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Productivity of Honey Bees (Apis *mellifera*) Fed with a Stimulating Feed Additive

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ABSTRACT

The study aimed to assess the effectiveness of dihydroquercetin, a natural biologically active stimulant in the beekeeping industry. Studies on the effectiveness of the preparation were conducted in the field on four experimental groups, using different dosages of dihydroquercetin in each group. The maximum egg production of queens of bee colonies was observed in the second and third measurements in experimental group No. 3 when using dihydroquercetin at the rate of 15 mg/bee colony. The amount of commercial and gross honey obtained from bee colonies in experimental group No. 3 was recorded in the amount of 43.0 kg of gross honey and 20.1 kg of commercial honey. The difference with the control group, where dihydroquercetin was not used, was 41.5% and 17.4%, respectively. Thus, when introduced into the technology of keeping bee colonies as a stimulating feed additive in the amount of 15 mg per bee colony, the efficiency and vital activity of honey bees improves, which affects the increase in productivity of honey bees.

Keywords: Dihydroquercetin, Beekeeping industry, Egg production, Russia.

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INTRODUCTION

The mass death of bee colonies observed in the past few years in many countries of the world causes serious damage not only to the beekeeping industry but also to crop production since honey bees are the main pollinators of many crops [1, 2]. To prevent the spread of diseases, a wide range of therapeutic preparations is being developed, but the preparations presented do not achieve the goals set. The mass death of bees in Europe and America has led to the need to create international research organizations and centers dedicated to finding out the causes of the high mortality of bee colonies around the world [3-5]. In recent years, beekeepers in many regions of Russia have countered the mass death of bee colonies caused by the irresponsible use of pesticides, alongside the spread of bee diseases. Various infectious and invasive diseases harm the physiological state of individual bees forming a colony and are the cause of significant economic losses in beekeeping [6-9].

The medical system for the treatment of sick bee colonies began being used after the transfer of the content of bees from fixed-comb hives to frame hives. Specialists in bee-keeping had to search and develop medications for the treatment of brood diseases, as well as diseases of adult bees and queens. Pathogens, in turn, after several generations adapted to preparations and became immune to them, and people were forced to invent new ones [1, 2, 10, 11]. Each new medication became dangerous for the pathogens of the disease, and their residual amount in bee products became dangerous for human life [12, 13].

Thus, an important problem arose, concerning keeping bees without medication and curing them without medication in case of illness [14-16].

The damage caused by bee diseases, as well as the costs of combating them, are reflected in the cost and quality of bee products. Most bee diseases are usually treated with antibiotics. However, in this case, the use of some preparations weakens the immunity of bees, which contributes to the outbreak of a new disease. It is better to use natural and environmental remedies that would not only help to cope with bee diseases, but also stimulate their vital activity and dynamic development [17, 18].

Hence, the development of preventive methods of keeping bee colonies aimed at creating optimal conditions for the winter keeping of bee colonies and increasing the natural immunity of honey bees through the use of organic stimulating fertilizer is an urgent objective today.

MATERIALS AND METHODS

Comprehensive studies on the effect of dihydroquercetin (DHQ) on the productivity and vital activity of honey bees were conducted on the territory of the Udmurt Republic from 2017 to 2020. The Udmurt Republic is located in a zone with a temperate continental climate. The average long-term air temperature is -9.9°C in January and +20.9°C in July, while annually, the average precipitation is from 450 to 600 mm. The duration of the winter period is 5-6 months.

The breed diversity of honey bees inherent in the territory of the Udmurt Republic consists of a traditional breed, the Central Russian bee breed, as well as recorded gray mountain Caucasian and Carpathian bee breeds. It should be noted that the studies were conducted on crossbred bees, with a greater proportion of the Central Russian breed.

The study aimed to evaluate the effect of DHQ on the economically useful characteristics of honey bees in the conditions of the Udmurt Republic.

