EFFECT OF PERIOD OF THE SEASON AND ENVIRONMENTAL CONDITIONS ON RATE OF CLEANING CELLS WITH DEAD BROOD

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Summary

The study was done in the years of 2004, 2005 and 2007 in carniolan bee colonies, of Zosia line. The hygienic behaviour of bee colonies with assays of freeze-killed brood was measured. In 2007 the hygienic behaviour of colonies was related to the weather conditions and natural honey flow.

Some differences were found in the removal rate of dead brood during the experiment. In the first 12 hours after the brood was killed a significantly lower percentage of cleaned cells was observed in the year of 2005. After 3 days of cleaning, bees removed a significantly higher percentage of freeze-killed brood in 2007 than in 2004 and 2005. Some differences were found also in the rate of cell cleaning in particular periods of the season. During the first 12 hours after the brood was killed, bees removed the least freeze-killed brood in May. In the first three days, after the brood was killed, bees cleaned the highest percentage of dead brood in June and August.

No correlation was found between cell cleaning rate and average air temperature and air humidity. Also the nectar income on the day of measurement did not affect the rate of dead brood removal. However the nectar income on the day before the measurement of the cleaning rate, affected positively the number of removed dead brood.

Keywords: hygienic behaviour, period of the season, environmental conditions.

INTRODUCTION

The hygienic behaviour of the honey bee is one of the mechanisms for disease resistance. It depends on genetic factors (Rothenbuhler 1964, Heath 1982, Bühler 1996, Spivak and Reuter 1998, Palacio et al. 2000, Lapidge et al. 2002, Panasiuk et al. 2008), strength of bee colony (Momot and Rothenbuhler 1971, Robinson 1992, Johnson 2003, Arathi and Spivak 2001), and manner of brood killing (Kefuss et al. 1996, Békési and Szalai 2003, Bieńkowska et al. 2004, Panasiuk et al. 2008). Hygienic behavior depends also on several weather conditions that ensure good colony development and a source of honey flow. During a good flow, bees remove dead brood from the cells faster. Then the bees prepare the cells for the collection of honey (Thompson 1964, Momot and Rothenbuhler 1971, Spivak et al. 1995, Spivak and Reuter 1998). However, the activity of foragers drops in adverse weather conditions and leads to lower pollen and honey stores. This subsequently affects brood rearing and the structure of the bee colony. The result is lower bee colony strength (Mattila and Otis 2006).

Jasiński et al. 2004 stated the positive dependence of higher honey storage on faster dead brood removal by the bees. However the air temperature observed during the study, which ranged between 19 and 31°C, did not affect the rate of cell cleaning. Nevertheless on chilly and rainy days bees were observed to have difficulties in foraging. On these chilly and rainy days, bees cleaned a lower number of cells with dead brood (Jasiński et al. 2007). The temperature in the colony is correlated with the temperature outside the hive (Flores et al.1996).

The aim of the study was to verify the influence of the period of the season; weather conditions and natural nectar flow on the hygienic behaviour of honey bee colonies.

MATERIAL AND METHODS

The observations were carried out at the Department of Bee Breeding of the Institute of Pomology and Floriculture, Apiculture Division in Puławy, Poland in the years of 2004, 2005 and 2007. Bee colonies of the carniolan race, from Zosia line were used in the research. The hygienic behaviour of bees was estimated three times in the years of 2004 and 2005 and four times in 2007 on the basis of the freeze-killed brood cleaning rate (Table 1).

Three randomly chosen honey bee queens were kept in a single-frame queen excluder insulator for 48 hours with experimental comb pieces to be filled with eggs. The comb pieces were in a wooden frame and contained about 500 cells on each side. When brood reached the prepupa stage (12 to 13 days old), the experimental combs were moved to a refrigerator for 12 hours. The temperature of the refrigerator was -18°C. Foil patterns with sealed cells were prepared in order to make the cleaned cell-counts easier. Next combs were moved to colonies. The number of cleaned cells was estimated after 12, 24, 48, and 72 hours and then once a day until all cells with dead brood were cleaned.

In order to verify the influence of environmental factors on hygienic behavior of bees in 2007 the meteorological data were collected from the meteorological station of the Institute of Soil Science and Plant Cultivation. The station is about 1 kilometer from the experimental apiary. The rate of cell cleaning was analyzed and compared to the average daily air temperature and relative air humidity measured at midday. Additionally, in order

Table 1

Plan of experiment.

