EFFECT OF CHANGING OF COLONY STRUCTURE ON TRAPPED POLLEN

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S u m m a r y

The goal of the experiment was to establish the effect of the changing of the structure of bee colonies on the amount of trapped pollen. Colonies were divided into 5 groups: the group PTC (pollen trapping - control), the group PTF (pollen trapping and transferring colonies onto comb foundation), the group PTN (pollen trapping and nuclei building from brood and bees), the group PTI (pollen trapping and isolation of queens). The total production was established that consisted of harvested honey, trapped pollen and calculated honey (trapped pollen, wax, bees and brood taken from colonies expressed as kgs of honey).

Pollen trapping method applied in the group PTN (8.5 kg) was the most efficient during the experiment. The average amount of collected pollen was the largest by a highly dignificant degree in comparison with the other groups: PTC (3.6 kg), PTI (5.2 kg) and PTF (5.7 kg).

The highest honey yield was harvested from the control colonies (PTC - 16.3 kg) and the group transferred onto comb foundation (PTF - 14.4 kg), while the lowest one from the colonies where nuclei were created (PTN - 7.9 kg) and those differences were confirmed statistically ($p=0.01$).

Regulation of colony structure through taking brood and bees out in order to create nuclei (group PTN) as well as caging queens (group PTI) decreased significantly honey production in comparison with the control colonies (group PTC).

It can be said that the lower honey yield and the significant increase of pollen production in colonies of the group PTN were the result of the applied technology of regulation of colony structure.

Keywords: honey, pollen, pollen trapping, total production, brood, bees, queens.

INTRODUCTION

Pollen has been used for feeding honeybee colonies (Bobrzecki et al. 1994), bumblebees (Maciejewska, Wilkaniec 1998) and its therapeutic effect on the human body has been demonstrated as well (Drożdż, Gwizdek 1986, Stojko et al. 1997). The great interest in therapeutic properties (Taber 1984) of pollen as well as its usefulness for feeding honeybee colonies (Bobrzecki et al. 1994) recommend the aplication of pollen trapping in the apiaries. It has been proved, that this kind of bee management increases the gross income from an apiary (Cichoń, Wilde 2002, Marcinkowski 1994, Nelson et al. 1987, Wilde, Cichoń 1997).

Flow conditions, strength and condition of colony as well as applied pollen trapping technology are the main factors that decide about the amount of trapped pollen (Bobrzecki, Wilde 1991, Bratkowski et al. 1999, Bratkowski, Wilde 2002, Duff, Furgala 1986, Nelson et al. 1987). In foreign cuntries with a longer growing season and richer pollen flows ca 13 kg of pollen loads per one colony are obtained (Nelson et al. 1987), while under Polish climatic and weather conditions it is supposed to be about 2 kg (Bratkowski, Wilde 1998).

The installation of a pollen trap is the

simplest pollen trapping method. A 10-day-cycle of pollen trapping installation has been recommended in order to avoid making pollen trapping difficult to bees: pollen is trapped for 5 days and after that period it should be stopped for the next 5 days (Poliščuk 1984). Duff and Furgala (1986) also applied a 14-day-cycle but they obtained a lower pollen production (from 1.4 to 2.9 kg) in comparison with traps application lasting the whole season. Better results in the amount of trapped pollen have been obtained by interference in the structure of the honeybee colony (Wilde et al. 1994a).

The goal of the experiment was to establish the effect of the changing of the structure of bee colonies on the amount of trapped pollen.

MATERIALS AND METHODS

The experiment was carried out in 1997-1999. Colonies of *Apis mellifera carnica* Pollm. were used in the experiment in 1997, 1998 and 1999, respectively: 48, 43 and 49, and were divided into 5 experimental groups. In the group PTC (pollen trapping, control) traditional bee management method were applied and pollen was trapped. In the group PTF (pollen trapping, foundation) all combs were replaced by frames with comb foundation as soon as as the eggs appeared in queen-cell cups. Honey and brood combs were given to the colonies of the same group that did not show symptoms of the swarm mood. In the group PTN (pollen trapping, nuclei) a part of combs with capped brood and some bees crowding its surface were used to make the nuclei. The nuclei were delivered with egg laying queens and pollen traps were installed. Their trapped pollen was included into productivity of the colonies from which they were built (Wilde et al. 1994b). In the group PTI (pollen trapping, isolation) queens were put into the Zander cages for 2 weeks as soon as they started laying eggs into queen cell cups. The queens got easy in touch with bees because of a peace of queen excluder installed on the cage sides.

