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Queen bee egg-laying dynamics: evaluation of Roger-Delon and Warre hives

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Abstract: The aim of the present study is to evaluate the egg-laying dynamics of queen bees in Roger-Delon and Warre hives located in an apiary at an altitude of less than 1000 m. The study was conducted during the active season of 2023, in an apiary located at an altitude of 860 m in south-western Bulgaria, Pernik district. The bee colonies were balanced before the beginning of the experiment. Two groups of 6 colonies were formed from each Roger-Delon and Warre system. Sealed worker brood was measured until the appearance of constant nectar flow (April – June), and after the appearance of constant nectar flow (September – November). There is currently a need to examine and quantify the egg-laying dynamics of queens in new hive systems. Queen egg-laying activity is affected by a variety of seasonal, nutritional and social factors. According to the results obtained, the average sealed worker brood in Warre hives and Roger-Delon hives are 10484±1031 cm^2 and 9564±1057 cm^2 (mean±SD) respectively, for the whole period until appearance of constant nectar flow.

Keywords: sealed worker brood; egg-laying dynamics; Roger-Delon hive; Warre hive

INTRODUCTION

Honey bees (*Apis mellifera* L.), are social insects, with a colony organisation divided into separate castes that allow specialisation in particular tasks (Page et al., 2006). The queen bee is an important reproductive female member of a honey bee colony. She is responsible for egg-laying and development of the colony (Lee et al., 2019). Worker honeybees contribute significantly to the production of agricultural crops throughout the world. Their pollination services are essential for maintaining food security of the world's growing human population. In the last few decades researchers have identified the main factors that negatively impact honey bee health: poor nutrition, exposure to pesticides, pathogens, and parasites (Spivak et al., 2011; Goulson et al., 2015). Many factors contributing to the decline of honey bee colonies are still not well understood. The poor quality of queen bees has been identified as a further reason for the decline in the bee population (Pettis et al., 2016; Lee et al., 2019). Egg-laying activity of queen bees is one of the parameters that can be used for determination of their health and productivity. Rangel et al. (2013) found that queen bee reproductive potential did not affect the amount of brood produced. Furthermore, Yu et al. (2022) demonstrated that the quality of queens reared in the spring from high-quality mother queens was also high.

Fine et al. (2018) present a novel laboratory-based system for quantitative assessment of egg-laying and utilize it to investigate the impact of pollen nutrition on queen fecundity. The authors introduce an innovative laboratory-based method for the quantitative evaluation of egg-laying. They use it to examine the effect of pollen nutrition on queen bee reproductive capacity. In most cases, these are laboratory methods, which would allow an experimental control and to accelerate progress in queen health research (Fine et al., 2018). Additionally, Miranda et al. (2003) studied

the effect of the proctolin (a bioactive neuropeptide) on egg-laying activity in Africanized honey bees. Queen bees injected with proctolin laid more than 1 egg per cell more frequently than the control group (p=0.004). Both honey and brood production were found to be significantly associated with queen body size by Nelson and Gary (1983). The monitoring of queen egg-laying is important due to the many factors that can affect it, such as nutrition, genotype of the queen bee, pollen sources and pesticides (Svoboda et al., 2023; Fèvre and Dearden, 2024).

According to Doğaroğlu (2004), Langstroth and Dadant hives are the most common types of hives used in modern beekeeping. Research has shown that the type of hive has a significant impact on the health and productivity of honeybee colonies, playing a role in such important aspects as disease prevalence, brood production and honey yield. To date, a small number of quantitative studies on queen egg-laying in full-sized bee colonies held at different types of hives. To perform daily egg counts and assessments most researchers cage the queen (Fine et al., 2018). Quantitative studies of queen egg-laying activity for hives, such as Roger-Delon system and Warre hives, are relatively scarce. In this context, the aim of the present study is to evaluate the egg-laying dynamics of queen bees in Roger-Delon and Warre hives located in an apiary at an altitude of less than 1000 m.

MATERIAL AND METHODS

The study was conducted during the active season of 2023 in an apiary located at an altitude of 860 m in south-western Bulgaria, Pernik district. The bee colonies were balanced before the beginning of the experiment by equalizing the amount of bees (kg), amount of honey and pollen supply. Two groups of 6 colonies were formed from each Roger-Delon and Warre system. The queen bees are sisters at the age of 1 year. The measurement of sealed worker brood was carried out during a period of 12 days, immediately after the first spring hive inspection until the appearance of constant nectar flow. The area, where the bee colonies are reared does not have a permanent first main pasture. Sealed worker brood was not measured during the constant nectar flow. After this period (in September), the sealed worker brood was measured again until the natural cessation of egg-laying (in November). The brood was measured using a frame with wires forming a 5/5 cm square. The number of sealed worker brood cells in the square of these dimensions is equal to 100.

The results were processed with the SPSS 23.0 program for Windows. The data are presented as mean ± standard deviation for each period. Student's t-test was used to determine the significance of the differences. Level of statistical significance was defined as $p<0.001$.