Year of the research	Date of experiment	Number of colonies
2004	25.05 – 04.06	5
	06.07 – 14.07	3
	13.08 – 19.08	4
2005	05.06 – 15.06	5
	12.07 – 20.07	5
	23.08 – 31.08	2
2007	25.05 – 29.05	10
	26.06 – 29.06	10
	17.07 – 24.07	10
	07.08 – 11.08	10

to verify the influence of natural nectar flow on the cleaning rate, colony weight was checked every evening during the whole beekeeping season of 2007. A hive scale was kept in the experimental apiary.

The average rate of dead brood removal was calculated and given as percentages. Data were calculated according to the Bliss' transformation. The two-way ANOVA was used for statistical calculation. Duncan's multiple range test was applied to determine significant differences between the means. The correlation between the environmental conditions and rate of dead brood removal was calculated according to Pearson's correlation coefficient.

RESULTS AND DISCUSSION

Dynamics of cell cleaning in different years and periods of the season

In particular years different dynamics of cell cleaning were observed. Detailed analysis was done for the first 3 days of research. During the first 12 hours after the brood was killed, the bees cleaned a significantly lower percentage of cells with dead brood in the year of 2005 than in 2004 and 2007. No significant differences were noted between these two last years (Table 2). After 24 and 48 hours no significant differences were found in the cleaning rate of the cells. After 72 hours, the bees removed a significantly higher percentage of freeze-killed brood in 2007, than in the other years.

All cells with freeze-killed brood were cleaned within 150 hours in the year of 2007 and within 250 hours in years 2004 and 2005.

In May (Table 3), regardless of the year, bees cleaned significantly lower percentage of cells with dead brood during the first 12 hours after the brood was killed (about 5%), than in the other months. In later months they cleaned a higher percentage of cells; from 10 to 15%. Twenty four hours after the brood was killed, the lowest rate of cell cleaning was still observed in May, however differences were significant only for June and August. After 2 days, the average rates of cell cleaning in May, July and August did not differ significantly, however were significantly lower than in June. On the third day, the lowest cleaning rate was observed in July and May (about 60%), not significantly higher in August and significantly highest in June (more than 83%).

Table 2

Average percentage of cleaned cells with freeze-killed brood in different years of the research.

Year	The number of experimental combs	Brood cells cleaned after hours							
		12		24		48		72	
		average (min-max)	SD	average (min-max)	SD	average (min-max)	SD	average (min-max)	SD
2004	12	13.86 b (0.6-34.6)	14.40	21.53 a (1.8-54.7)	19.12	39.78 a (2.4-93.4)	30.67	52.62 a (5.4-100)	30.72
2005	12	5.96 a (0-18.4)	6.20	17.42 a (1.0-50.7)	16.08	43.34 a (3.1-97.0)	35.14	56.32 a (9.5-100)	35.65
2007	40	11.23 b (0.3-35.5)	8.12	23.85 a (3.7-82.1)	15.29	53.91 a (20.9-100)	22.46	78.76 b (37.6-100)	20.76
Sum and averages	64	10.74	9.50	22.21	16.12	49.50	26.92	69.65	28.20

Different letters indicate significant differences in columns $p \leq 0.05$ (using the Bliss' transformation).
SD – standard deviation.

Table 3

The rate of cleaning cells with freeze-killed brood in different months of 2004, 2005 and 2007.

Month	Number of experimental combs	Brood cells cleaned after hours							
		12		24		48		72	
		average (min-max)	SD	average (min-max)	SD	average (min-max)	SD	average (min-max)	SD
May	15	4.94 a (0.3-33.3)	8.37	13.23 a (1.8-40.3)	10.42	39.90 a (2.4-78.3)	22.40	64.24 a (5.4-100)	27.82
June	15	13.03 b (0-35.5)	10.00	29.75 b (1.0-82.1)	19.82	65.23 b(8.6-100)	29.90	83.04 b (9.5-100)	31.33
July	18	9.62 b (1.5-31.0)	6.40	18.80 ab (4.3-50.7)	13.13	39.54 a (16.3-85.7)	22.00	58.30 a (24.0-99.3)	24.22
August	16	15.29 b (0-34.6)	10.50	27.40 b (1.6-54.7)	15.74	55.00 ab (3.1-93.4)	26.51	74.95 ab (10.2-100)	25.37
Sum and averages	64	10.74	9.50	22.21	16.12	49.50	26.92	69.65	28.20

Different letters indicate significant differences in columns $p \leq 0.05$ (using the Bliss' transformation).
SD – standard deviation.

