Productive Qualities of Gray Mountain Caucasian Bees of Type Krasnopolyansky

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Abstract*: *The article discusses the research aimed at studying the productive qualities of gray mountain Caucasian bees of type Krasnopolyansky and improvements in breeding them. The study was based on the data of zootechnical accounting performed in 2018 at the apiaries where comparative assessment of the diversity and the differentiation of gray mountain Caucasian bees' populations had been previously performed based on the morphometric analysis and microsatellites for identifying the differences in the structure of the genealogical tree of gray mountain Caucasian bees of type Krasnopolyansky built for seven loci of microsatellites and three morphological features. Four groups of medium strength of bee colonies were formed (for each apiary). All apiaries were geographically isolated from each other. During the experiment, the bee colonies were self-sufficient in carbohydrate and protein food. The amount of sealed brood was assessed three times in 12 days' periods using a frame-mesh. The following were determined: the average daily egg production by queen bees in the spring and before the main honey flow; the number of bees grown in the spring and by the beginning of the main honey flow. After comparative assessment of the bee colonies' productivity, the group with the best development of the bees before the main honey flow was identified. Queen bees in this group were on average by 16 % superior in terms of egg production to gray mountain Caucasian queen bees of type Krasnopolyansky, while in the other three bee colonies, according to the latest accounting, the average daily egg production by queen bees was 1,933 – 2,242 pcs. This apiary will be further used in breeding for identifying queen bees, the offsprings of which will inherit the economically useful features, and which can potentially become ancestors of new bee lines with the productivity increased by at least 15 %.

Index Terms*: *honey bee, beekeeping, queen bee, efficiency, egg productivity, gray mountain Caucasian bees of type Krasnopolyansky.

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I. INTRODUCTION

About 30 various subspecies are identified in species Apis mellifera. In the territory of the Russian Federation, the following bee breeds are cultivated: Middle-Russian, gray mountain Caucasian, Carpathian, and Far-Eastern. By the set of economically valuable traits (the longest proboscis of worker bees, the highest efficiency and productivity, the ability to use a wide range of honey plants species, extremely weak swarming ability, peacefulness, etc.), the gray mountain Caucasian breed is one of the best bee breeds [1-3]. The structure of the breed is not homogeneous, it consists of populations that are veracious by their biological and economic features. To determine the species affiliation of the bees and assign them to a certain line, assessment of exterior, physiological, and ethological characteristics, and indicators of economic value were used [4-6]. Preservation of honeybees' genetic resources, their breeding improvement, and rational use allows increasing the honey production by at least 20 % [7-9].

The population of bees in the Russian Federation is insufficient for meeting the needs of agriculture. In recent decades the number of bees has decreased by 30 % [10, 11]. The pollinating activity of bees increases the yield of agricultural entomophilous crops by more than 40 %. An example of a typical cross-pollinating entomophilous crop that requires additional pollination by bees to reach its potential productivity is the sunflower. Many insects can gather nectar and pollen from it, but only honeybees can ensure the complete pollination of this crop, and create a sufficient load of pollinating insects [12-14]. In the recent decades, the importance of bees in the modern anthropogenic ecosystems has increased considerably as a result of the widespread use of chemical means of plant protection, and due to the death of most natural pollinators.

Increasing the productivity of bee colonies that are capable of efficient pollination of entomophilous agricultural crops and of using various honey flow is the most important task in beekeeping. Obtaining bee products is only profitable with the use of high-yielding bees' colonies, which can mobilize the maximum number of bees from each colony for collecting nectar and pollen in each honey flow. The bees grown in strong colonies are superior to those from weak colonies in the following characteristics: size and weight; length of the proboscis; the level of muscles development, the volume of the honey bag; the flight range; resistivity to

diseases; life duration [15-17].

Development and productivity of bee colonies are determined by external and internal factors, among which an important role is played by the age of the queen bees and their quality (physiological state, activity) [18-20]. The process of egg-laying by a queen bee is determined by the following factors: individual ability, age, the number of bees in the colony and their ability to contribute to egg-laying, the amount of feed available in and brought to the nest on a daily basis in the form of nectar and pollen, availability of cells suitable for egg-laying in the honeycomb, and seasonal climatic phenomena [21, 22].

