

Foraging initiation and foraging behavior in high and low performance of Iranian honeybee, *Apis mellifera meda* (Hym.: Apidae), colonies

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Abstract

The starting of foraging is likely the most important phenomenon in the age based division of labor in honeybees. It also prepare one of the most complicated phenotypic trait in biological system since the intercourse of different external, social and personage factors. Pollination effect is related to foraging behavior and foragers' population, so this research aims to determine foraging initiation and foraging behavior of worker bees in high and low performance colonies. There is a significant correlation between foraging behavior and honey production in different colonies and in various regions. Early foraging leads to higher production of honey in a colony. Also, based on the results obtained, the peak of foraging initiation in high performance colony was longer (age of 16-23 day) and in low performance colony was shorter (age of 17-21 day). The results indicate that the returned bees ($P < 0.05$) and returned bees with pollen load ($P < 0.05$) in high production colonies are more than low production colonies. Results have shown differences in the age of first foraging (AFF) comparing to previous studies, in which represented AFF starts 21 days after birthday of worker foragers. Obtained results have shown that the number of forager bees has positive correlation with honey production in honeybee colonies and also AFF of high production colonies was started in earlier age that can due to higher production in these colonies.

Key words: Iran, honey bee, foraging initiation, high performance, low performance

چکیده

بررسی آغاز جستجوگری و رفتار جستجوگری در کلنی‌های با عملکرد بالا و عملکرد پایین زنبور عسل نژاد ایرانی، *Apis mellifera meda* (Hym.: Apidae)

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آغاز جستجوگری در دوران زندگی زنبورهای کارگر، مهم‌ترین و برجسته‌ترین پدیده در تقسیم کاری وابسته به سن در زندگی زنبور عسل می‌باشد. به علت اثرات متقابل عوامل خارجی، اجتماعی و فاکتورهای فردی زنبوران کارگر، شروع جستجوگری یکی از صفات پیچیده فنوتیپی و عملکردی در سیستم بیولوژیک زنبور عسل است. تأثیر گرده‌افشانی به میزان رفتار جستجوگری و جمعیت زنبوران جستجوگر بستگی دارد. بنابراین، این تحقیق سعی در تشخیص سن شروع جستجوگری و رفتار جستجوگری زنبورهای کارگر در کلنی‌های با عملکرد بالا و عملکرد پایین دارد. رفتار جستجوگری و تولید عسل در کلنی‌های مختلف زنبور عسل در مناطق متفاوت، همبستگی معنی‌داری دارد. اگر یک کلنی جستجوگری را زودتر شروع کند، می‌تواند عسل بیشتری تولید نماید. همچنین، براساس نتایج به‌دست‌آمده از این تحقیق، طول پیک شروع جستجوگری در کلنی‌های با عملکردهای بالا (سن ۱۶ تا ۲۳ روزگی) طولانی‌تر از کلنی‌های با عملکرد پایین (سن ۱۷ تا ۲۱ روزگی) بود. نتایج نشان داد که زنبورهای برگشتی ($P < 0.05$) و زنبورهای برگشتی با گرده به‌دست‌آمده از این کلنی‌های پرتولید بیش از کلنی‌های کم‌تولید می‌باشد. نتایج این تحقیق اولین سن جستجوگری متفاوتی را در مقایسه با مطالعات قبلی نشان می‌دهد. در مطالعات قبلی اولین سن جستجوگری زنبوران کارگر ۲۱ روز بعد از تولد گزارش شده بود. نتایج به‌دست‌آمده نشان می‌دهد که تعداد زنبورهای جستجوگر همبستگی مثبتی با تولید عسل در کلنی‌ها دارد. همچنین اولین سن جستجوگری در کلنی‌های با تولید بالا در سنین زودتری مشاهده می‌شود که می‌تواند منجر به تولید بیشتر در این کلنی‌ها شود.

