production was significantly increased in the peripheral areas from March, (54.0%) and reach its climax in May, (65.3%). Then, the rearing of drone brood in peripheral areas of brood nest was seadily decreased through summer months and the reverse was noticed for the central octads (Figure 3).

The obtained results showed that the maximum drone brood production was concentrated in April, March and May. These results are in agreement with previous findings in the nearly circumstances, (El-Dakhakhni, 1980; Ghoniemy, 1983; Abou El-Enin, 1992; Zeedan, 2002 and Marzouk, 2009). The highest percentage of reared drone brood occurred in the middle area of brood nest followed by the left outer brood nest areas then the right outer areas in the last, especially during late winter, (February), spring, (March to May) and early autumn, (September). This may be attributed to the constant and warmest of brood nest temperature that is in this area, (Dunham, 1933; Abd Al-Fattah, 1983 and Levin & Collison, 1990). However, with increasing colony population through season progression (during summer), under the environmental conditions of this study, the outer brood nest temperature, (34.5°C) is approximately similar to the central brood nest temperature, (34.7°C) as reported by Fathy

(1980). Similar findings of central and outer brood nest temperature were also registered by Abd Al-Fattah (1983). Therefore, about 49.6% of drone brood were produced in the left outer brood nest against 30.7% in the middle ones during summer season. When the workers of a colony withdraw from the cells at the outsides of the combs during September, (with the decline of air temperature), the highest proportion of the reared drone brood was mainly in the middle brood nest areas, (Table1).

Levin & Collison (1990) reported that areas containing workers larvae and pupae had significantly higher temperatures than those of drones. On the other hand, they also mentioned that drone brood temperatures were significantly lower than those of workers in the upper, lower and peripheral octads of comb, while not significantly differed in the centre octads. Besides, several researchers found that the outer regions of the brood area had greatest temperature fluctuations, reach up to 4°C, (Dunham, 1933; Budel, 1960; Simpson, 1961; Drescher, 1968; El-Dakhakhni, 1980 and Abd Al-Fattah, 1983). So, the obtained results may be supported by the previous researchers in case of increasing the drone brood percentage in peripheral comb octads than those in central ones. Free (1967) and Levin & Collison (1990) appeared that the availability of drone cells is considered one of the important factors affecting the distribution patterns of drone brood in the colony, Furthermore, Johansson & Johansson (1971) mentioned that in spring, colonies deprived of drone comb will often build it in any space available in their hives, even destroying worker cells at the corners of comb in order to make drone cells instead.

The predominant of drone brood percentage in the upper comb octads, (upper half of comb) than that in the lower ones had confirmed the findings of Free & Williams (1974). They found in their experiments during June, 1970 and May, 1971, that the built drone cells percentages in the top parts of combs were higher (20% & 41% in brood combs, respectively), than those found in the lower parts of comb (18% & 23%, respectively).

Table 1. The monthly mean number and percentage of drones sealed brood in different sites of brood nest throughout active season of 2015

Month	Position within brood nest						
	Left outer ± SD	%	Middle ± SD	%	Right Outer ± SD	%	Total
February	71.0±9.0	*26.7*	137.0±26.7	*51.6*	57.6±9.6	*21.7*	265.6
March	138.4±3.7	*33.6*	188.0±25.2	*45.6*	86.0±10.2	*20.9*	412.4
April	170.0±5.9	*31.3*	272.2±12.6	*50.2*	100.2±15.3	*18.5*	542.4
May	138.0±30.6	*37.1*	170.2±16.4	*45.8*	63.8±12.4	*17.2*	372.0
June	64.4±15.2	*49.1*	43.0±4.8	*32.8*	23.8±4.6	*18.1*	131.2
July	74.4±16.2	*47.0*	47.8±22.7	*30.2*	36.2±6.1	*22.8*	158.4
August	129.6±27.3	*52.6*	71.6±25.7	*29.1*	45.2±4.8	*18.3*	246.4
September	52.2±9.4	*27.2*	108.6±4.9	*56.6*	31.2±3.7	*16.2*	192.0
Average	104.8	36.1	129.8	44.8	55.5	19.1	290.1
	A		A		B		

