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The relationship between comb age and performance of honey bee (*Apis mellifera*) colonies

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ABSTRACT

A study on the relationship between the age of comb and the activity of the hybrid Carniolan honey bee colonies in collecting pollen activity, worker brood production, colony strength, and honey yield was conducted. In comparison to colonies with combs aged 4-years, colonies with combs aged 1, 2 and 3-years significantly exceeded in the number returning workers, number returning workers with pollen loads, rate of storing pollen, rate of worker brood production, and size of colony population. Colonies with combs aged 1, 2 and 3-years produced significantly more honey than colonies with combs aged 4-years (5.25, 4.90 and 4.65 kg/colony vs. 4.45 kg/colony, respectively). It can be concluded that the foraging rate, gathering and storing pollen, brood production, colony population size, and honey yield significantly depended on the age of combs. Beekeepers can replace old combs with new ones to increase brood and honey production.

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1. Introduction

The color of beeswax when first built is near white. The main components of comb beeswax are ester and hydrocarbons components (Tulloch, 1980) that can absorb several materials. Food storage in comb makes the color of wax yellowish over time because of the pollen residual accumulation (Free and Williams, 1974). Rearing brood in the comb several times makes it darker and almost black (Hepburn, 1998; Taha et al., 2010), the cell walls become thicken and the cells become smaller (Coggshall and Morse, 1984; Winston, 1987) because of the accumulation of cocoons and fecal material that precipitated within the cell during the stages of larvae and pupae (Jay, 1963), pollen and propolis (Free and Williams, 1974; Taha and El-Sanat, 2007; Taha et al., 2010). The darker color of the comb may also result from unidentified contaminants absorbed in the beeswax by the time (Taha et al., 2010).

The activity and performance of the colony of the honey bee are influenced by several factors such as: nectar and pollen floral resource (Helal et al., 2003; Taha et al., 2006; Taha and Bayoumi, 2009; Awad et al., 2017), time of the year (Taha, 2000; Shawer et al., 2003; Taha, 2015; Taha and Al-Kahtani, 2019), colony population size (Taha and Al-Kahtani, 2013; Kasangaki et al., 2018), and bee species/subspecies (Taha et al., 2016; Awad et al., 2017; Taha and Al-Kahtani, 2019). In addition, the productivity of honey bee colonies has been affected by feeding on proteinaceous diets (Pokhrel et al., 2006; Mahmood et al., 2013; Taha, 2015; Puškadija et al., 2017).

The aim of the present study is to investigate the activity of the honey bee (*Apis mellifera* L.) colonies in storing pollen, brood production, growth of the colony, and honey production in relation to the age of comb age.

2. Material and methods

The study was carried out at the apiary of the Training and Research Station, King Faisal University, Al-Ahsa oasis, in eastern Saudi Arabia during the summer and autumn seasons in 2017. Al-Ahsa lies at longitude 49° 37′ 19″ E, latitude 25° 25′ 46″ N and an altitude of 121 m above sea level. Twenty colonies of 14,000 bees (seven combs) of hybrid Carniolan (*A. m. carnica* Pollmann) honey bees were selected for this experiment. The colonies were equalized to be about the same strength (brood, bees, and food)

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and were requeened by newly mated sister queens. The colonies were divided into 4 groups of 5 colonies. The combs in these colonies have been replaced by empty combs aged 1, 2, 3 and 4-years in groups 1, 2, 3 and 4, respectively. The number of returning workers into the colony within one minute was counted to determine the activity of foraging. The number of returning workers carrying pollen loads was recorded at the same time. These procedures were done periodically a day weekly at 0700–0800 hrs from July to September, and at 0900–1000 hrs from October to December. The flight activity reached the highest rates at the selected times (Taha, 2014).

A standard frame divided into square inches was used to measure the areas of worker sealed brood and stored pollen at 12 days intervals. The monthly number of combs covered with bees in each colony was counted for determination the colony population size according to bees Taha (2007). By the end of sidr (*Ziziphus* spp., Rhamnaceae) season flow (September and October), honey yield was determined by calculating the difference between the weight of combs before and after honey extraction. Data were analyzed by the one-way analysis of variance using SAS® software computer program (SAS Institute, 2003). A comparison between the means of treatments was done using the Duncan's Multiple Range Test (Duncan, 1955).