A detailed analysis of the dynamics of removing freeze-killed brood until the cleaning was completed, showed that in the year 2007, the highest cleaning rate occurred in June, when the bees cleaned all cells with dead brood within the first four days, after the brood was killed (Fig. 1). In May and August bees cleaned all cells with dead brood within 120 hours and in July, the latest, within 150 hours.

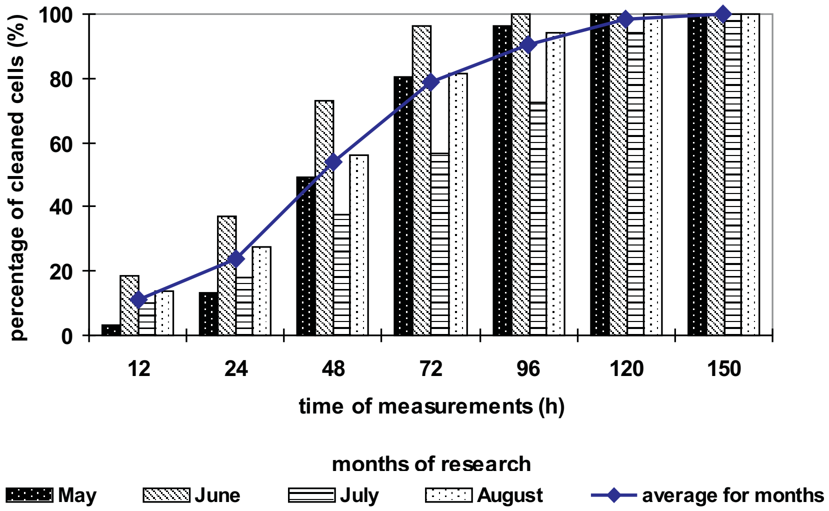

Fig. 1. Dynamics of cleaning cells with freeze-killed brood in different months of the year of 2007.

Effect of environment on hygienic behaviour of bees

The observations were conducted in the season of 2007. Dynamics of the daily cell cleaning rate, did not indicate a direct relationship between that factor and the average air temperature and air humidity

In May (Fig. 2) advantageous foraging conditions existed, but bees did not clean high numbers of cells with dead brood. Only on the 26th of May did bees clean more than 20% of the cells. Lower numbers of cells were cleaned in the remaining days. The bees cleaned all inserted freeze-killed brood within the initial 5-day period.

In June, the average air temperature in the research period was below 20°C. In this relatively worse foraging conditions, bees regularly cleaned high numbers of cells with dead brood within the 4 days. The highest temperature in the beekeeping season of 2007 was in July (from 20 to 25°C). During that month, as well as in May, the bees did not intensively clean cells. It can be assumed that the lower the air temperature and thus the worse the foraging conditions, the more intensive the cell cleaning occurs. However in advantageous weather conditions in August with the average temperature of 20°C, bees quickly removed dead brood from the combs.

No significant correlation between the rate of cleaning cells with freeze-killed brood and the average air temperature was found $r = 0.004$, $df = 17$, $p = 0.07$ as well as between that factor and the air humidity $r = -0.30$, $df = 17$, $p = 0.12$.

No relationship between the natural nectar flow and the dynamics of removing freeze-killed brood was indicated. In May, during the first day after the brood was killed, the hive weight increased for about 0.3 kg. At the same time bees removed a low percentage of dead brood. However during the next two days, when the hive weight increased for about 0.1 kg, bees removed a high percentage of dead brood. In June, however, on the first day after the brood was killed, no increase in nectar income was noted and on the following day a decrease was recorded, but bees cleaned a high percentage of cells with dead brood. A relatively high percentage of cells were cleaned on the fourth day, in June, when a significant increase in nectar income was recorded (0.4 kg). In the next two months no increase in nectar income was observed. Bees cleaned low percentages of cells in July, while in August they cleaned a slightly higher percentage of cells.

No significant correlation was found between the rate of cleaning cells and honey income on the day of measurement ($r = 0.08$, $df = 17$, $p = 0.74$). However, during the four months, there was a positive correlation between nectar income on the day before the measurement and the cleaning rate $r = 0.56$, $df = 17$, $p = 0.016$. In May and July when an increase in the nectar income was observed, the correlation coefficient was $r = 0.61$, $df = 8$, $p = 0.075$.