واژگان کلیدی: ایران، زنبور عسل، آغاز جستجوگری، عملکرد بالا، عملکرد پایین

Introduction

The onset of foraging through the lifetime of honeybee workers is the greatest opportunity to finding out division of labor in social insect. The evolution from within-hive activities to foraging, describes a central step in the lifetime of honeybee worker and is attended by a suite of behavioral and physiological variation (Rösch, 1925; Lindauer, 1952; Free, 1961). The combination of correlated behavioral and

physiological features was primarily identified in artificially selected high and low pollen hoarding populations (Page & Fondrk, 1995) but is one of general significance to find out honeybee's behavior and social evolution (Pankiw, 2003; Page & Amdam, 2007). The pollen hoarding mainly includes selects of foragers, sucrose and low sensitivity, ovary size, the age at which workers evolution from in hive duty to foraging (= age of first foraging: AFF) (Page & Erber,

2002; Rueppell *et al.*, 2004b, 2006; Humphries *et al.*, 2005; Page & Amdam, 2007). Marceau *et al.* (1990) had reported positive correlation between honey production and foraging behavior ($r = 0.86$). Based on Seeley (1985) study, hoarding behavior is estimable parameter in social life of honey bee; therefore, foraging behavior is focused in ethology.

After one generation of selection, strains varied in respect to stored pollen and by third generation, the high strain colonies stored an approximate 6 times more pollen than low strain colonies (Page & Fondrk, 1995). Calderon & page (1988, 1991, 1992) studied individual worker behavior in the same strains and mentioned that workers of the high strain more likely forage for pollen, even when grew in the same environments as low strain workers. Workers of the high strain also initiated foraging behavior at the younger age. These traits should result in greater numbers of pollen foragers in high strain than in low strain colonies leading to a potentially higher rate of pollen intake. Generation 3 high strain colonies had 37% more pollen foragers and 16% less non-pollen foragers than the low strains (Page & Fondrk 1995).

Modern technologies are efficiently helpful in molecular genetics studies of bees and provide reliable tools for using genetic markers to choose favored characters. Hunt *et al.* (1995), using RAPD marker and interval mapping method, found two loci effective on (Pln_1 - Pln_2) amount of loading pollen by foragers.

The aim of this research is to determine foraging initiation and foraging behavior of worker bees in high and low performance colonies.

Materials and methods

High and low production colonies were selected from 11th generation of Iranian Honeybee Breeding Project. The number of departing and returning bees as well as those foragers with pollen load was counted during two minutes in front of each hive entrance mornings and afternoons for ten high production and ten low production colonies. For foraging onset, queen of each colony was caged on brown comb by comb

excluder (fig. 1). Egg-laying of queen on brown combs in colonies was recorded after 24 hours. The combs were caged in comb excluders after 18 days of egg laying and covered with net. 21 days after egg-laying, worker bees appeared on the covered comb.

Then, those worker bees in the excluder were tagged in two different colors, used for tagging of high and low performance colonies (fig. 2). Tagged bees returned to their hives that were placed in the dark room. Traffic of worker bees was monitored for their AFF through a glass passage (fig. 3). The traffic of bees started at the age of 5 days until the age of 35-days.

Returning foragers from nature were monitored daily for 2 hours during the peak of foraging. The returning foragers were captured, and their dates of capture were recorded (which corresponded to their AFF). Our observation period proved long enough to capture the majority of marked bees flying in any specific day. Following Pankiw & Page (2001), the flights shorter than 5 minutes were considered as orientation flights, but the longer ones recorded as foraging flights.

Results and discussion

Our results are inconsistent with Winston's (1987), in which the transition from within-hive activities to foraging typically has been expressed for a worker bee of about 3 weeks old and found that its age of first foraging (AFF) starts 21 days after birthday. We found that AFF of workers in a high performance colony started earlier, from 9 days old through 33 days old, while in a low production colony it began from 12 days old until 29 days old.

The moment of change from in-hive to forager bees have important influence on colony energy supply and individual fatalities (Rueppell *et al.*, 2007, 2008). Therefore, it is a major feature for colony survival and social development, and similar age related division of labor can be spotted in different social insects.