Certain relationships among the organs, tissues, and features that ensure their coordinated functioning and correlative development are formed in the bees in the process of ontogenesis. Studies aimed at identifying the correlations among various bee characteristics for improving the efficiency of bee breeding have revealed significant and positive relationship between the queen bees' egg-laying ability and the gross output of honey in colonies of gray mountain Caucasian bees [23-26].

Scientific activities at the Krasnaya Polyana experimental beekeeping station ensure preservation and improvement of gray mountain Caucasian bees of type Krasnopolyansky. By providing the source material for the farms involved in beekeeping for mass reproduction in the breeding regions for this bee breed, the institution contributes to resolving the problem of increasing the efficiency of entomophilous crops' pollination. The main area of scientific activity is breeding work or obtaining new lines of gray mountain Caucasian bees of type Krasnopolyansky.

Breeding work had started in the 60s of the last century with the improvement of breeding and productive qualities of the colonies of gray mountain Caucasian bees (Apis mellifera Caucasica) based on the mass (phenotypic) selection. Next, 500 bee colonies had been imported from Georgia, out of which, by the results of two years' trials, the most valuable 10 % were chosen by a set of traits of purebred bee colonies. Further selection was performed by the methods of individual selection with checking the offspring quality of queen bees, followed by uniform selection and moderate inbreeding. As a result of years of work, six lines of bees had been obtained, which were used for mass reproduction of queen bees, which allowed to significantly increase honey productivity of bee colonies by 1984 [27-29]. Improving the productive and breeding qualities of gray mountain Caucasian bees was continued with the use of line breeding and interline crossing.

According to the program developed by the Research Institute of Beekeeping, the many years' breeding work with gray mountain Caucasian bees ended with the creation in 2008 of a new breed type — type Krasnopolyansky of gray mountain Caucasian bees. Bees of this type were superior to those in the initial population of gray mountain Caucasian bees by the following characteristics: honey productivity — more than 1.5 times, egg-laying ability of queen bees — by 20.5 %, intensity of colonies' spring development — by 30.5 %, summer growth — by 25.9 %, wax productivity — by 35.5 %, and preservation rate in the winter — by 18.2 % [24, 30].

Studies aimed at comparative assessment of the diversity and the degree of differentiation of the lines of A. m. caucasica based on the morphometric analysis and microsatellites have revealed differences in the structure of the genealogical tree of gray mountain Caucasian bees of type Krasnopolyansky built for the seven loci of microsatellites and three morphological features, which is a consequence of their geographic isolation [31, 32].

This research is aimed at a comparative assessment of queen bees' productivity in the period of spring development and preparation of colonies of gray mountain bees of type Krasnopolyansky to the main honey crop in the conditions of Greater Sochi.

II. MATERIALS AND METHODS

The research was based on the materials obtained from the Krasnaya Polyana Experimental Station of Beekeeping (Sochi Krasnodar Krai) in 2018. For the research, four groups of medium strength bee colonies were formed (for each apiary). All apiaries were geographically isolated from each other. During the experiment, the bee colonies were self-sufficient in carbohydrate and protein food. The first group — apiary 12, the second group — apiary 13, the third group — apiary 19, and the fourth group — apiary 24.

The amount of sealed brood was assessed three times in 12 days' periods using a frame-mesh. Based on the data obtained, the average daily egg-laying ability of queen bees was calculated. The number of bees grown in the spring by the time of the main honey flow was calculated by summarizing the data for three accountings for sealed brood. The data of zootechnical accounting were analyzed (40 bee colonies). The dynamics of the egg-laying capacity of queen bees and the development of bee colonies in the spring and before the main honey flow were analyzed.

III. RESULTS AND DISCUSSION

Using the results of the morphometric studies annually performed in the laboratory, and the genetic studies previously performed together with the scientists of the all-Russian Institute of Animal Breeding n.a. L. K. Ernst, four apiaries of the institution had been selected, where experimental groups of bee colonies were formed in 2018 for accounting for bee colonies' development in the spring and before the main honey flow. The main honey flow in the territory of Greater Sochi is ensured by sweet chestnuts that flower from June 10 – 15 to July 5 – 10, and limes that flower from July 20 – 25 to Aug 1 – 5.

