



Journal of  
**Entomology**

ISSN 1812-5670



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## Relationship between Population Size and Productivity of Honey Bee Colonies

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### ABSTRACT

This study was carried out to investigate the relationship between colony strength and each of stored pollen, worker brood rearing, colony population density and honey production. The areas of stored pollen and worker sealed brood, colony population size and honey yield were significantly ( $p < 0.001$ ) higher in the strong than the weak colonies. The strong colonies produced honey 286.80 and 291.67% more than the weak colonies during clover and sidir season, respectively with an average increase of 289.24%. It can be recommended from the research findings to unite the weak colonies to be strong for obtaining high rates of stored pollen and brood production and high honey yield.

**Key words:** Pollen, brood, honey, colony population, colony strength

### INTRODUCTION

The amount of pollen and brood in the colony reflects its status and can be used to expect the honey yield produced at the end of the season. Several investigators have proved positive correlation between stored pollen, brood production and honey yield (Kolmes and Sam, 1990; Schneider and McNally, 1993; Fathy, 1998; Mladenovic *et al.*, 1999; Shoreirt *et al.*, 2002; Jevtic *et al.*, 2009).

Pollen collection, brood production and honey yield are affected by many factors such as nectar and pollen flora (Matheson, 1991; Williams *et al.*, 1993; Abdella, 1996; Shower *et al.*, 2003; Taha, 2007; Taha *et al.*, 2009), time of the year (Shower *et al.*, 1987; Sattigi and Lingappa, 1993; Khanbash and Bin-Ghodel, 1994; Rana and Goyal, 1994; Al-Humyarie *et al.*, 1999), feed supply (Goodwin and Houten, 1979; Shoreirt and Hussein, 1993; Goodwin *et al.*, 1994; Castagnino *et al.*, 2004; Mattila and Otis, 2006; De Grandii-Hoffman *et al.*, 2008) and colony strength (Shower *et al.*, 1986; Marceau *et al.*, 1990; Georgijev *et al.*, 2003).

The weakness of honey bee colonies has become a dominant feature for the colonies not only in Saudi Arabia but also in most of the other Arabian countries as reflected by the low productivity of the colony as compared to the international colony productivity, Therefore, the present study investigated the relationship of colony strength with stored pollen, brood rearing and honey yield.

### MATERIALS AND METHODS

The study was carried out at the apiary of Agricultural and Veterinary Training and Research Station, King Faisal University, Al-Hassa, Saudi Arabia during 2012 season. Thirty colonies

(each 5 combs) in the same strength of hybrid Carniolan honeybees, *Apis mellifera carnica* imported from Egypt were selected for this study. Ten of these were used as weak colonies (each having 10000 bees). The remaining twenty colonies were united (each a set of two weak colonies) to form ten strong colonies (each having 20000 bees). All the colonies were headed by the young open-mated sister queens.

The areas (square inches) of stored pollen and the worker's sealed brood were measured at an interval of 12 days using an empty standard frame divided into square inches. Number of combs covered with bees/colony were recorded monthly to determine the colony population size. The bee population per colony was counted as one comb well covered with bees in the two sides equals 2000 bees (Taha, 2007). By the end of clover (*Trifolium fragiferum*) and sidir (*Ziziphus* spp.) seasons, honey yield was calculated from the difference between weight of honey combs before and after extraction.

**Data analysis:** Data were analyzed by the analysis of variance (ANOVA). Treatment means were compared by LSD Test. Simple correlation was made by using SAS (2003).

## RESULTS AND DISCUSSION

The obtained results showed that, the areas of stored pollen and worker sealed brood, population density of colony and honey yield were significantly ( $p < 0.001$ ) higher in the strong than the weak colonies.

Figure. 1 showed that strong colonies collected pollen significantly more than the weak ones (1155.11, 1319.89, 935.22 and 998.78 sq. inches/colony vs. 501.55, 558.11, 408.67 and 411.00 sq. inches/colony for spring, summer, autumn and winter seasons, respectively). As shown in Fig. 2 the strong colonies exceeded to weak colonies in worker sealed brood area (4165.12, 5264.58, 2865.67 and 3955.99 sq. inches/colony vs. 1485.67, 2400.90, 1461.78 and 1193.67 sq. inches/colony for spring, summer, autumn and winter seasons, respectively). The highest population density of