The main economically useful features that were studied in this work include the growth and development of the bee colony (measurement of brood, open and sealed), based on which the egg production of queen bees was determined; honey and wax productivity, and also the indicators related to winter hardiness (the safety of bees during the wintering period, the consumption of feed honey).

Taking into account the long duration of the winter period of 5-6 months and low temperatures that can reach up to -30°C, wintering of bee colonies was traditionally carried out in the winter garden, where the air temperature was in the range from 0 to -3°C, for a long time. Prolonged wintering of bees negatively affects the condition of honey bees, from the point of view of their general state of strength before leaving the wintering area in the spring. To improve the overall immunity status and resistance of bees to harmful factors, studies were conducted using a biological stimulating preparation.

DHQ is a unique substance of the flavonoid group extracted from Siberian larch wood. DHQ acts as a strong antioxidant that helps to maintain the body's natural immunity, thereby increasing the ability to fight diseases [19].

The method of administration of the preparation consisted in giving DHQ added to sugar syrup in the amount of 1 kg in the first spring examination during the formation of four equal experimental groups. The control group received 1: 1 sugar syrup without any additives, while experimental groups No. 1, No. 2, and No. 3 additionally received a nutritional supplement (DHQ) with the syrup at the rate of 5, 10, and 15 mg per bee colony. The number of bee colonies selected in experimental groups was equal to 10 hives. DHQ was given to bees for the second time after 12 days. The study was guided by the methodological recommendations "Research methods in beekeeping" (2006).

The number of broods was measured every 21 days three times using a grid frame according to V.V. Malkov's (1985) method.

The acquired data underwent biometric processing by methods of variational statistics with verification of the reliability of the results using the Student's t-test and the level of significance of the reliability.

RESULTS AND DISCUSSION

The study of the dynamics of the growth of the bee colony in the spring-summer period is shown in **Figure 1** based on the study of the egg production of queen bees. During the study, the number of broods was measured three times.

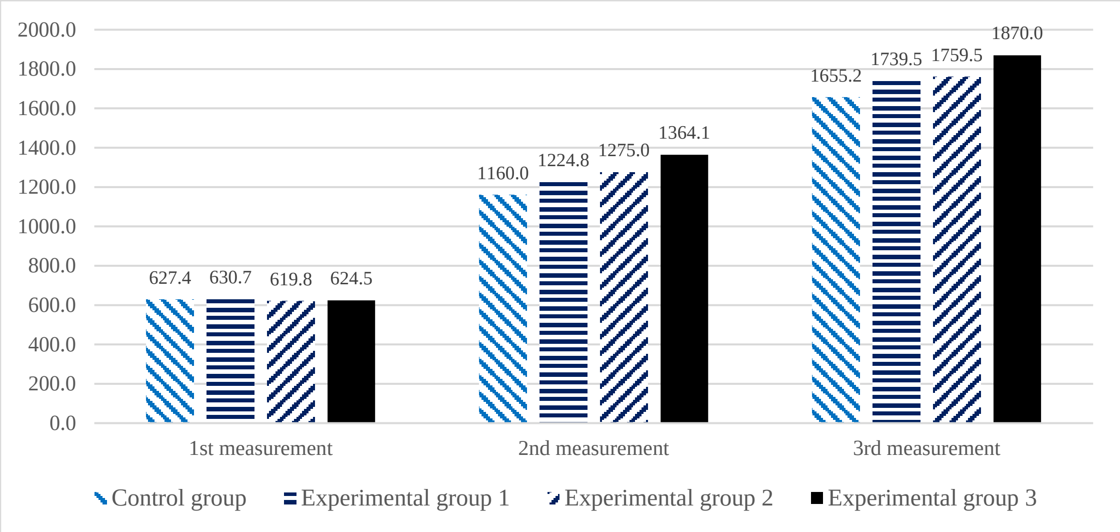

Figure 1. Egg production of queen bees in the spring-summer period, eggs

The maximum egg production of queens of bee colonies was observed in the second and third measurements in experimental group No. 3 where DHQ was administered at the rate of 15 mg/bee colony In bee colonies of experimental groups No. 2 and No. 1, the egg production of queens was slightly lower and was within the range of 1,224.8 to 1,275.0 eggs in the second measurement and 1,739.5 to 1,759.5 eggs in the third measurement.