3. Results

The obtained data showed that colony performance including foraging activity, storing pollen, brood production, colony growth, and honey production differed and significantly ($p < 0.01$) affected by comb age. Colonies with combs aged 1, 2 and 3-years were significantly ($p < 0.01$) more active in foraging rate in comparison to colonies with combs aged 4-years (66.40, 64.20 and 61.60 workers/min./colony vs. 59.20 workers/min./colony, respectively). The highest number of returning workers carrying pollen loads (19.85 workers/min./ colony) was recorded in colonies with combs aged 1-year, followed by 18.94 workers/min./colony from colonies with combs aged 2-years, while the lowest number of returning workers with pollen loads (16.95 workers/min./colony) was recorded in colonies with combs aged 4-years (Fig. 1). The stored pollen area could be arranged in descending order: colonies with combs aged 1-year > colonies with combs aged 2-years > colonies with combs aged 3-years > colonies with combs aged 4-years (Fig. 2).

Data illustrated graphically in Fig. 3. showed that, colonies with combs aged 1, 2 and 3-years significantly ($p < 0.01$) exceeded colonies with combs aged 4-years in worker sealed brood area (2412.00, 2289.60 and 2092.80 sq. inches/colony vs. 1950.33 sq. inches/colony, respectively). The largest colony population size (20,000 bees/colony) was recorded in colonies with combs aged 1-year, followed by 19,200 bees/colony from colonies with combs aged 2-years, while the smallest population size (18,000 bees/-colony) was recorded in colonies with combs aged 4-years (Fig. 4).

The largest amount of honey (5.25 kg/colony) was obtained from colonies with combs aged 1-year, followed by 4.90 kg/colony from colonies with combs aged 2-years, while the lowest honey yield (4.45 kg/colony) was obtained from colonies with combs aged 4-years (Fig. 5). The correlation between honey yield, number of returning workers, number of returning workers carrying pollen loads, stored pollen area, sealed brood area, and growth of the colony was significantly ($p < 0.01$) positive (Table 1).

4. Discussion

The performance of the colony of honey bee (*Apis mellifera* L.) was measured from the determination of foraging rate, gathering and storing pollen, brood production, colony population growth, and honey production. In comparison to the colonies with combs aged 4-years, colonies with combs aged 1, 2 and 3-years significantly ($p < 0.01$) exceeded in the number of returning workers, and number of returning workers carrying pollen loads by 12.16 & 17.10, 8.44 & 14.45, and 4.05 & 6.48%, respectively. The superiority of colonies with new combs may be due the large bee population resulted from the high rate of brood rearing. Significant ($p < 0.01$) positive correlation was found between size of the colony population with the number of returning workers ($r = 0.94$) and the number of returning workers with pollen loads ($r = 0.78$). These results are in harmony with the results obtained by Taha (2014).

Colonies with combs aged 1, 2 and 3-years stored significantly ($p < 0.01$) more pollen than colonies with combs aged 4-years by 19.70, 13.06 and 7.79%, respectively. The large stored pollen area in colonies had new combs in comparison to colonies had old ones may be due to the large number of workers colleting pollen which occurred from the high rate of brood production in new combs (Berry and Delaplane, 2001; Dizaji et al., 2008) which correlated with the stored pollen area. Strong positively correlation ($p < 0.01$) was found between stored pollen area with the number of returning workers with pollen loads ($r = 0.93$) and colony population size ($r = 0.74$). Our results confirmed by those obtained by

Fig. 1. Foraging activity in relation to age of combs.

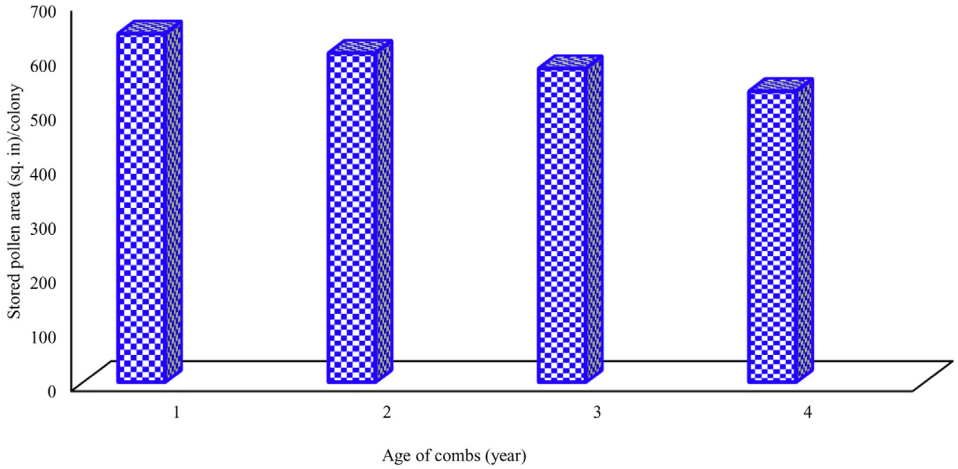

Fig. 2. Stored pollen area in relation to age of combs.

