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Correlations between the strength, amount of brood, and honey production of the honey bee colony

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Summary

Strong bee colonies rear more brood and produce more honey than weak colonies. The aim of the study was to determine the correlation between the strength of bee colonies, the amount of brood reared, and the amount of honey produced. Thirty bee colonies of different strength were observed. The amount of brood reared in each colony was determined one month before the beginning of the nectar flow from winter rape and the production of honey after the nectar flow period. A significant positive correlation was established between the strength of the bee colony and brood amount (r = 0.442), between colony strength and honey production (r = 0.456), and between brood amount and honey production (r = 0.568).

Keywords: honey bee, strength of colony, brood amount, honey production

The amount of brood is usually positively correlated with colony size, the exact correlation differing in various sources (2, 17, 26). The number of brood cells in a colony is directly proportionate to the number of bees, but the number of brood cells per bee is inversely proportionate to the number of bees (11). Strong colonies rear more brood in the spring, but the differences are not always statistically significant (20). Wilde and Krukowski (25) do not report a significant influence of colony strength on brood amount.

The production of honey is positively correlated with colony size (1-3, 7- 9, 13, 17, 18, 22, 24, 27). According to Woyke (27), the correlation is greater in the spring than in the summer. In strong colonies, honey collection per bee forager is higher than in weak colonies (6), and during the dearth period honey consumption is lower (12). Forager bees from strong colonies make longer flights and bring back to the hive significantly bigger loads of nectar compared to forager bees from weak colonies (5). Wilde and Krukowski (25) found that colony strength did not have a significant influence on honey production, though strong colonies obtained better results.

Bees use about 163 mg of honey to rear one worker bee (11). There are about 800 cells on both sides in 1 dm² of a comb, holding approximately 300 g of honey. It results from the above that to rear one comb of brood, bees use more than two combs of honey. Restricted oviposition by queens during nectar flow periods has a positive influence on the collection of honey, but a negative influence on the utilization of subsequent nectar flows due to the reduced number of forager bees. The annual production of honey depends on the fertility of queens – the more eggs they lay, the greater the production of honey (4, 17, 23). Honey production during nectar flow periods is smaller, however, in colonies which rear more brood (9). Pidek (19) found that restricted oviposition by queens during nectar flow periods may increase honey production by more than 130%. Honey yield increases in line with the increasing number of bees in the colony relative to the amount of open brood (10, 28). Bees rearing less brood live longer (16, 26, 27), which additionally contributes to a better utilization of nectar flows. In studies conducted by Mattila and Otis (15) and by Roman and Dawidowicz (21), honey yield per season was the highest in colonies with the largest amount of brood in the spring. Similarly, Bhusal and Thapa (2) and Bhusal et al. (1) found a significant positive correlation between the production of honey and the amount of brood reared. Kostarelou-Damianidou et al. (14) report that the production of honey usually increases with the amount of brood, but the correlation is not always positive. According to Szabo and Lefkovitch (24), the production of honey is significantly positively correlated with the number of brood cells only in the first half of the season. Similarly, Woyke (26) found a high positive correlation between the amount of brood and the production of honey in the spring, and a low correlation in the summer. Zmarlicki and Marcinkowski

(29) did not find a relationship between the amount of brood reared and the production of honey.

The aim of the study was to determine the correlation between the strength of bee colonies, the amount of brood reared, and the production of honey.

Material and methods

The experiment was carried out in south-eastern Poland in 2006 on 30 colonies of *Apis mellifera ligustica* bees in Dadant beehives. All queens were one-year old, originated from one reproductive queen, and were naturally mated. The experiment included 10 colonies covering 6, 7 and 8 combs in the beginning of April. Then, the amount of brood was determined on the basis of brood area by measuring two ellipse diameters. Honey production was evaluated following the nectar flow of winter rape, which was in bloom from the beginning until the end of May.

Statistical calculations were performed by a one-way ANOVA. The significance of differences between particular groups was calculated by Duncan's test.