Productivity of bee colonies

Top pollen traps were used in the experiments (Bobrzecki et al. 1989), that were installed on the bottom of the hives (Wilde, Bobrzecki 1989). Their functional parts were provided by plastic bars with round holes 5 mm in diameter. Pollen traps were installed at the hive bottom at the beginning of winter rape blooming, and taken off in the end of July on the following respective dates over the study years: 10th May and 30th July in 1997, 17th May and 27th July in 1998, and 20th May and 27th July in 1999. The weight of pollen loads was determined individually for every single colony in the each group.

The amount of harvested honey was measured twice in each year for two main honey flow periods, after blooming of winter rape and of buckwheat (Bornus et al. 1974, Wilde, Siuda 1996).

Converted production consisted of additional bee products expressed as kgs of honey which was evaluated as honey value units as follows: 1kg of bees = 2.5 kg of honey, 10 dm^2 of sealed brood = 4 kg honey, 1 kg of wax = 3.5 kg of honey (Bornus 1973, Bornus et al. 1974), 1 kg of pollen loads = 4 kg of honey (Wilde, Siuda 1996). The total production was expressed as kgs of honey and it consisted of centrifuged honey and converted production (Bornus et al. 1974, Wilde, Siuda 1996).

Average mean ($\bar{x}$) was the main numerical value for analized characters. The collected data were evaluated statistically using the computer programme STATISTICA. The estimation of significance of differences was made by variance analysis and the least significant differences (LSD) method.

RESULTS

Influence of method of bee colony regulation on pollen production

In 1997 the amount of pollen loads, concerning pollen trapped from nuclei, trapped in the group, where nuclei were created (PTN - 7.1 kg) was high significantly more in comparison with the control group (PTC - 3.0 kg - tab. 1), and significantly higher than amount of pollen collected from the group, in which queens were kept in cages (PTI - 3.6 kg). In 1998 the biggest amount of pollen loads was trapped again from the colonies of the groups PTN and PTI, 11.1 and 7.6 kg, respectively. The differences for the amount of trapped pollen in the group with nuclei vs. the control group (PTC - 3.5 kg) and vs. the colonies transferred onto comb foundation (PTF - 6.2 kg) were highly significant and they were significant compared with the group where queens were kept in cages (PTI - 7.6 kg). As in the previous years, in the season of 1999 the largest pollen yield was obtained from the nuclei group (PTN - 7.4 kg). This value was significantly higher compared with the groups where traditional bee management (PTC - 4.3 kg) was applied and queens were caged (PTI - 4.4 kg).

In the whole period of the experiment the creating of nuclei (PTN - 8.5 kg) was the most efficient pollen trapping method. The average amount of collected pollen was, to a highly significant degree, the largest of all the other groups. The pollen production of the rest of the colonies was very similar, and statistical differences appeared only between the colonies transfred onto comb foundation (PTF - 5.7 kg) and the control colonies (PTC - 3.6 kg).

In 1997, 1998 and 1999 nuclei were created in the group of PTN: 10, 11 and 18, respectively. In 1997, the average production obtained from one new colony was only 1.6 kg, whereas in the last year it increased to an average of 3.1 kg of pollen loads (fig. 1).

Influence of bee colony structure regulation on honey yield

In 1997, 13.9 kg of honey was harvested from control colonies, which was highly significantly more than from the colonies in which which nuclei were created (PTN - 4.4 kg - tab. 2). In 1998, the total honey yield ranged from 13.5 kg (group PTI) to 18.4 kg (group PTF) in the season, but the differences between all the groups came

Table 1

Pollen trapped in 1997, 1998 and 1999 as well as in the course of the experiment (averages in kg)