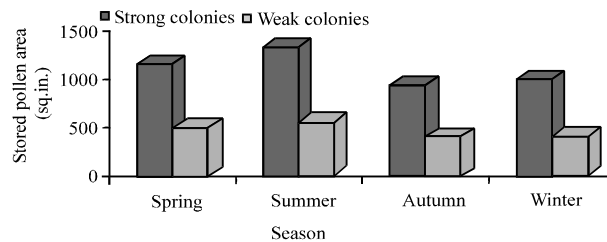


Fig. 1: Stored pollen area (sq. inches) in relation to colony population size

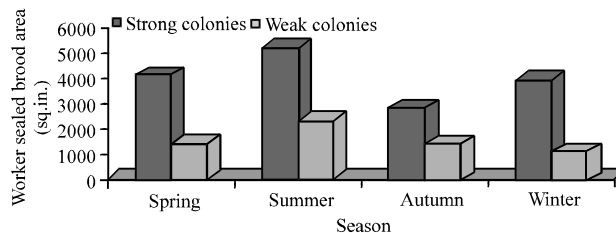


Fig. 2: Worker sealed brood area (sq. inches) in relation to colony population size

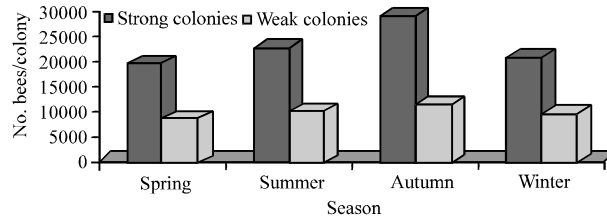


Fig. 3: Effect of colony strength on bee population size during the different seasons

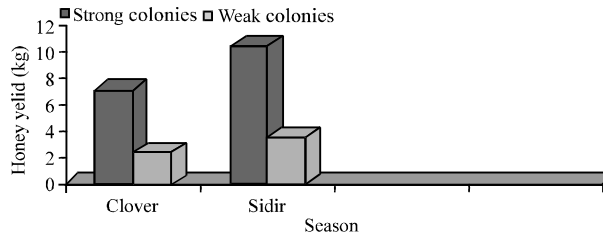


Fig. 4: Honey yield (kg) in relation to colony population size

colony was recorded during autumn (sidir season flow), while the lowest population densities were observed during spring in both the strong and weak colonies (Fig. 3). Data in Fig. 4 showed that strong colonies produced more honey than weak ones (7.17 and 10.50 kg/colony vs. 2.50 and 3.60 kg<sup>-1</sup> colony for clover and sidir seasons, respectively).

## DISCUSSION

**Stored pollen:** The amount of pollen stored in the colonies depends on the amount of collected pollen as well as the rate of pollen consumption by brood and bees. Also, the pollen stored by strong colonies was significantly ( $p < 0.001$ ) higher than that stored by the weak colonies. Similar results were obtained by Jevtic *et al.* (2005, 2009) who reported that collection of pollen was highly influenced by the colony strength. In the present study, a strong colony having 20000 bees stored pollen more than 2-times to that stored by the two weak colonies with each having 10000 bees which accounted up to 28.84-43.01% with an average of 34.66%. This increase in pollen storage may be due to the high numbers of pollen foragers resulted from the high bee population in strong colonies as compared to weak colonies. These results were supported by the findings of Shaver *et al.* (1986), Pidek (1988) and Fathy (1998) who reported that pollen collected by strong colonies was higher than that collected by the weak colonies. The amount of pollen in the colony increased in parallel to the amount of the brood (Shaver, 1987; Georgijev *et al.*, 2003). The differences between colonies due to colony strength, seasons and interaction between them were highly significant (Table 1).

The largest areas of stored pollen in both the strong and weak colonies were obtained during summer which collected from cucurbitaceae, sunflower (*Helianthus annus* L.) and clover (*Trifolium fragiferum*) plants followed by spring which collected from date palm (*Phoenix dactylifera* L.), rape (*Brassica* spp.), Cucurbitaceae and sunflower. The current results are in agreement with the findings of Al-Jabr and Nour (2001) who stated that the main pollen sources of Saudi honeys were sidir, rape, sunflower, clover, date palm and the *Acacia* sp.

Table 1: Analysis of variance of the effect of colony strength, seasons and interaction between them on stored pollen area, worker sealed brood areas, colony population and honey yield

	Stored pollen area	Worker sealed brood area	Colony population	Honey yield
Colony strength	**	**	**	**
Seasons	**	**	**	**
Colony strength×Seasons	**	**	**	**

\*\*Indicate  $p < 0.01$

Table 2: Pearson correlation coefficients for areas of stored pollen and worker sealed brood, colony population and honey yield

	Stored pollen area	Worker sealed brood area	Colony population	Honey yield
Stored pollen area				
Worker sealed brood area	0.95**			
Colony population	0.73**	0.63**		
Honey yield	0.72**	0.73**	0.71**	

\*\*Indicate correlation is significant at the 0.01 level (2-tailed)

Data in Table 2 showed significant ( $p < 0.01$ ) positive correlations between stored pollen area and colony population size ( $r = 0.73$ ).