Results and discussion

Colony Strength and Amount of Brood. One-way ANOVA did not show a significant influence of colony strength on the amount of brood reared ($F_{2,29} = 3.303$; $P = 0.052$). Duncan's test, however, showed that colonies covering 8 combs had significantly more brood (20.8 dm^2 on the average) than colonies covering 6 combs (15.5 dm^2) (Tab. 1). This may have been caused by the fact that a greater number of worker bees were available to warm and feed more brood. A significant positive correlation was established between colony strength and the amount of brood ($r = 0.442$, $P = 0.014$). In studies by other authors, that correlation was r = 0.39-0.77 (17); r = 0.26-0.83 (26); r = 0.99 (2). Wilde and Krukowski (25) and Bobrzecki et al. (3) did not find a significant influence of colony strength on the amount of brood.

Colony Strength and Honey Production. One-way ANOVA showed a significant influence of colony strength on the production of honey ($F_{2,29} = 3.928$; $P = 0.032$). Colonies which covered 8 combs in early April produced significantly more honey by the end of May (the average of 30.8 kg) than those covering 6 combs (22.1 kg) (Tab. 2). These findings confirm studies by other authors (2, 8, 9, 17, 22, 24, 27). Wilde and Krukowski (25) and Bobrzecki et al. (3) found that colony strength does not have a significant influence on the production of honey.

A significant positive correlation between colony strength and production of honey was established ($r = 0.456$; $P = 0.011$). Bhusal and Thapa (2) and Bhusal et al. (1) obtained higher correlation r = 0.963, while Woyke (26, 27) reported r = 0.38-0.88 and r = 0.39--0.70.

Brood Amount and Honey Production. One-way ANOVA showed a highly significant influence of the amount of brood, one month before the beginning of nectar flow, on the production of honey ($F_{2,29} = 8.617$; $P = 0.001$). Colonies with less than 15 dm^2 of brood in early April produced significantly less honey by the end of May (the average of 17.9 kg) than those rearing 15-20 dm^2 and more than 20 dm^2 of brood (26.9 and 30.1 kg, respectively) (Tab. 3). A highly significant positive correlation was discovered between the amount of brood reared before nectar flow and the production of honey ($r = 0.568$; $P < 0.001$). A similar correlation was reported by Moeller (17) (r = 0.43-0.50) and by Soller and Bar-Cohen (23) (r = 0.45-0.51), and a higher factor by Woyke (26) (r = 0.85), Genç and Aksoy (9) (r = 0.63-0.79), and by Bhusal and Thapa (2) (r = 0.918).

Tab. 1. Brood area (dm^2) depending on the number of combs covered by bees

Number of combs	Number of colonies	Min-Max	Mean ± se
6	10	10.2-25.2	15.5 ± 1.41[a]
7	10	9.9-23.9	17.8 ± 1.52[ab]
8	10	16.0-30.8	20.8 ± 1.46[b]
Overall	30	9.9-30.8	18.0 ± 0.91

Explanation: *Different letters indicate significant differences between the means ($P < 0.05$) higher correlation r = 0.963, whereas Woyke (26, 27) reported r = 0.38-0.88 and r = 0.39-0.70.

Tab. 2. Production of honey (kg) depending on the number of combs covered by bees

Number of combs	Number of colonies	Min-Max	Mean ± se
6	10	15.1-33.3	22.1 ± 2.01[a]
7	10	12.2-43.1	24.3 ± 2.85[ab]
8	10	21.4-39.1	30.8 ± 1.88[b]
Overall	30	12.2-43.1	25.7 ± 1.45

Explanation: *Different letters indicate significant differences between the means ($P < 0.05$)

Tab. 3. Honey production (kg) depending on the amount of brood

Area of brood (dm^2)	Number of colonies	Min-Max	Mean ± se
Less than 15	8	12.2-25.5	17.9 ± 1.58[a]
15-20	11	17.0-37.6	26.9 ± 2.07[b]
More than 20	11	19.5-43.1	30.1 ± 2.14[b]
Overall	30	12.2-43.1	25.7 ± 1.45

Explanation: *Different letters indicate significant differences between the means ($P < 0.05$)

The strength of bee colonies is significantly positively correlated with the amount of brood reared.

The production of honey is significantly positively correlated with the size of bee colonies.

The amount of brood reared in bee colonies before nectar flow is highly significantly positively correlated with the production of honey.

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