ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Efficiency of Selection of Bee Colonies with Paternal Origin.

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ABSTRACT

The aim of the research was to study the influence of the method of rearing and maintenance of drones on their quality for artificial insemination of queen bees. During the research it was found out that according to the exteriors and biological signs the bees of the experimental groups corresponded to the standard of purebred bees. According to the development and ability to build strong colonies to the main honey harvest, the best were the colonies with maternal origin, and in assessing the average daily egg-laying of the second year queens the colonies with paternal origin were more effective, that also has a breeding effect due to the haploidity of drones. Thus, for the preservation and improvement of Carpathian bees, selection and reproduction should be carried out not only on the maternal line, but also with the use of the drone background, that is, colonies with paternal origin.

Keywords: bees, colony with paternal origin, colony with maternal origin, nurse colony for queen rearing, development evaluation.

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ISSN: 0975-8585

INTRODUCTION

Breeding work towards paternal bee colonies is an important reserve for increasing the productivity and improving the quality of bees themselves. The number of colonies supplying drones is directly dependent on the number of virgin queens [1].

The ecological situation that has changed in many places and, in particular, the food base, the spread of new diseases, the swarming of bee colonies in certain places have a significant effect on the vital activity of bee colonies, on the realization of genetic opportunities of bees and on the efficiency of selection [4].

Beekeepers of queen-rearing apiaries pay a little attention to the rearing of drones. This attitude is based in most cases on the deep conviction of both beekeepers and zootechnical beekeeping personnel, that bee colonies themselves produce enough drones for mating with queens. The less queens are reared, the less drones are needed for their qualitative mating [2, 3].

The most reliable way to control the transfer of genetic information to offspring, necessary in breeding work and studying genetics of bees, is artificial insemination of queens by sperm of specially selected drones [1,5,6,7].

The formation of drones as sexually mature individuals is significantly influenced by a number of key factors, one of which is rearing conditions and methods of keeping [1,8,9].

Big drones with more developed musculature are stronger and they are the first who participate in the process of insemination of queens. However, information on the quality of sperm of drones is extremely necessary, since it can be non-viable because of the infestation of bee colonies, for example, by varroosis [1].

The aim of the research was to study the influence of the method of rearing and maintenance of drones on their quality for artificial insemination of queens.

The situation with hybrid structure of bees in the North Caucasus, as well as the changed conditions for the existence of colonies and beekeeping, associated primarily with varroosis and attacks of bees by *Varroa* mite in 2017, require specialized beekeeping enterprises to introduce such methods and techniques of purebred breeding, which would ensure both the breeding of purebred bees in their apiaries and the production of purebred bee products for sale.

METHODOLOGY OF RESEARCH

In 2017 on the apiary № 25 of Federal State Unitary Enterprise of Bee Breeding "Maikopskoe" as a result of the spring audit bee colonies were selected into three main experimental groups of 10 colonies each:

1. group of colonies with paternal origin – colonies №100, 1-9.
2. group of colonies with maternal origin – colonies №5-7, 25, 33, 45, 51, 62-64.
3. group of nurse colonies for queen rearing – colonies № 9, 13, 19, 21, 26, 32, 43-44, 61, 75.

Experimental groups were formed to conduct a test on the effectiveness of selection of colonies with paternal origin in order to increase the effectiveness of artificial insemination. Due to the weather conditions of 2017, experimental groups of bees were formed at the end of April. By this time in the colonies with the paternal origin there were also drone combs with eggs laid in the cells.

Bee colonies were evaluated by a complex of biological and economically useful indicators according to the methodology developed by the State Research Institute of Beekeeping and approved by the Russian Academy of Agricultural Sciences (2000).

The morphological features of queens, drones and worker bees were studied by the method of prof. V.V. Alpatov (n=10). The following morphological features were studied:

a) for worker bees – length of the proboscis, length and width of the right forewing, cubital and tarsal

indices, discoidal shift, length and width of the third and the fourth tergites, length and width of the third sternite and area of the wax mirror on the third sternite;

b) for drones – body mass, length of proboscis, length and width of the right forewing, cubital index and discoidal shift, length of the third and the fourth tergites, length and width of third sternite;

c) for queens – body mass, length of proboscis, length and width of the forewing, cubital index and discoidal shift, length and width of the third tergite and the third sternite. As the main interior features that characterize the quality of queens, the weight of the ovaries and the number of ovarian tubes were taken.

To form the bee colonies into a group of nurse colonies, the colonies were selected according to the following economically useful characteristics: the best development from spring period, the greatest amount of honey harvest, allocation of a large amount of wax, winter hardiness and resistance to diseases.

The obtained data were processed by the methods of variation statistics with verification of the reliability of the results using the Student's test and significance level (P), (N.A. Plokhinsky (1969), K. Doerffel (1994)).