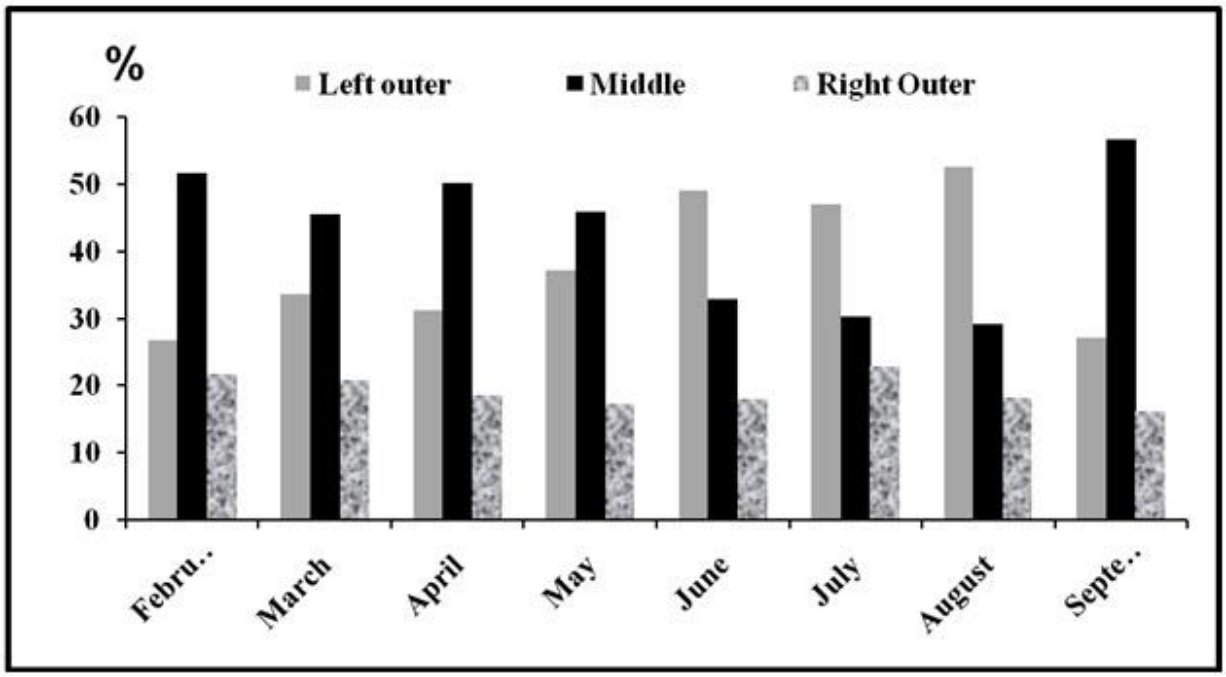

Figure 1. The monthly percentages of drones sealed brood in different sites of brood nest throughout active season of 2015

Table 2. The monthly mean number and percentage of drones sealed brood reared in the upper and lower part of combs throughout active season of 2015

Month	Drone brood reared in upper part of combs		Drone brood reared in lower part of combs		Total
	Mean±SD	%	Mean±SD	%	
February	134.1±2	50.5	131.5±8.8	49.5	265.6
March	177.3±6.1	43.0	235.1±5.6	57.0	412.4
April	341.7±5.9	63.0	200.7±8.6	37.0	542.4
May	267.1±2.7	70.5	111.6±4.2	29.5	378.7
June	99.8±1.7	75.7	32.1±1.9	24.3	131.9
July	103.0±5.3	65.0	55.5±2.7	35.0	158.5
August	168.8±7.1	68.5	77.6±2.7	31.5	246.4
September	120.0±5.5	62.5	72.0±1.8	37.5	192.0
Average	176.5	60.7	114.5	39.3	291.0
	A		B		