Grupa	1997	1998	1999	1997-1999
PTC - control, pollen trapping	3.0^{aA} n=11 d=1.7	3.5^{aA} n=12 sd=1.5	4.3^{aA} n=12 sd=2.4	3.6^{aA} n=35 sd=2.1
PTF - pollen trapping, foundation	5.4 n=12 sd=3.9	6.2^{abA} n=10 sd=3.0	5.4^{a} n=12 sd=2.1	5.7^{bA} n=34 sd=3.4
PTN - pollen trapping, nuclei	7.1^{bB*} n=13 sd=4.1	11.1^{cB*} n=10 sd=5.8	7.4^{bB*} n=13 sd=3.1	8.5^{bB} n=36 sd=5.1
PTI - pollen trapping, isolation of queen	3.6^{a} n=12 sd=1.2	7.6^{b} n=11 sd=4.0	4.4^{aA} n=12 sd=1.6	5.2^{abA} n=35 sd=3.2

* - including pollen trapped from nuclei,

Explanations: Different letters indicate significant differences at p=0.05 (small letters), and at p=0.01 (capitals)

Journal of Apicultural Science

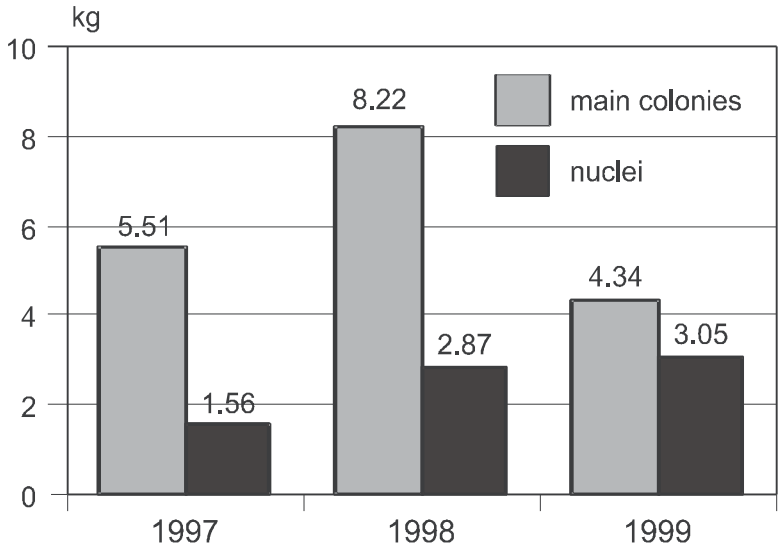

Fig. 1 Pollen trapped from main colonies and their nuclei in the group PTN in 1997, 1998 and 1999 (average in kg)

Table 2

Centrifuged honey in 1997, 1998 and 1999 (averages in kg)

Grupa	1997	1998	1999	1997-1999
PTC - control, pollen trapping	13.9^{B} n=11 sd=6.8	15.6 n=12 sd=18.1	19.5^{bcB} n=12 sd=9.5	16.3^{cB} n=35 n=13.6
PTF - pollen trapping, foundation	9.2 n=12 sd=8.2	18.4 n=10 sd=8.2	15,6^{bc} n=12 sd=5.5	14.4^{bcB} n=34 n=7.6
PTN - pollen trapping, nuclei	4.4^{A} n=13 sd=5.1	13.8 n=10 sd=9.1	5.5^{aA} n=13 sd=3.6	7.9^{aA} n=36 n=7.3-
PTI - pollen trapping, isolation of queen	8.4 n=12 sd=5.8	13.5 n=11 sd=6.4	11.9^{abA} n=12 sd=8.3	11.3^{ABab} n=35 sd=9.1

Explanations: Different letters indicate significant differences at p=0.05 (small letters), and at p=0.01 (capitals)

within the limits of the experiment error. In 1999 highly significantly more honey was centrifuged from the control group (PTC - 19.5 kg) in comparison with the PTN (5.5 kg) and PTI (11.9 kg) colonies, whereas the group PTF (15.6 kg) significantly outyielded the colonies of the group PTN.

During the whole experiment the highest honey yield was obtained from the control colonies (PTC - 16.3 kg) and from the group transferred onto comb foundation (PTF - 14.4 kg), while the lowest yield was from the colonies, where nuclei were created (PTN - 7.9) and these differences were confirmed statistically (p=0.01). Significance of differences was confirmed for the average efficiencies obtained from the PTC vs. the PTI colonies.