When the queens were reared, the strength of the bee colonies and the number of brood of various age were determined, taking into account the reception of larvae for queen nursing, the number of queens that emerged from the queen cells and their mass. The body mass of drones emerging from the cells was measured, and when they reached the puberty the amount of sperm was determined. The mass of the virgin queen was measured by weighing after leaving the queen cell, the mass of the drone was measured after leaving the cell on the torsion balance.

The prepared testes of the drones were weighed on a micro analytic balance and the sperm volume was determined with a pre-calibrated capillary. The average daily egg-laying ability of the queen was calculated by the number of the sealed brood recorded in the hive of the bee colony on a certain date, dividing it by 12. Honey productivity of the bee family was determined by the amount of comb-honey taken and honey left in the hive. The method of rearing and maintenance of mature drones was estimated by the number of sealed drone brood and the live mass of daily drones.

Virgin queens were received on 6th and 13th of May. When obtaining virgin queens (M_1) the following aspects were taken into account: the number of laid queen cells on the frame, the number of virgin queens obtained and their live mass.

RESULTS

Colonies with paternal origin increased the total mass of bees in general and it was higher than in nurse colonies or in colonies with maternal origin. In the paternal colonies of queens of the first year of reproduction (№1-5) was revealed the superiority in terms of the results of the spring audit relatively to the group of maternal colonies by 0,5 kg, in the summer period the superiority was 0,2 kg. An interesting can be the fact that the indicator of the mass of bees in spring period is identical in nurse colonies of the paternal generative group, but already in summer period the superiority of the latter was 0,5 kg.

This tendency maintained for the next year too: in the colonies of queens of the second year the mass of bees was 5,8 ± 0,33 in spring and 8,2 ± 0,44 kg in summer, which is on 5,0% and 10,8% higher, than the same indicator in the maternal colony group. The group of colonies with queens of the second year of nurse colonies also exceeded the similar parameter of the maternal colonies in spring period by 0,2 kg and in summer period it exceeded by 0,3 kg.

The study of the dynamics of the coefficient of variability in the reproductive experimental groups revealed a more pronounced genetic homogeneity according to the data of the spring audit in the maternal colonies and according to the data of the summer audit in the paternal colonies. This phenomenon we consider as the result of polyandry. However, the difference in the indicators was within the deviation from the average values and is not reliable, that is confirmed by a low reliability factor (td = 0,5 and 0,8).

ISSN: 0975-8585

The lowest value of weakening colonies is determined for nurse colonies and the highest is determined for the paternal colonies, which is explained by the higher content of drones. However, an insignificant deviation was found in maternal colonies, which indicates a significant drone brood (Table 1).

Table 1- Evaluation of colonies by a complex of economically useful characteristics (spring-summer audits)

Indicator	Average indicator		
	paternal colonies	maternal colonies	nurse colonies
Cost of feed per bee space, kg	2,0 ± 0,3	1,9 ± 0,2	1,9 ± 0,2
Weakening the strength of colonies, bee sp.	1,6 ± 0,2	1,5 ± 0,2	1,1 ± 0,4
Strength of the colony in spring period, kg	4,4 + 0,2	4,8 + 0,3	5,1 + 0,5
Strength of the colony in summer period, kg	6,8 + 0,3	7,5 + 0,4	7,7 + 0,6
Gross honey productivity, kg	59,7+2,7	68,9+3,3	71,9+2,3
Obtained marketable honey per 1 kg of bees, kg	8,2+0,5	9,6+0,7	9,9+0,5

It was found out that according to the data of spring and summer revision the paternal colonies are significantly behind from the colonies of other experimental groups in terms of the strength of colonies that can be explained by the higher content of drones in these colonies and does not contradict the functional significance of these colonies in the study format.

The obtained results are also confirmed by the data of gross honey productivity, which was the maximum in the group of nurse colonies – 71,9 kg, which is higher than in the maternal and paternal colonies by 2 kg and 12,2 kg, respectively. Analysis of the receipt of marketable honey per 1 kg of bees also revealed the lowest level in paternal colonies, which lagged behind the nurse colonies by 1,7 kg and the maternal colonies by 1,4 kg.

In general, according to the generally accepted method for rearing drones in specially trained colonies, the rearing of drones in other colonies should be reduced, which was actually done in the apiary in a group of maternal and nurse colonies. This was the basis for the formation of higher results of the strength of the colonies of these experimental groups.

The evaluation of the development of colonies was made according to two criteria: the egg-laying of queens and the strength of colonies at the beginning of June (Table 2).

Table 2 – Average daily egg-laying of the second year queens (n=10)

Indicators	Colonies		
	maternal	paternal	nurse
Average daily egg-laying of queens from 22 April to 3 May	591 ± 31,2	670 ± 40,2**	661 ± 32,0***
Average daily egg-laying of queens from 4 May to 15 May	1002 ± 34,9	1203±35,7***	1192±35,6***
Average daily egg-laying of queens from 16 May to 27 May	1807 ± 33,8	1706 ± 35,9	1721 ± 34,2
Average indicator for the whole period	1133± 34,7	1193 ± 38,9	1191,33± 343,9
Total number of bees in the colony on 8 June	39611±1125,6	42938±1318,5	41677±1214,8***

Note: * – P < 0,05,** – P < 0,01, *** – P < 0,001.