Honey productivity of bee colonies was studied by the amount of gross honey yield, as well as by the amount of pumped commercial honey, taking into account the remaining amount of feed honey for the winter **(Table 1)**.

Table 1. Productivity of honey bees on average per bee colony for the analyzed period

Indicator	Control group	Experimental group No. 1	Experimental group No. 2	Experimental group No. 3
Gross honey	36.6±1.22	38.7±1.45	39.7±1.77	43.0±2.02*
Commercial honey	14.2±1.28	16.3±1.31	17.7±0.99	20.1±1.57**
Feed honey	22.4±0.76	22.3±1.01	22.0±0.84	22.9±0.63
Wax productivity	4.2±0.53	4.5±0.44	4.6±0.58	4.9±0.49
Built from a given number of honeycomb base sheets (6), %	70	75	77	82

Note: * $P \geq 0.95$; ** $P \geq 0.99$.

The analysis of the obtained commercial and gross honey showed that in experimental group No. 3 the maximum indicators of honey productivity were recorded, equaling 43.0 kg of gross honey and 20.1 kg of commercial honey. The difference with the control group, where DHQ was not used as a stimulating feed additive concerning the amount of commercial honey, was 5.9 kg or 41.5%, and concerning gross productivity, it equaled 6.4 kg or 17.4% ($P \geq 0.99$).

The study of the results on wax productivity for the systematic replacement of outdated frames showed that in the control group 70% of the maximum possible number of honeycomb base sheets was built, in experimental group No. 1 this number equaled 75%, in experimental group No. 2 77%, and in experimental group No. 3 82%, which was the best result for this indicator.

After the final honey pumping operations had been carried out, preparations were made for further studies of bee colonies on their winter

hardiness. The following parameters were taken into account when forming the brood nest:
the amount of feed honey left in the brood nest for high-quality wintering is 25-27 kg;
the amount of beebread left in the brood nest as a necessary supply of protein feed is 1 frame;
the strength of the colony was expressed in the number of seams occupied by bees in the autumn and spring periods; the difference between these indicators was determined;
the age of the queen bee; as a rule, there was a queen in the nest, bred in the current analyzed year;
the suitability of the honeycombs for wintering; fresh light rebuilt frames were left in the nest.
The bee colonies were kept in the winter garden during the winter. After the bee colonies were taken out from the hive and the air temperature reached up to 14°C which was acceptable for the first inspection, a spring audit was carried out. The obtained data on the results of wintering are shown in **Table 2**.

Table 2. Dynamics of changes in colony strength during wintering

Group	Autumn, seams	Spring, seams	Difference, %
Control	7.5	7.0	6.7
Experimental No. 1	7.8	7.4	5.1
Experimental No. 2	7.9	7.5	5.1
Experimental No. 3	8.2	7.9	3.7

Analysis of the degree of winter hardiness of bee colonies when using an antioxidant preparation, depending on different dosages, showed that the safety was higher in bee colonies of experimental group No. 3. The percentage of death of honey bees during the winter keeping period was 3.7%, which is 3.0% less in comparison with the control group.
When forming the bee brood nest during the winter, mainly white honey in the amount of 25-27 kg was left as feed honey. During the winter keeping of bees, the consumption in the analyzed groups ranged from 17 kg to 19 kg **(Figures 2 and 3)**.