During the research, the nectar and pollen were brought by the bees from Robinia, laurel cherry, rhododendron, blueberries, raspberries, blewit, blackberries and other plants flowering at this time. Figure 1 shows the data about the dynamics of queen bees' egg-laying capacity in the bee colonies in the spring.

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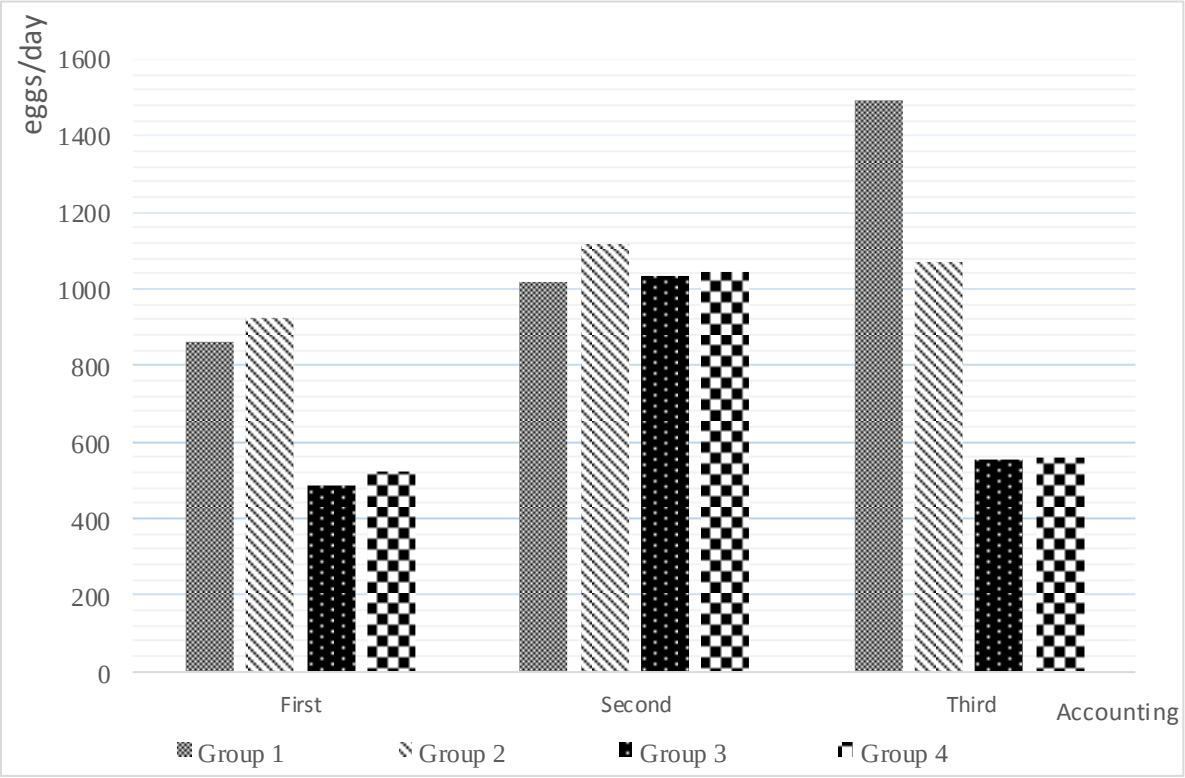

Fig. 1: The dynamics of queen bees' egg-laying capacity in the bee colonies in the spring by quarters.

It has been found that the first and the second groups showed steady growth of queen bees' egg-laying capacity within the period of study, which allowed bee colonies in these groups to obtain the largest number of bees. It is important to note that in these groups, the number of bees grown in the spring was by more than 35 % greater than in groups 3 and 4 (Table 1). The highest egg-laying capacity was noted in queen bees in the first group — 1,430 ± 83.82 (lim. 1,183 – 2,058).

Table 1: Bees grown in the spring, kg.

Group	n	lim	M ± m	Cv, %
1	10	2.75 – 4.19	3.37 ± 0.2	18.6
2	10	3.31 – 4.20	3.73 ± 0.1	8.33
3	10	2.05 – 2.80	2.48 ± 0.1	9.22
4	10	2.05 – 2.87	2.55 ± 0.3	11.62

Figure 2 shows the data about queen bees' egg-laying capacity during the period of bee colonies' preparation for the main honey flow. To predict the gross honey productivity of bee colonies, one can use the data about brood dynamics, since there is a close positive correlation between queen bees' egg-laying capacity and the gross honey productivity of gray mountain Caucasian bee colonies [33].