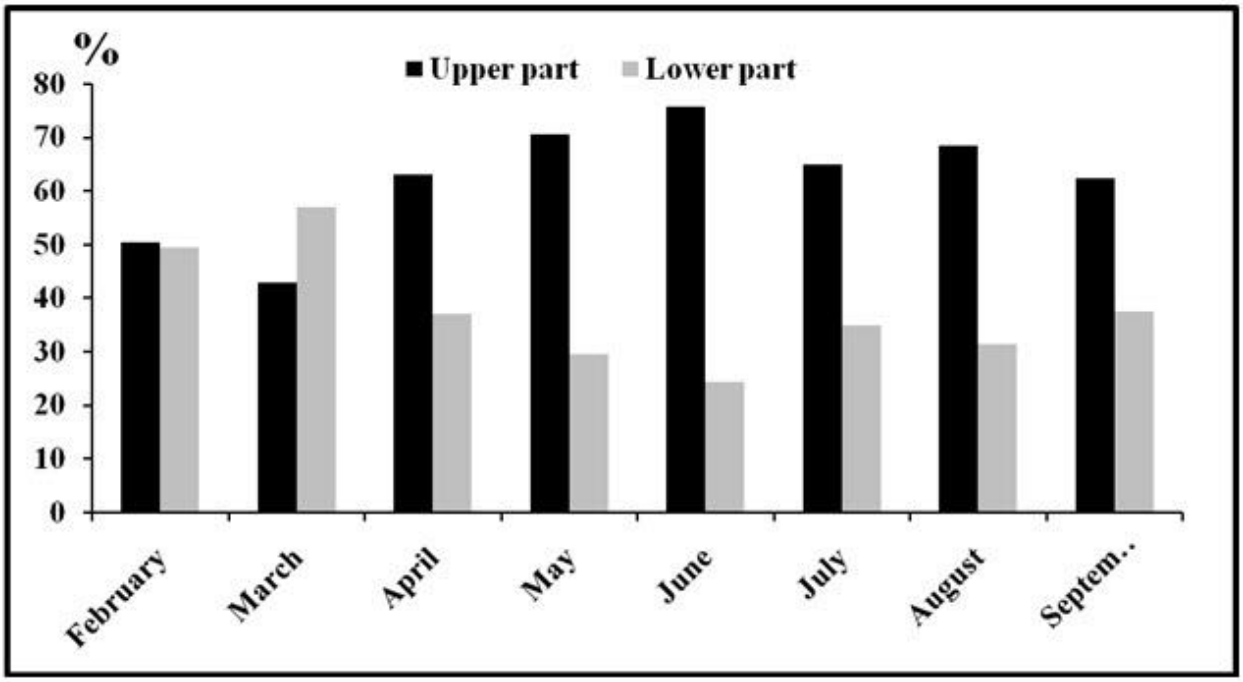

Figure 2. The monthly percentages of drones sealed brood reared on the upper and lower parts of comb throughout active season of 2015

Table 3. The monthly mean number and percentage of drones sealed brood reared in the peripheral and central positions of comb throughout active season of 2015

Month	Drone brood reared in peripheral Position		Drone brood reared in central Position		Total
	Mean±SD	%	Mean±SD	%	
February	115.3±3.7	43.4	150.3±4.7	56.6	265.6
March	223.0±2.6	54.0	189.7±3.6	46.0	412.7
April	341.4±3.8	63.0	200.7±6.7	37.0	542.1
May	243.7±2.1	65.3	129.6±4.9	34.7	373.3
June	78.1±3.3	59.5	53.1±4.7	40.5	131.2
July	79.2±1.6	50.0	79.2±4.7	50.0	158.4
August	110.9±2.4	45.0	135.5±4.8	55.0	246.4
September	65.3±2.2	34.0	126.7±3.1	66.0	192.0
Average	157.1	54.1	133.1	45.9	290.2
	A		B		

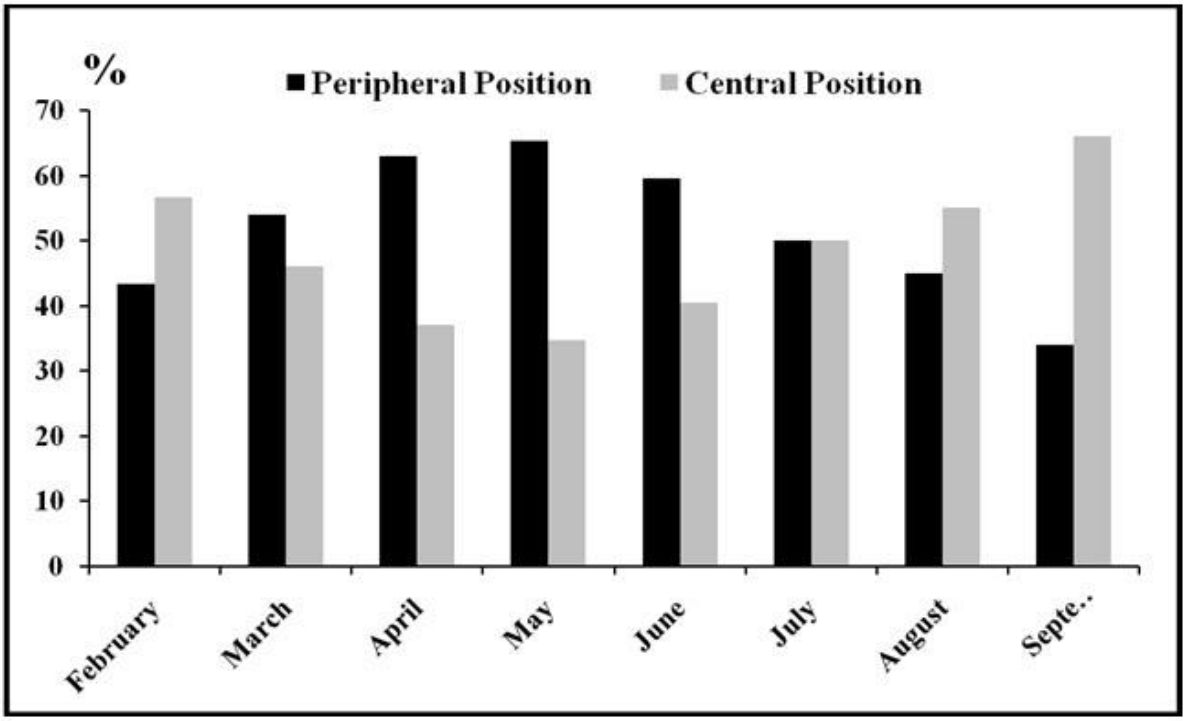

Figure 3. The monthly percentages of drones sealed brood reared in the peripheral and central positions of comb throughout active season of 2015

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