RESULTS AND DISCUSSION

The brood rearing process is a fundamental activity for bee colonies. The success of the brood rearing process depends on a number of factors, including the availability of nectar and pollen in nature, climatic conditions, the health of the queen bee, the presence of worker bees to care for the larvae, and the overall hive environment. Proper brood rearing is essential for the growth and sustainability of the colony, allowing effective pollination and honey production.

In both hive systems the brood area increased from April to June. The results for each date are presented on Figure 1. The highest value of sealed worker brood is on 19.06.2023. The results for egg-laying activity in Roger-Delon hives are similar to those, obtained for the same hive system in our previous study (Tsvetanov et al., 2013). For the whole period up to the appearance of constant nectar flow from April to June, the average values for sealed worker brood are significantly higher ($p<0.001$) in Warre hives compared to Roger-Delon hives. Akyol et al. (2008) found lower average values for brood area (in cm^2). The queens are 1 year old settled in standard Langstroth hives. The brood rearing can have a positive effect on bee colony productivity.

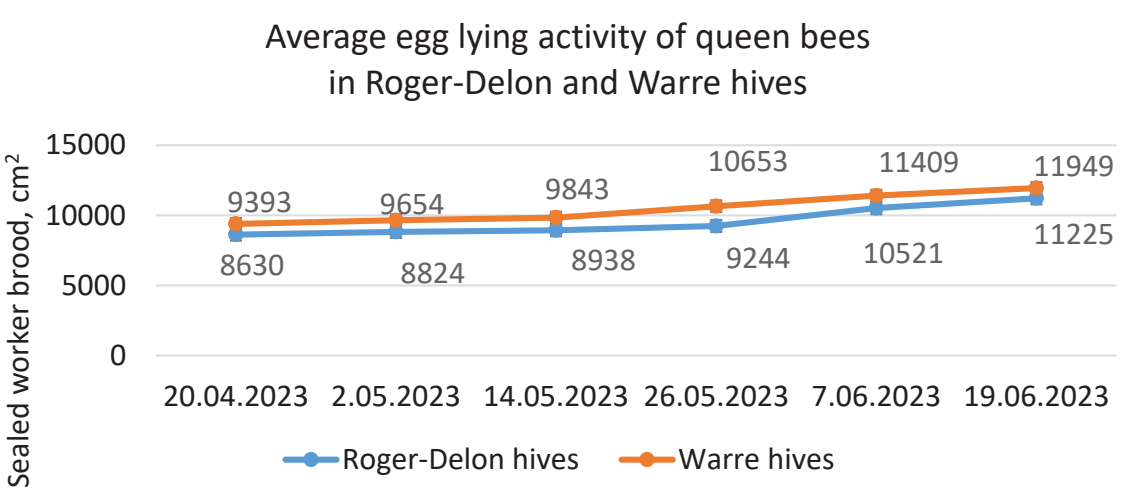


Figure 1. Egg-laying dynamics of queen bees reared in Roger-Delon and Warre hives until the appearance of constant nectar flow. All values are significant at $p<0.001$