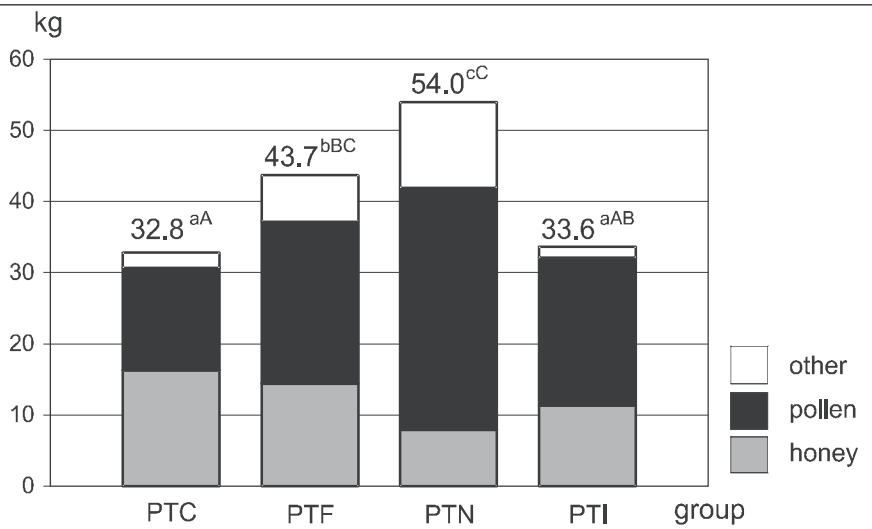

Fig. 2 Harvested and calculated honey expressed as the total production and contribution of particular components during the course of the experiment (in kg of honey)
Explanations: Different letters indicate significant differences at p=0.05 (small letters), and at p=0.01 (capitals)

Influence of structure changes of bee colonies on total production

Colonies, from which nuclei were created (PTN - 54.0 kg - expressed as kg of calculated honey as well as colonies transferred onto comb foundation (PTF - 43.7 kg) gave the highest total production (fig. 2). These groups highly significantly surpassed the control group (PTC - 32.8 kg). Highly significant differences also appeared between the PTN group and PTC (32.8 kg) and colonies with queens kept in cages (PTI - 33.6 kg). However, differences at p=0.05 were found between all the groups, along with PTC and PTI.

The obtained values expressed as the percentages of the total production show the importance of the particular components of the total production for shaping the productivity of the colonies. Trapped pollen decided about the total production of the colonies in all groups. In the control group (PTC) it had a lower importance and contributed 41% of the total production, whereas in the best group, where nuclei were created (PTN), pollen decided about the total production and its contribution was 63.2% of the total value. That is why honey had a marginal importance in that group. That value was similar in the group PTI (61.8%). It is characteristic of the best group PTN, that the high pollen contribution to the total production is also accompanied by the high calculated production which came from conversion to honey units of brood, bees and wax, having much more influence on productivity than honey. Such relationships only occurred in that one group. In the other groups the importance of production got from calculated honey and expressed as the percentage of the total production was not as important as the contribution of honey.

DISCUSSION

The differences in quantity of collected pollen in particular groups confirmed that changes of bee colony components decided about the volume of pollen production. In the case of the group PTN (creating of nuclei) the values were better than those achieved by Duff and Furgala (1986),

the latter investigators having trapped 9.6 kg of pollen loads on average. However, Nelson et al. (1987) collected an average of 13 kg of pollen for 3 months, using, like the previous authors, a method based only on the installation of traps. Such a method applied in this study (pollen trapping without additional operations on bee colony - group PTC) did not allow the obtaining of comparable efficient results. However, the chances are that pollen production will be increased through making smoller the diameter of pollen bars wholes. Wilde et al. (1994a) produced on average 8.1 kg of pollen loads without changing the structure of bee colonies, using plate with meshes 4.8 mm in diameter. Bieńkowska and Pohorecka (1996) proved, that the wider diameter of the holes in the plate from 5.0 mm to 4.8 mm caused the 50% increase in pollen trapped. Taking into consideration that relationship, our result obtained in the group PTC (control) agrees with dates of Wilde et al. (1994a). However, pollen trapping and traditional management of bee colonies was less efficient as evaluated against the other methods, but it was statistically confirmed in comparison with the groups PTN ($p=0.01$) and PTF ($p=0.05$).