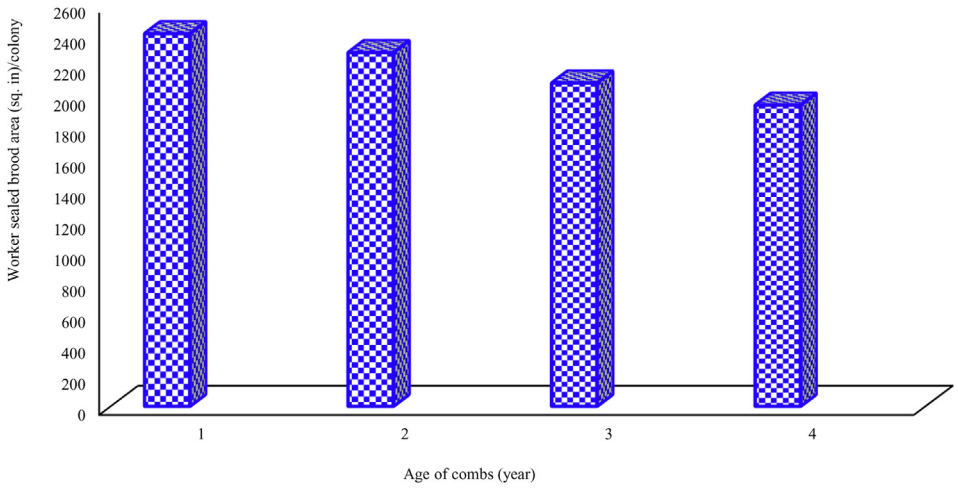

Fig. 3. Worker sealed brood area in relation to age of combs.

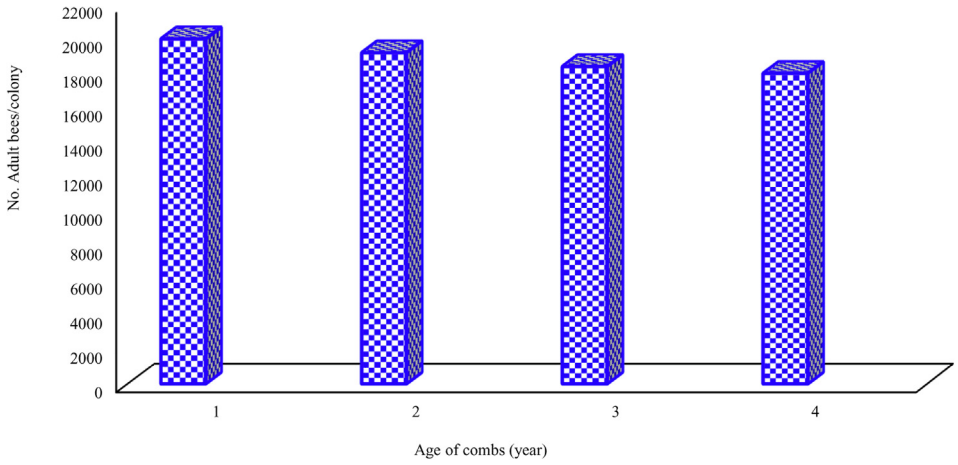

Fig. 4. Colony population size in relation to age of combs.

Taha (2015); Taha and Al-Kahtani (2019) who found a positively correlation between stored pollen area and size of the colony population.

In addition to the colony population size, brood production was affected by egg laying ability of the queens and food providing (DeGrandi-Hoffman et al., 1989; Taha, 2005; 2015). At the beginning of the experiment, the experimental colonies were headed by sister queens, adult populations and brood areas were relatively similar in all colonies, so any variations should due to the age of combs. Colonies had combs aged 1, 2 and 3-years reared worker