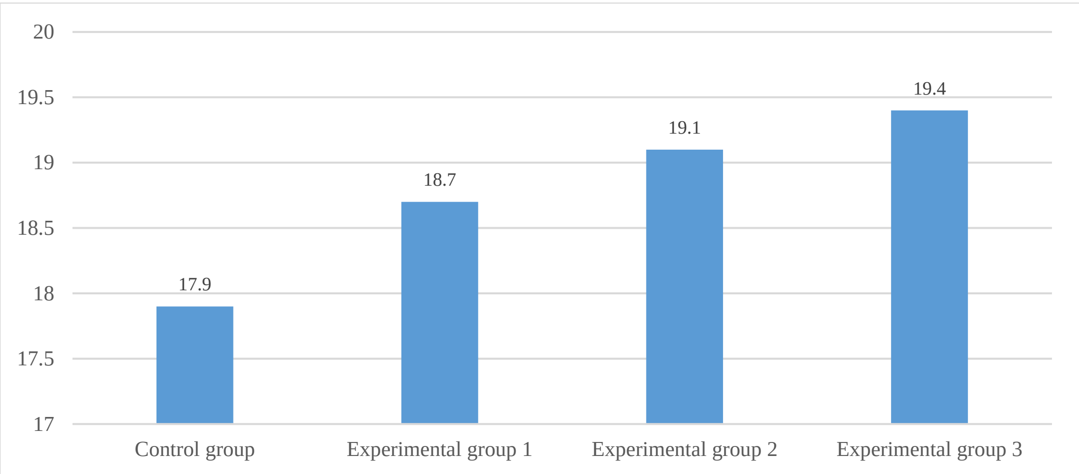

Figure 2. Consumption of feed honey per bee colony during the study period

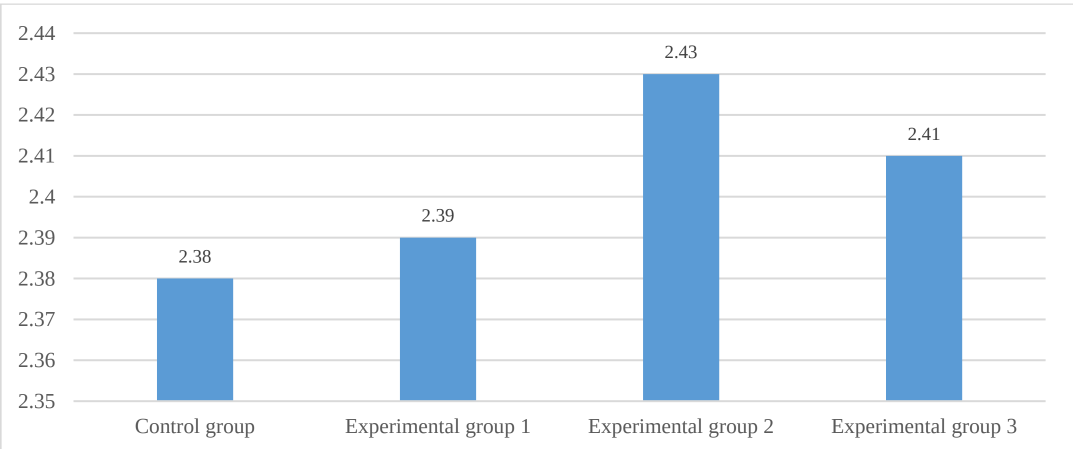

Figure 3. Feed consumption per seam of bee colonies during the study period from 2017 to 2019

The lowest feed consumption was recorded in the control group bee colonies and was 2.38 kg, and the maximum consumption was observed in experimental group No. 2, where this indicator reached 2.43 kg. The difference between the groups was 0.05 kg, which is not significantly indicative.

CONCLUSION

Thus, when introducing into the technology of keeping bee colonies in the natural and climatic zone of the Udmurt Republic with a long winter period and low temperatures, the element as a stimulating feed additive in the amount of 15 mg per bee colony improves the efficiency and vital activity of honey bees, which affects the increase in productivity of honey bees.

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