Fig. 1. Caging the queen of colony on the brown comb by comb excluder.



Fig. 2. Tagging the worker bees by special queen numbers on their backs.



Fig. 3. Controlling the traffic of worker bees through glass passage.

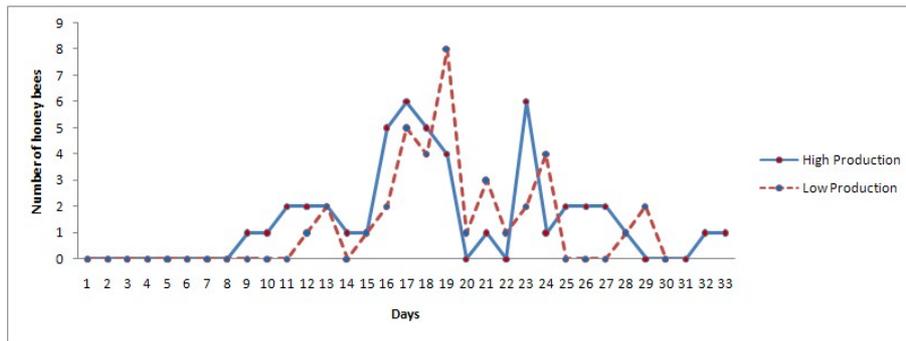


Fig. 4. Comparison of foraging initiation in high and low performance colonies.

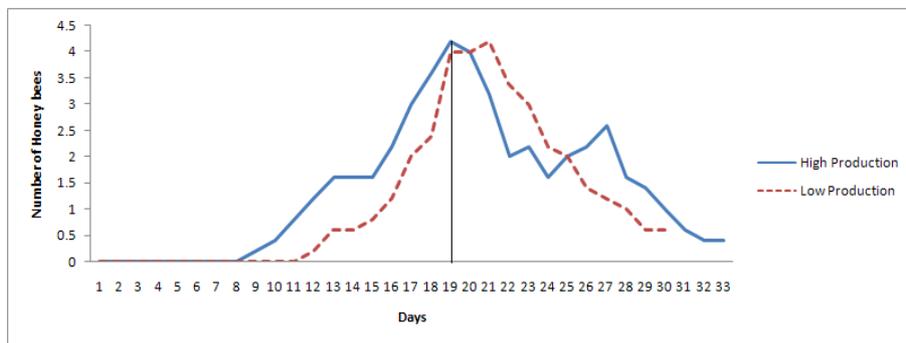


Fig. 5. Comparison of foraging onset in high and low performance colonies by moving average.

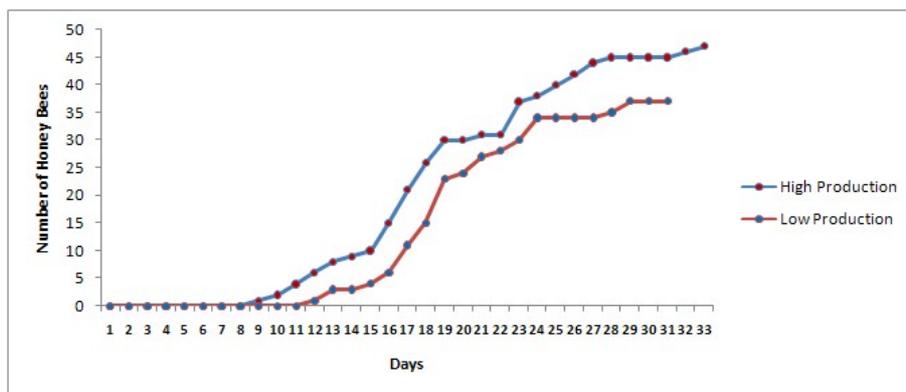


Fig. 6. Comparison of onset of foraging in high and low performance colonies by cumulative frequency.

Also, recent advances in knowledge of molecular genetics of bees emphasize the potential for using genetic markers to select favored traits. Quantitative trait locus studies, for example, have been carried out on foraging onset (Hunt *et al.*, 1995; Page *et al.*, 2000).