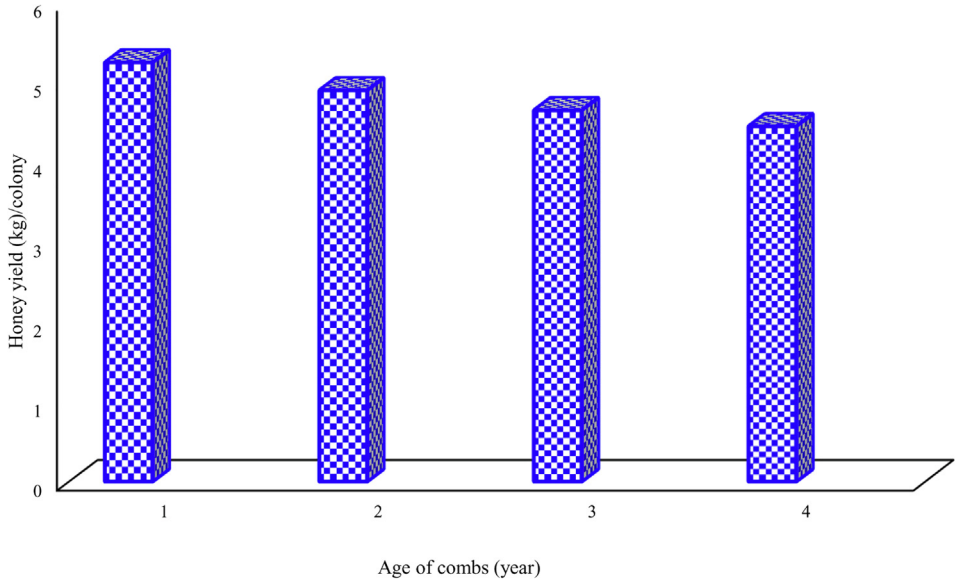

Fig. 5. Effect of comb age on amount of honey yield (kg)/colony.

Table 1
Correlation coefficients between number of incoming workers, number of incoming workers with pollen loads, stored pollen area, worker sealed brood area, colony population size and honey yield.

Items	No. incoming workers	No. incoming workers with pollen loads	Stored pollen area	Worker sealed brood area	Colony population size
No. incoming workers					
No. incoming workers with pollen loads	0.89**				
Stored pollen area	0.86**	0.93**			
Worker sealed brood area	0.88**	0.94**	0.93**		
Colony population size	0.94**	0.78**	0.74**	0.93**	
Honey yield	0.92**	0.84**	0.96**	0.92**	0.89**

** Indicate correlation is significant at the 0.01 level, respectively (2-tailed).

brood significantly ($p < 0.01$) more than colonies had combs aged 4-years by 23.67, 17.39 and 7.30%, respectively. These results endorsed the findings of Berry and Delaplane (2001) and Dizaji et al. (2008). The correlation between bee population size and the area of worker brood was strongly positive ($r = 0.93$; $p < 0.01$). These results were in line with those of Jevtić et al. (2009); Taha (2015); Taha and Al-Kahtani (2019) who found a positive correlation between colony populations and the sealed brood area.

In comparison to colonies with combs aged 4-years, the colony population size of colonies with combs aged 1, 2 and 3-years significantly ($p < 0.01$) increased by 23.98, 13.06 and 7.79%, respectively. The large population size in colonies with new combs resulted from the higher brood production in new combs (Berry and Delaplane, 2001). In addition, workers reared in new combs were bigger than workers reared in old ones (Al-Kahtani, 2018). Bigger bees with larger wings can gather more nectar and pollen, and rear more brood, which resulted in a large population size. Positive correlations between length and width of the forewing, the hindwing length and colony population size were found (Mostajeran et al., 2006).

The amount of harvested honey yield significantly ($p < 0.01$) decreased in parallel with the increase of comb age; i.e. honey yield had an opposite relationship with the age of combs. In comparison to colonies with combs aged 4-years, the amount of honey harvested from colonies with combs aged 1, 2 and 3-years increased by 23.98, 13.06 and 7.79%, respectively. Our results confirmed by Taha and El-Sanat (2007) and Dizaji et al. (2008) who obtained the largest honey yield from colonies had new combs, while the lowest honey yield was obtained from colonies had old combs. The superiority of colonies with new combs in honey production in comparison to colonies with old ones may be due to the higher brood production in new combs (Berry and Delaplane, 2001; Dizaji et al., 2008) resulted in large bee population size that gathered more nectar and produced high honey yield. The correlation between honey yield with worker sealed brood area ($r = 0.92$; $p < 0.01$) and with colony population size ($r = 0.89$; $p < 0.01$) were strong positive. Relatively similar results were obtained by Taha (2015) and Taha and Al-Kahtani (2019). In addition, old combs with smaller cells resulted in smaller workers. Body size was significantly positively correlated with most body characteristics (Al-Kahtani and Taha, 2014). The honey yield was significantly correlated with the wings and the leg characteristics (Mostajeran et al., 2006), and the area of corbicula (Kolmes and Sam, 1991).

5. Conclusion

The foraging rate, gathering and storing pollen, growth of the colony, and honey yield significantly depended on the age of combs. Beekeepers can replace old combs with new ones to increase brood and honey production.

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