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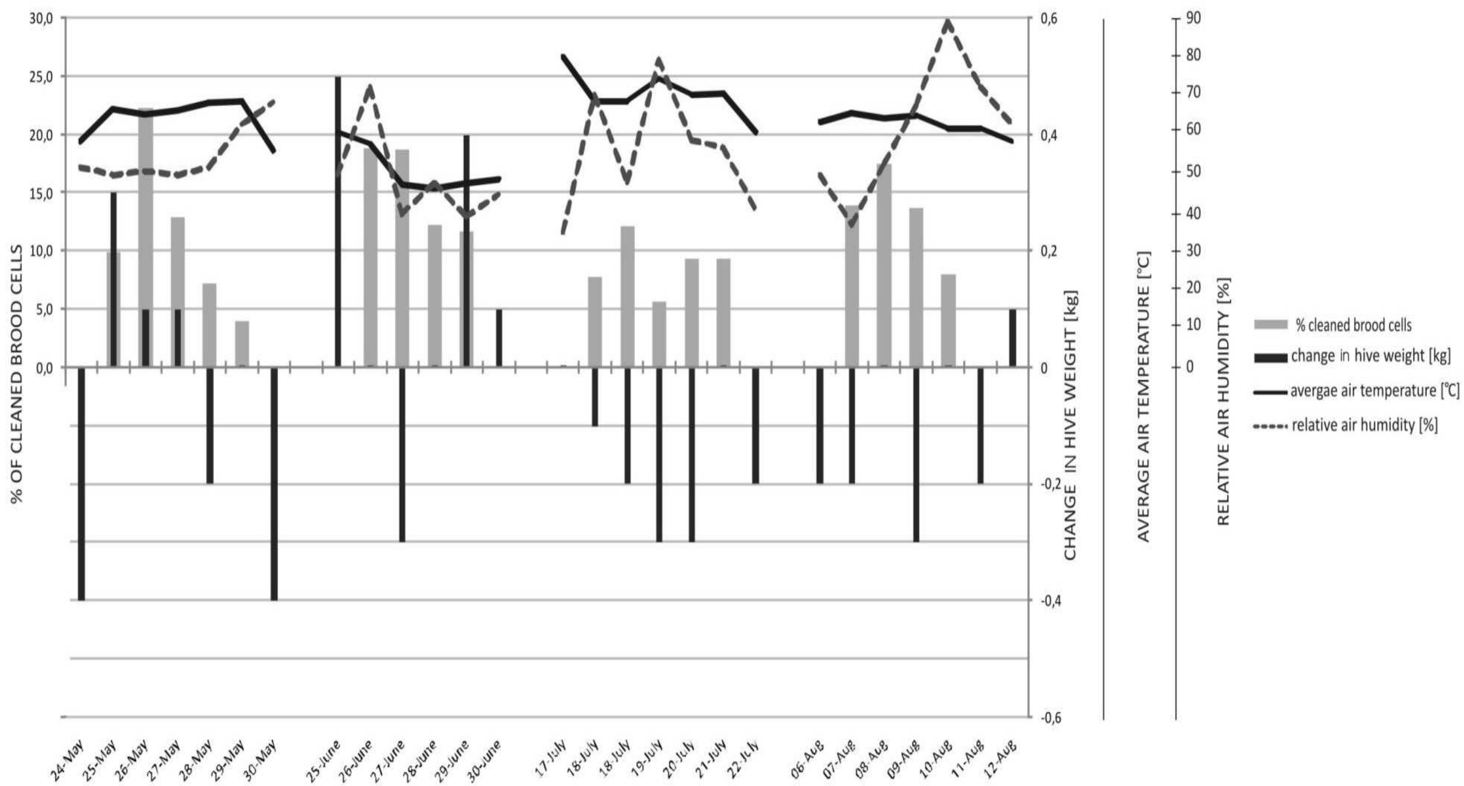

Fig. 2. Daily cells cleaning rate, average air temperature, relative air humidity, and nectar income in the year of 2007.

DISCUSSION AND CONCLUSIONS

Besides genetic factors (Rothenbuhler 1964, Heath 1982, Bühler 1996, Spivak and Reuter 1998, Palacio et al. 2000, Lapidge et al. 2002, Panasiuk et al. 2008), strength and bee colony structure (Momot and Rothenbuhler 1971, Robinson 1992, Arathi and Spivak 2001, Johnson 2003), and manner of brood killing (Kefuss et al., 1996, Békési and Szalai 2003, Bieńkowska et al. 2004, Panasiuk et al. 2008) the rate of cells cleaned of dead brood depends on environmental factors.