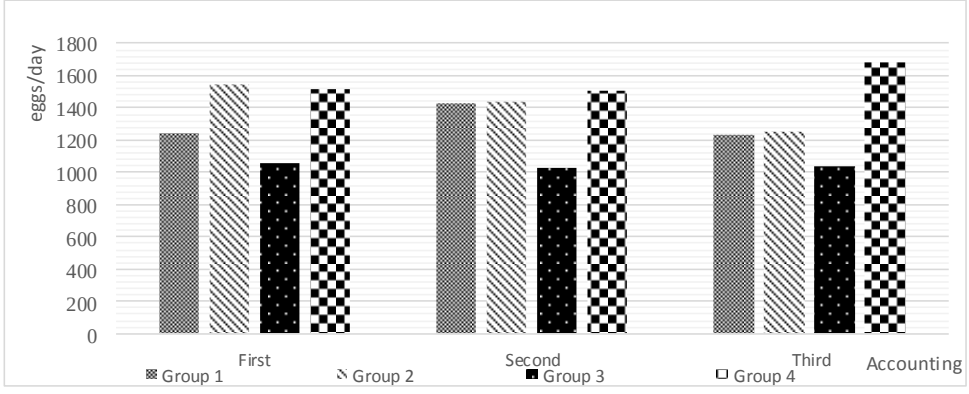

Fig. 2: Queen bees' egg-laying capacity in the period of bee colonies' preparation for the main honey flow by quarters

The sum of the three sealed brood accountings performed 12 days later characterizes the total number of bees in the colony on the 12th day after the last accounting. The data in Table 2 characterize the honey-production efficiency of the gray mountain bee breed of type Krasnopolyansky in the natural honey-gathering conditions of Greater Sochi.

Table 2: Indicators in bee colonies before the main honey flow

Group	n	The egg-laying capacity of queen bees, eggs/day			Bees grown by the time of the main honey flow, kg.		
		lim	M ± m	Cv, %	lim	M ± m	Cv, %
1	10	1,158 – 1,575	1,375 ± 46.62	10.73	3.53 – 5.93	4.69 ± 0.2	14.6
2	10	950 – 1,625	1,253 ± 64.6	16.30	4.69 – 5.82	5.09 ± 0.1	6.82
3	10	767 – 1,283	1,036 ± 63.32	19.03	3.09 – 4.67	3.74 ± 0.2	12.74
4	10	1,333 – 2,242	1,684 ± 224.0	39.90	3.58 – 6.36	6.05 ± 0.4	19.45

As one can see from the data shown, the largest number of bees was grown by the time of the main honey flow in the fourth group. By the beginning of the main honey flow, colonies in the first group had the average weight of less than 5 kg, the weight in the bee colonies of the third group within the three accountings was not consistently high, thus, the average weight of the colonies was less than 4 kg. Bee colonies in the second and fourth groups were able to build up sufficient strength (the average weight of over 5 kg).

The average queen bees' egg-laying capacity in the fourth group exceeded by 16 % the previously published data about the productivity of gray mountain Caucasian queen bees of type Krasnopolyansky before the main honey flow [34], and in the three bees colonies, according to the latest accounting, the average daily egg production of queen bees was 1,933 – 2,242 eggs.

Without receiving incentive fertilizing in the period of preparation for the main honey yield, bee colonies depended on the weather conditions in this period. Gray mountain Caucasian bees of type Krasnopolyansky are extremely hardworking, adventurous to seek new sources of feed, switch quickly from the worst sources of nectar and pollen to the best, and also have high mobilization activity (restrict the queen bee's egg-laying upon the onset of medium and strong honey flow). The best results were obtained in the fourth group. Despite some delay in the spring development, and later, bee colonies showed the best results, allowing to compensate for the delayed spring development, and to increase the maximum number of bees.

IV. CONCLUSION

By the set of the data obtained for further breeding, it is necessary to choose the fourth group (apiary 24). This apiary will continue to be used for the research study aimed at identifying the queen bees, the offsprings of which consistently transfer economically useful traits by succession, and that potentially can become ancestors of new lines of bees with the queen bees' productivity increased by no less than 15 %.

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