In 1998, in the group made up of nuclei (group PTN) 11.1 kg of pollen loads was trapped in the authors' experiment while Wilde et al. (1994a) obtained with that method only 3.9 kg of pollen. However, Wilde and Bratkowski (1996) increased the efficiency of that method to 7.4 kg, which is a value close to the average for the whole experiment of this study (PTN - 8.5 kg). Wilde et al. (1994b) stressed the influence of new nuclei on the production obtained, the amount of pollen trapped being similar to that in the colonies in which the nuclei were built. Such results can be explained by stimulation of egg laying by the queens and by the positive correlation between pollen collection by bees and reared brood (Crailsheim et al. 1992, 1996, Fewell, Bertram 1999), which was especially manifest in the last year of investigations.

The relationship between trapped pollen and honey yield showed that the applying of colony structure regulation methods may have caused a decrease in pollen production especially under unfavourable climatic and flow conditions. In 1999 the results confirmed such a finding and that the year was considered as cold and rainy. In the groups PTF, PTN and PTI not more that 1kg of pollen on average was trapped in the second part of season, while in the group PTC (control) that production was 2.7 kg. It was especially interesting that colonies transferred onto comb foundation (group PTF) responded like this in each year which suggested a very negative influence of this method on pollen collection. Comparing collection of honey and pollen in particular parts of the season it may be also noticed that high rate of pollen trapping was connected with a low honey yield, while low pollen production was associated with a high honey yield, which is consistent with results obtained by Poliščuk (1984).

On the basis of honey yield in investigated colonies it was found that applied technologies of pollen trapping decreased honey output which is consistent with the findings by Wild et al. (1994a). Silmilar relationship for pollen production vs. honey yield was found by Wilde and Bratkowski (1996). Alongside the group with nuclei, the group in which the queens were kept in cages also showed lower honey production in comparison with the group from which pollen was trapped and traditional bee manegement methods were applied, the relevant differences being statistically valid. Nelson et al. (1987) found only once in the course of 3 years a negative effect of pollen trapping on the honey yield. Wilde et al. (1994a) explained the decrease in honey production observed in the group, in which nuclei were made, by

the weakening of the colonies rather than by pollen trapping only. In our experiment significantly lower amounts of honey were centrifuged from the colonies from which brood and bees were taken out compared with honey yielded by the group PTC, which confirms a negative effect of removing brood and bees on honey yield. Thus, when trapping plenty of pollen and using nuclei we have to take into consideration a significant decrease in honey production. A increase from 9.5 kg (1997) to 14 kg (1999) in honey centrifuged was found in the group PTN in comparison with the group PTC (control), which is equivalent to the increase in honey yield, 0.74 and 1.89 kg, respectively, for every kg of trapped pollen. Caging queens (group PTI) also caused significant decrease in honey yield ($p=0.05$) in comparison with the group PTC (control), but the amount of trapped pollen was at one time the smallest during the experiment. The observed relationships between pollen and honey production in those two last groups in comparision with the control group allows the conclusion that such kind of regulation of colony structure decides about the efficiency of pollen trapping.

Pollen trapping increased to a large extent the total production in the group PTN - 63.2%, despite a significant decrease in centrifuged honey, compared with that in the control group. Our results were superior to those obtained by Pidek (1988), who noticed a decrease of only about 15.4%, Nelson et al. (1987), in whose study the decrease in output was about 26% and Poliščuk (1984), who got production more about 33%. It should be said, that they did not regulate structure of colonies, from which pollen was trapped, but they compared their productivity with colonies without pollen traps.

Biological conditions of bee colonies were very important and decided about different reaction of bees to applied methods (Page, Fondrk 1995). A permanent swarm mood was a very negative symptom in the group of PTF, which was observed in each colony transferred onto comb foundation. We could suppose that the reason for this phenomenon was removing of brood, which changed the biological relationships in colonies (Pankiw et al. 1998, Seeley 1989) and disturbed pheromons interaction between brood, queen and bees (Fewell, Bertram 1999, Hrassnigg, Crailsheim 1998, Winston et al. 1991). Pettis et al. (1997) demonstrated that brood pheromones and of queen in relation with queen's pheromones decreased about 50% the number of queen cells. Among colonies with caged queens (group PTI) bees made quen cells after queens were placed into cages. Such behaviour was observed by Muszyńska (1987). We may draw the conclusion, that queen cells were the result of the lack of a spread of the queen substance (Seeley 1989). Creating of nuclei was the only guarantee to eliminate the swarm mood, because in the group PTN there were no symptoms of swarming in any of the years (Wilde, Bratkowski 1996). Such behaviour caused a necessity for an additional inspection of bee colonies and for more frequent visits to the apiary to which increased costs.