In the first period (from 22.04 to 3.05) the average daily egg-laying of queens was from 490 to 670 eggs. According to this indicator, the Carpathian queens of the paternal colonies were significantly (P <0,01) superior to the maternal colonies. In the second period (from 4.05 to 15.05.) the advantage of paternal colonies was preserved. However, in the third period (from 16.05 to 27.05.) in the first place in this indicator were the queens of the maternal colonies, the nurse colonies left behind them by 86 units. A similar indicator of paternal colonies differed from the indicator of maternal and nurse colonies by 101 and 15 units, respectively.

The cut-off data for June 8, 2017 showed the superiority of paternal colonies in the total number of bees (42,938 individuals) relative to maternal and nurse colonies by 7,8% and 32,9%, respectively.

Thus, the bees of their paternal colonies due to their genetic characteristics did not "hurry" to early development. After the establishment of warm weather and the steady supply of nectar with pollen, the colonies of this reproductive group began to develop more actively and in the second half of May surpassed the indicators of maternal colonies.

According to the measurements of the length of the proboscis all the bees were placed in the norm of the Carpathian breed and had an average proboscis from 6,54 ± 0,06 to 6,75 ± 0,05 mm. The coefficient of variation in this case is reflected in the period of 2,6-3,5%, that indicates a sufficient leveling of the material under the study.

The bees in all experimental colonies were fairly big, the width of the third tergite was 4,85 ± 0,05 mm in average with a swing from 4,86 ± 0,02 to 4,96 ± 0,03 mm (Cv =2,4-3,8%). Measurements of the cubital index did not have sharp deviations and its value varied from 2,5 to 3,3 with a difference of 0,8 units. The discoidal shift in the bees of the experimental group is positive in 74-94 cases.

In the class of color, the bees were rather dark, especially compared to the average data of the apiary, where there was still some yellow color and the class of color was 1,2 ± 0,07 points. Drones in all experimental colonies were dark, with no signs of yellowness, young drones were with a silvery-gray downiness. It is necessary to note the class of color in the maternal colonies (local selection), where it was 1,5 and phenotypically it was expressed in the appearance of bees with yellowness. This phenomenon we are can relate to the diploid heterogeneity of the genotype and splitting in the offspring. Characterizing this indicator in paternal colonies, we note its lower level (1,1), which is most corresponds to the purpose of the selection process. We explain this dynamics by the haploidity of drones.

In the nurse colonies the least number of drones has been identified, that is explained by the features of the biology of the bee colony and the maintenance of the hierarchy. The maximum number of drones is noted in paternal colonies and it is due to the fact that in the selected colonies of this generative group according to the results of spring audit there were queens of the second year of life. In the maternal colonies there were queens of the first year of life. However, an interesting fact is that the percentage of drones within colonies is equal to the eversion of endophallus: in maternal colonies this indicator was 80% and in absolute terms there were 933,6 drones, in nurse colonies there were 359 drones. In paternal colonies this indicator was 90% or 1305 drones (Table 3).

Table 3 – Evaluation of the maturity of drones, n=10

Colonies	Live weight, mg	Number of drones	Eversion of endophallus, %	Number of drones with sperm at the end of endophallus		Sperm concentration, million units
				individuals	%	
maternal	247±2,5	1167	80	7	70	2,3±0,3
paternal	260±3,01	1450	90	9	90	2,5±0,5
nurse	238±1,8	528	68	5	50	2,2±0,7

Analyzing the indicator of the number of drones in the colony with sperm at the end of endophallus, this indicator was the lowest in the nurse colony that is explained by the structure and functional purpose of these colonies. In maternal colonies the indicator was 70%, or 653,5 drones out of the total amount of the colony. In paternal colonies this indicator exceeded the maternal colonies on 521 drones.

The sealed brood in the maternal colonies was lower according to the data of the September audit of the data of the paternal colonies. However, already since October there has been a reverse trend and paternal colonies have lagged behind the maternal ones.

Nurse colonies throughout the period of revision studies exceeded both the maternal and paternal colonies in terms of the sealed brood, which is a normative indicator.

CONCLUSION

Summarizing the results of the work carried out to evaluate the best maternal and paternal colonies, the following conclusions for selection with the purpose of forming a genetic nucleus can be made:

1. For exteriors and biological signs the bees of the experimental groups corresponded to the standard of purebred bees.
2. In terms of development and ability to build strong colonies to the main honey harvest, maternal colonies were ahead (group 2).
3. In evaluation of the average daily egg-laying of second year queens, paternal colonies proved to be more effective, that also has a breeding effect due to haploid drones.

Thus, proceeding from the needs of the marketable honey, breeding and other directions of the beekeeping specialization, the increase of the drone selection is perspective.

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