Totally, results of this survey show that AFF in high production colony was started sooner in comparison with low production colony. Also, the peak of foraging initiation was longer in high production colony (fig. 4). Obtained results have

shown that AFF of high production colonies was started in earlier age that can due to higher production in these colonies.

The starting of foraging is considered as the most important phenomenon in the age based division of labor in honeybees. Pankiw & Page (2001) reported remarkable genotypic effect on the evolution of foraging between tow lines of honeybees from *Apis mellifera*, which were basically chosen on pollen hoarding behavior. On the other hand, in primary sections or first 10 days, also in the peak of foraging initiation, foraging onset in worker bees of high production colonies occurs earlier, which goes with what Rueppell *et al.* (2004a) have previously reported.

Moving average method was used to reach normal condition like what is in nature (fig. 5). The peak of foraging initiation (more than average) in high performance colony was longer (age of 16-27 days) than low performance (age of 17-25 days) colonies. It shows that longer initiation foraging peak may cause more honey production.

The under curve areas that is related to high production colony were 38.34 cm² and 30.09 cm² for

low production colony (fig. 5). In the period of foraging initiation, between the ages of 9 to 33 day, the number of foraging worker bees in high production colonies was higher than worker bees in low production colonies. But in the first 10 days of foraging initiation in high production colony, the under curve area was 15.68 cm² and 8.35 cm² for low production colony. So, there were the more number of worker bees which had started their foraging in high production colony in the first 10 days of foraging initiation period. This is one of the most important reasons in order to have the higher performance.

Therefore, these two methods have shown that when in one colony, foraging flights start at lower age, the higher amount of honey production is available. These results are similar to the results found by Gary & Lorenzen (1976) and Tahmasbi *et al.* (2014) that have shown increase in honey production in colonies that had more foragers. In high performance colonies, worker bees start their foraging behavior earlier; leading to more honey production (Tahmasbi *et al.*, 2012).

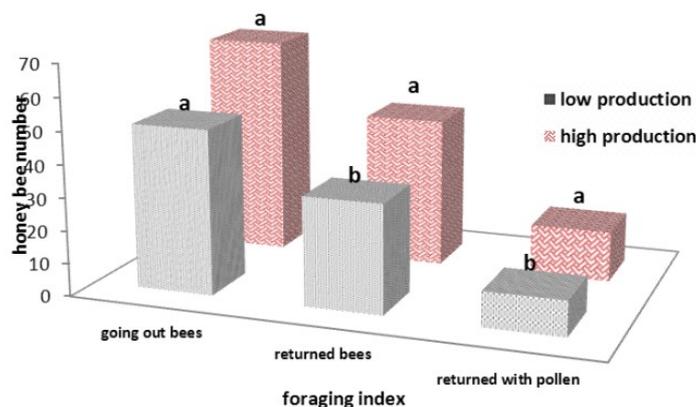


Fig. 7. Comparison of foraging behavior in high and low production colonies.

Results related to the number of bees that had started their foraging behavior in high and low production colonies, show that initiation of foraging in

high production colony might be earlier (fig. 6). In addition, the cumulative numbers of foragers showed the percentage of bees that start foraging behavior in

high production colonies is higher (fig. 6). The obtained data of foraging behavior comparison in high and low performance colonies were showed the returned bees ($P < 0.05$) and returned bees with pollen load ($P < 0.05$) in high production colonies were more than low production colonies. But the number of bees that were going out of colonies has not significant differences. The number of forager bees in high production colonies was more than low production colonies (fig. 7).

The results of this study is consistent with what Sekiguchi & Sakagami (1962), Marcean *et al.* (1990),

Tahmasbi *et al.* (2011) found before. The results suggest that the age of first foraging is different in comparison with previous studies, in which colonies started foraging at the age of 21 day.

The results of this research have shown the significant effect of foraging onset on honey production, so that in future studies the effects of foraging initiation on the productive and functional characteristics require further attention.

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