Variable dynamics of cell cleaning in particular years or periods of the beekeeping season of this research may depend on various factors. The air temperature and relative air humidity, atmospheric precipitation and natural nectar flow have been considered as the most affecting dynamics of the cell cleaning (Thompson 1964, Momot and Rothenbuhler 1971, Spivak et al. 1995, Spivak and Reuter 1998). Weather conditions that foster foraging, positively affect the dynamics of removing dead brood from colonies (Momot and Rothenbuhler 1971, Jasiński et al. 2007). However, in this research, no significant influence of the air temperature and relative air humidity on the dynamics of brood removing was confirmed. A low correlation coefficient for both, average air temperature ($r = 0.004$), and relative air humidity ($r = -0.30$) do not indicate even their moderate influence on dead brood removal. Nevertheless, the second factor indicates the faster cleaning cells while lower relative air humidity.

The natural nectar flow impact seems to be a more complicated factor. Regular nectar income was noted only in May. At this time bees were unequally removing dead brood from cells. In June, however, during the observed days of the study, no increased nectar income to the colony was noticed or even some decreases were recorded. However the bees cleaned a high number of cells. During the remaining two months, in spite of some decrease of nectar income, the bees regularly cleaned cells with freeze-killed brood. However, the increased nectar income in May and June suggests, that bees respond with some of cell cleaning to the nectar flow. Nectar accessibility on the day before measurement positively influenced the dynamics of removing dead brood, while its shortage restrained it.

CONCLUSIONS

The dynamics of removing dead brood from cells is various in different years as well as periods of the season.

There is no relationship between the dynamics of cell cleaning, and average air temperature as well as relative air humidity.

Natural nectar income in the day of cleaning cells with dead brood does not influence the cleaning dynamics. However nectar income on the day before the research may positively influence the cleaning dynamics.

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WPŁYW PORY SEZONU ORAZ WARUNKÓW ŚRODOWISKOWYCH NA SZYBKOŚĆ USUWANIA MARTWEGO CZERWIU Z KOMÓREK PLASTRA

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Streszczenie

Badania przeprowadzono w latach 2004, 2005 i 2007 w rodzinach pszczelich rasy kraińskiej linii Zosia. W poszczególnych latach oceniano szybkość usuwania z komórek przedpoczwarek uśmierconych przez mrożenie. Liczbę usuniętych przedpoczwarek oceniano po 12, 24, 48 oraz 72 godzinach, a następnie w dłuższych odstępach czasu aż do całkowitego wyczyszczenia komórek z martwego czerwiu. Celem zbadania wpływu pory sezonu na szybkość oczyszczania komórek obserwacje powtórzono trzykrotnie w dwu pierwszych latach oraz czterokrotnie w 2007 roku. W ostatnim roku dodatkowo analizowano wpływ temperatury i wilgotności względnej powietrza oraz nasilenia naturalnego pożytku na szybkość oczyszczania komórek.

Stwierdzono różnice w szybkości usuwania martwego czerwiu w poszczególnych latach. W ciągu pierwszych 12 godzin po zabiciu czerwiu, pszczoły najwolniej oczyszczały komórki w roku 2005. Po trzech dobach najwięcej komórek oczyściły w 2007 roku. Cały poddany czerw pszczoły usunęły w 2007 roku już po 150 godzinach, a w latach 2004 i 2005 po 250 godzinach.

Stwierdzono różnice w szybkości usuwania martwego czerwiu w różnych porach sezonu. Podczas pierwszych 12 godzin po zabiciu, czerw był najszybciej usuwany w czerwcu i w sierpniu, a najwolniej w maju. Taka tendencja, chociaż mniej wyraźna, utrzymała się także po 24 godzinach. Po 72 godzinach najwięcej komórek pszczoły oczyściły w czerwcu i w sierpniu, a najmniej w lipcu i w maju.

Nie stwierdzono wyraźnego związku między szybkością oczyszczania komórek, a warunkami środowiska. Nie miała no to wpływu średnia temperatura i wilgotność względna powietrza, ani wielkość pożytku w dniu obserwacji. Zaobserwowano natomiast dodatni wpływ przybytku nektaru w dzień poprzedzający pomiar na liczbę oczyszczonych komórek. Współczynnik korelacji dla tych wartości za okres czterech miesięcy wyniósł $r = 0,56$ i okazał się statystycznie istotny ($p = 0,016$).

Słowa kluczowe: zachowanie higieniczne, pora sezonu, warunki środowiska.