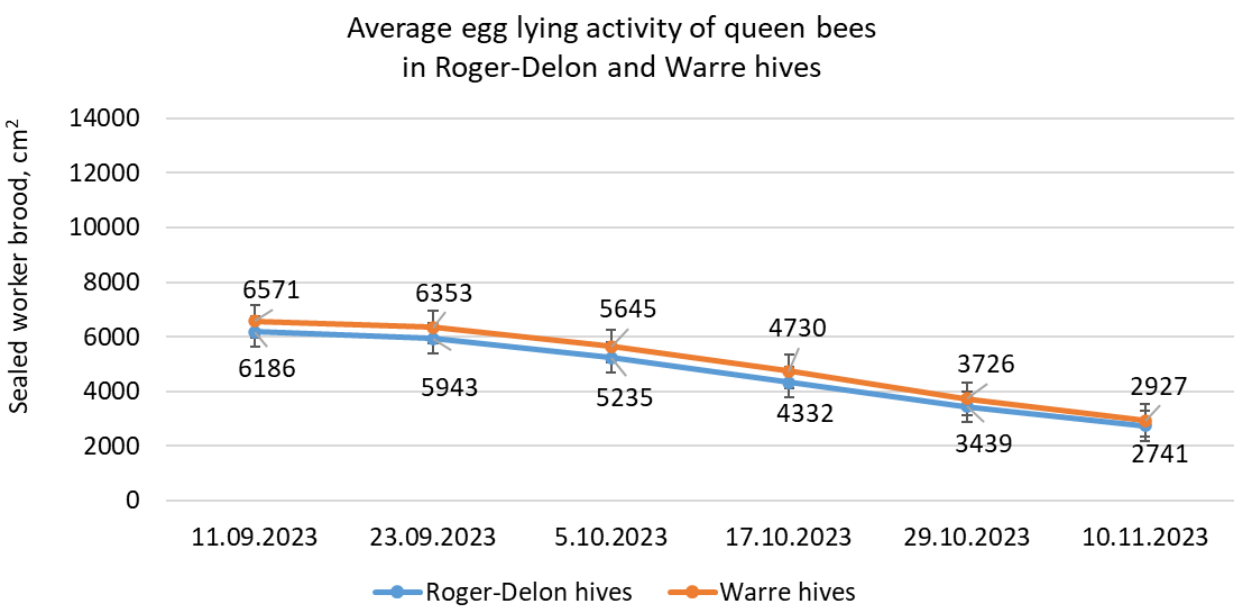
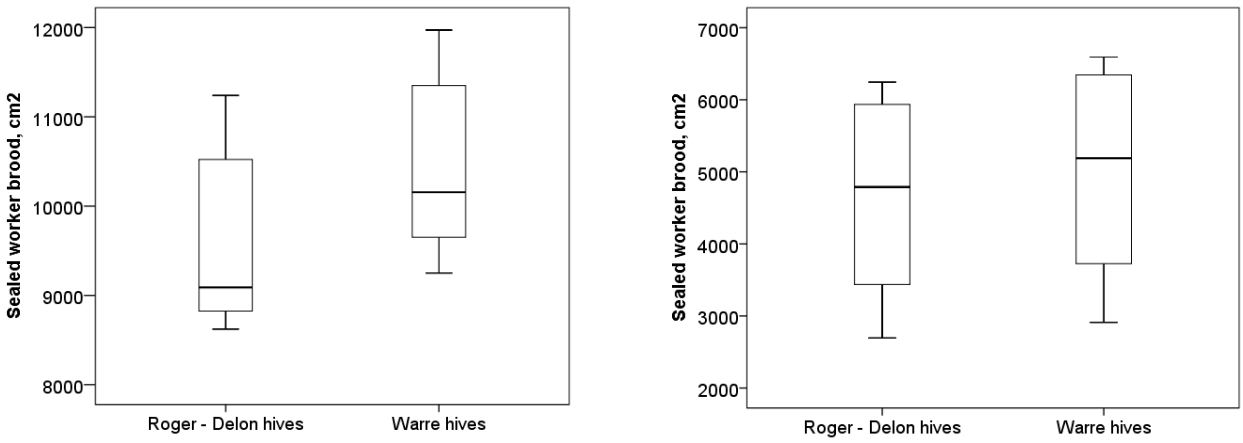


Figure 2. Egg-laying dynamics of queen bees reared in Roger-Delon and Warre hives after the constant nectar flow. All values are significant at $p<0.001$

By comparing egg-laying activity in different hive systems, insight can be gained into how hive design influences bee behaviour, queen egg-laying activity and colony performance. The data about egg-laying activity in different hive systems will help to improve beekeeping practices and bee colony overwintering. For this reason, a change in the rate of egg-laying and larval population was also identified from September to November. As illustrated in Figure 2, the highest average value (6571±24 cm^2 (mean±SD)) of the sealed worker brood was found on the first measurement 11.09.2023 in the Warre hives. The highest average value of sealed worker brood throughout the entire period is found in Warre hives (Figure 2).



A) *B)*

Figure 3. Box plot diagram of sealed worker brood (cm^2) until the appearance of constant nectar flow (A) and after the constant nectar flow (B). Minimal, maximal and median values are presented for the whole period (April – November)

For each date, the average sealed worker brood values are significantly higher ($p<0.001$) in Warre hives compared to Roger-Delon hives. For September-October period, Akyol et al. (2008) found lower mean values for brood area measured in standard Langstroth hives.

In Warre and Roger-Delon hives the rate of egg-laying was found to decrease from September to November. This is the normal process of seasonal brood reduction. During this period, as daylight hours shorten and temperatures decreased, queen bees naturally reduce egg production in response to the changing environment. This reduction in egg production allows the colony to conserve resources, particularly as the availability of food (nectar and pollen) decreases as winter approaches. These findings are confirmed by Shehata et al. (1981).

The average brood area was recorded for Warre hives 10484±1031 cm^2 (mean±SD) for the whole period until the appearance of constant nectar flow. For the Roger-Delon hives the result is 9564±1057 cm^2 (mean±SD) (Figure 3A).

The average brood area for Warre hives was 4992±1355 cm^2 (mean±SD) until constant nectar flow. For Roger-Delon hives it was 4646±1282 cm^2 (mean±SD) (Figure 3B).

CONCLUSION

There is currently a need to examine and quantify the egg-laying dynamics of queens in new hive systems. Queen egg laying activity is affected by a variety of seasonal, nutritional and social factors. According to the results obtained the average sealed worker brood in Warre hives and Roger-Delon hives are 10484±1031 cm^2 and 9564±1057 cm^2 (Mean±SD) respectively, for the whole period until appearance of constant nectar flow.

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