**Brood rearing:** In addition to the population size of colony, brood rearing and population growth in the colonies are affected by the quality of the queen and the nutritional factors (Winston, 1987; DeGrandi-Hoffman *et al.*, 1989). In this study, all colonies headed by sister queens and the nutritional factors were similar across both colonies (strong and weak), so the effects should have been the same regardless of the population size of colony. The area of worker sealed brood in strong colonies was larger than that of weak colonies through all the seasons. The areas of worker sealed brood in strong colonies ranged between 196.04 to 331.41% of that in weak colonies with an average of 256.77%, i.e. one strong colony reared more than twice as much brood as that reared by two weak colonies by 56.77%. The weak colonies were more active in brood rearing during the first part of sidir season flow for building colony population, so during September and October, the strong colonies reared only 190.94 and 193.41% of the weak colonies, respectively.

The largest worker sealed brood area was obtained during summer both in the strong and weak colonies. The amount of brood rearing was dependent on collection of feed (Fathy, 1998; Shoreirt *et al.*, 2002; Shower *et al.*, 2003) which depends on the availability of young and foraging workers (Rowland and McLellan, 1987). The differences between colonies in worker sealed brood areas due to colony strength, seasons and interaction between them were highly significant (Table 1).

Significant ( $p < 0.01$ ) positive correlations were found between worker sealed brood area and each of stored pollen area, colony population and the honey yield ( $r = 0.95$ ,  $0.63$  and  $0.73$ , respectively). These results agreed with the findings of Jevtic *et al.* (2009) who proved that there is a positive correlation between the colony population, brood area and honey yield. In addition, Kolmes and Sam (1990), Schneider and McNally (1993), Fathy, (1998) and Mladenovic *et al.* (1999) reported that there is a positive correlation between the increases of collected pollen activity and increase of brood rearing.

**Colony population:** The numbers of combs covered with bees in the strong colonies were higher than those in weak colonies. The numbers of combs covered with bees in strong colonies ranged

between 211.07 to 247.03% of that in weak colonies with an average of 224.25%. The differences between colonies due to colony strength, seasons and interaction between them were highly significant (Table 1).

The highest numbers of bees on combs were recorded during autumn (sidir season flow) as a result of the high rate of stored pollen and worker sealed brood during summer. These results agree with the results of Fathy, 1998 who found that the major peak of brood activity and higher rate of stored pollen were in May, consequently the maximum number of house bees was recorded during June and July. However, in this study, the lowest bee population density was recorded during spring in both the strong and weak colonies. The decrease in population size of colony resulted from low rate of brood rearing due to sharp decrease in pollen collecting activity as a result of death of most pollen flora and the presence of bee eating birds in the vicinity of apiary during April.

Significant ( $p < 0.01$ ) positive correlations were found between colony population and stored pollen and worker sealed brood areas. The present results were in line with those reported by Fathy, 1998 who stated that in winter and spring, there was a significant positive correlation between brood area and number of bees on combs.

**Honey yield:** The mean honey yield per colony was significantly ( $p < 0.001$ ) affected by the population size of colony. On relative basis, the strong colonies produced more honey up to 286.80 and 291.67% to that of weak colonies during clover and sidir season, respectively with an average of 289.24%, i.e. one strong colony having 20000 bees at the beginning of the experiment produced more than 2-times as much honey as that produced by the two weak colonies with each having 10000 bees by 89.24%. These results agree with the findings of Farrar (1937) who reported that large colonies surpassed the small colonies in honey production. The total honey production of two small colonies with each having half-bee population to that of the large one was significantly less than the production of a large colony. Besides, Graham (1993) found that a colony with 60000 bees made more than 2-times honey as that produced by two colonies with each having 30000 bees. The differences between strong and weak colonies may be due to the high rate of worker brood rearing resulted in forager bees, which could collect nectar from nectar sources. Furthermore, the reduction in honey yield in weak colonies may be due to the consumption of major part of the collected nectar for building colony population during the early part of flow season. In this regard, Shower *et al.* (1986) and Marceau *et al.* (1990) found that honey stored by strong colonies was higher than weak colonies. Also, the differences between colonies due to colony strength, seasons and interaction between them were highly significant (Table 1). The differences between honey yield harvested during sidir and clover seasons may be due to the variation in population size of colony which was higher in sidir season.

Significant ( $p < 0.01$ ) positive correlations were found between honey yield and each of stored pollen area, worker sealed brood area and colony population ( $r = 0.72, 0.73$  and  $0.71$ , respectively) (Table 2). In this respect, Duff and Furgala (1986) and Shower (1987) found that honey production of the trapped colonies was significantly less than un-trapped ones. In addition, Graham (1993) and Jevtic *et al.* (2009) found strong relationships between the colony size and the honey production of various sizes of colonies.

## CONCLUSION

The productivity of honeybee colonies was significantly influenced by its population size. So, it can be recommended to unite the weak colonies to form strong colonies for obtaining high rates of stored pollen and brood production and high yield of honey.

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