CONCLUSIONS

Regulation of colony structure thrugh taking brood and bees out in order to create nuclei (group PTN) as well as caging queens (group PTI) decreased significantly honey production in comparison with that in the control colonies (group PTC). Lower honey yield and significant increase of pollen production in colonies of the group PTN were the result of the applied technology of regulation of colony structure.

Taking brood and bees out in order to create nuclei and pollen trapping in this group was the most efficient method of the

intensification of the production. Results of pollen production obtained from nuclei as well as elimination of swarm mood in colonies influenced the effectiveness of that method.

Pollen trapping in colonies transferred onto comb foundation (group PTF) and in colonies with caged queens (group PTI) have the limited practical application because of a high costs of labour resulting from additional colony inspections to develop removed brood, liquidation of swarm mood, destroying of queen cells and looking for the queen.

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WPŁYW ZMIANY STRUKTURY RODZIN PSZCZELICH NA ILOŚĆ ODEBRANYCH OBNÓŻY PYŁKOWYCH

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Streszczenie

Celem badań było ocenienie wpływu zmian struktury rodzin pszczelich na ilość odebranych obnóży pyłkowych. Doświadczenie przeprowadzono w latach 1997-1999. Rodziny podzielono na pięć grup doświadczalnych. W grupie PTC (kontrolna) stosowano tradycyjne metody gospodarki pasiecznej oraz odbierano obnóża pyłkowe. W grupie PTF wszystkie plastry zastępowano ramkami z węzą. W grupie PTN tworzono odkłady, i zakładano im również poławiacze pyłku. W grupie PTI matki umieszczano na 2 tygodnie w klateczkach Zandera

Produkcja całkowita rodzin została wyrażona w kilogramach miodu i składa się z miodu odwirowanego i miodu przeliczeniowego. W całym okresie doświadczenia tworzenie odkładów (PTN - 8,5 kg) było najbardziej wydajną metodą produkcji pyłku. Średnia masa pozyskanego pyłku była wysoko istotnie wyższa w porównaniu z pozostałymi grupami. Produkcja w pozostałych grupach była zbliżona, a różnice istotne stwierdzono jedynie pomiędzy rodzinami grupy przesiedlanej na węzę (PTF - 5,7 kg) a grupą kontrolną (PTC - 3,6 kg).

W tym czasie najwięcej miodu odwirowano od rodzin grupy kontrolnej (PTC - 16,3 kg) i grupy, w której wymieniano gniazdo na węzę (PTF - 14,4 kg), zaś najmniej od rodzin, od których tworzono odkłady (PTN - 7,9 kg) i różnice te potwierdzono statystycznie ($p=0,01$). Istotność różnic przy $p=0,05$ wystąpiła pomiędzy średnimi wydajnościami uzyskanymi od rodzin grup PTC i PTI.

W doświadczeniu najwyższą produkcję całkowitą uzyskano od rodzin, w których tworzono odkłady (grupa PTN - 54,0 kg) i przesiedlano na węzę (PTF - 43,7 kg). Grupy te wysoko istotnie przewyższyły grupę kontrolną (PTC - 32,8 kg). Wysoko istotne różnice wystąpiły również pomiędzy grupą PTN a PTC (32,8 kg) i rodzinami, w których matki izolowano w klateczkach (PTI - 33,6 kg).

Można, zatem stwierdzić, że regulowanie struktury rodzin pszczelich przez odbieranie czerwiu i pszczół, w celu wykonywania odkładów (grupa PTN) oraz izolowanie matek (grupa PTI) obniżało istotnie produkcję miodu w porównaniu z rodzinami grupy kontrolnej (grupa PTC). Obniżenie produkcji miodu a istotny wzrost produkcji pyłku w rodzinach grupy PTN były wynikiem zastosowanej metody regulowania struktury rodziny.

Odbieranie czerwiu i pszczół w celu tworzenia odkładów oraz pozyskiwanie od nich obnóży pyłkowych było najbardziej wydajną metodą intensyfikacji produkcji.

Słowa kluczowe: miód, pyłek, pozyskiwanie pyłku, produkcja całkowita, czerw pszczeli, pszczoły, matki pszczele.