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Quality of queen bees in different ways of their production

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Abstract. Timely replacement of queens is one of the main zootechnical methods for maintaining the vital activity of bee families, and searching for ways to improve their quality is an urgent problem. The purpose of this study was to evaluate the effect of the method of obtaining queen bees of *Apis mellifera sossimai* and *Apis mellifera carpatica* breeds on their reproductive functions and bee family productivity. To conduct research in the conditions of the apiary of honey-pollination area, three groups were established - control and two experimental, with nine bee colonies in each. In the first (control) group, uteruses were artificially removed from the nursery, in the second group - fistula uteri and the third – swarm uteri. The apiary was located at a point of 50×50 meters, bee families were kept in hives. According to the results of the study, it was established that the queen bee *Apis mellifera carpatica* was heavier than the queen bee *Apis mellifera sossimai*. The queen bees from the nursery are the smallest, and the swarm queen bees are slightly heavier than in other groups, although the difference was not statistically significant. Fistula queen bees produce the most eggs and provide the best brood quality. Fistula queen bees have better weight uniformity than swarm bees, which affects the productivity of families. Colonies with swarm queen bees are characterised by different levels of development, which complicates the maintenance of these families. The quality of queens is affected by the breeding method and the location of the queen cell in the honeycomb. The more queens the colony grows, the worse their quality. As it is complicated to establish optimal conditions in the nursery and the number of queen cells is large, this is the reason for the worst quality of queens. The results obtained are of practical importance for choosing a method of rearing queen bees of high quality to establish well-developed bee colonies

Keywords: hive, bee family, fistula queen, swarm queen, nursery, bee brood

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Introduction

Honeybees can only live and work in a bee colony. There is normally only one queen bee in a typical bee colony. It is the colony's only fully matured female and the mother of a young queen, drone, and worker bees. When a bee colony loses its queen bee and is unable to reproduce a new one, it eventually dies. The queen bees have a sting, which they use during fights with other queens and when laying eggs.

The queen bee is much larger than a worker bee and longer than a drone but not as thick as he is. Her wings are longer than those of bees and drones. The movements are slow, although if necessary, she can run very fast. Day and night, she searches for honeycombs prepared by bees and lays eggs in them. She is constantly surrounded by young bees (retinue). They feed the queen bee with milk they produce, lick it and remove or eat its excrement. The egg production by queen bees depends on the strength of the colony. In a strong colony, the queen bee is larger, feeding is better, thus, it produces more eggs.

The queen bee lays an egg in a honeycomb, cleaned of dust, and old cocoons, and licked by young bees. She will not lay an egg in a dirty cell.

In a strong colony, where bees rebuild many cells, the queen bee can lay 2-3 thousand eggs a day. In a weak colony less, about 1-2 thousand eggs. Occasionally, a good queen bee lays 2-3 eggs in a cell if there are few clean cells. In this case, the bees leave only one egg, destroying the excess.

Analysis of Recent Researches and Publications

The presence of the queen bee in the bee colony of honey bees fully influences their flight activity in collecting bee pollen. In its absence,

the harvesting of pollen and its processing, the extraction of wax and the construction of honeycombs, the cultivation of brood, and the collection of nectar are significantly hindered and then completely stopped. With the appearance of the queen bee, all functions of the colony as an integrated biological system are restored (Niño *et al.*, 2012).

Timely replacement of queen bees every 2 years, and increasing and maintaining the strength of bee colonies are the main zootechnical measures to maintain the optimal vital activity of bees and obtain the maximum amount of production from them (Mishchenko *et al.*, 2020). Most parameters characterising queen bee quality are reflected in the queen's body weight, which is considered a robust and the best indicator of queen quality (Prešern & Smodiš Škerl, 2019). The age of grafted larvae had a statistically significant effect on the queen's weight, body length, thorax width and length, and wing length of the queen (Okuyan & Akyol, 2018).

Reducing the intensity of work or their complete cessation in the absence of the queen bee is an important biological adaptive response of bee colonies, which allows for maintaining the strength and ability of bees to grow large numbers of brood (Rangel *et al.*, 2016; Walsh *et al.*, 2016).

Regarding the age of the queen bee and the harvesting activity of bees, the research demonstrates that the age of the queen bee and the activity of collecting bee pollen are related: the younger the age of the queen bee, the greater the collecting activity, the more bee pollen comes to colonies (Mishchenko *et al.*, 2020). The species composition and weight of the pollen collected by bees are influenced by many factors, primarily

the number and variety of plant pollen in nature, the development of which depends less on climatic conditions than nectar productivity of plants (Urcan *et al.*, 2017; Radev, 2018).

The first question that arises when choosing queens concerns the optimal timing of their use. Some consider that queens in bee colonies should be replaced every year, while others suggest replacing them in the 2nd or even 3rd year. However, notably, according to the natural conditions, in particular, the duration of the active period, the strength of the bee colony, the intensity of egg-laying and breeding characteristics of queens, the terms of their effective use will be different. If the active period of life of the colony and the oviposition of the queen bee is short, the colony is weak and the queen bee lays about 75-100 thousand eggs a year, then its physiological age will come later. On the contrary, during a long active period in strong colonies, the queen bee can lay 150-200 thousand eggs per season. In this case, the queen bee's body deteriorates faster and physiological old age occurs earlier (Mishchenko *et al.*, 2020).

The purpose of the study was to compare the quality of reproductive function in queen bees of *Apis mellifera sossimai* and *Apis mellifera carpatica* breeds with different methods of obtaining them and the impact on the productivity of the bee colony.

Materials and Methods of Research

The apiary is located on a plot of land measuring 50x50 meters. Beehives with 20 frames are used to keep bee colonies. Bees are kept in the apiary of the Ukrainian field breed. The apiary has a honey pollination area. A winter house, a mobile vehicle, and a suitable chamber for honey pumping are all available at the apiary. Mustard is sown around the apiary every year.

To conduct experimental work in the apiary, three control groups and two experimental groups were established, with nine bee colonies in each group (Table 1). In the first group, the queen bees were artificially raised in the nursery, in the second group – fistulous queen bees, and in the third – swarm queen bees.

Table 1. The experimental design

Group	Number of bee colonies
1 – control	9
2 – experimental	9
3 – experimental	9

Results of the Research and their Discussion

Egg-laying, or queen bee reproduction, begins in March. The activity of the queen bee develops gradually. Initially, she lays several hundred eggs a day. After the overwintering of bees and their flight, the number of laid eggs increases. With the onset of warmth and

natural flow, egg-laying reaches a maximum. In steppe areas, it is the end of June, and in forest areas – the beginning of June. In the second half of summer, the work of the queen bee gradually hinders and, with the onset of colds, stops. If autumn is warm, egg-laying lasts until October. Thus, the queen bee rests only a few months a year.

The queen bee cannot live long without bees. Even under favourable temperature conditions and good feeding, she lives no more than 2-5 days. In a wooden cage with 10 bees, she lives 15-20 days, sometimes a month. In a bee colony, the queen bee lives up to 5-9 years, more than drones and bees. In the first two years, she lays the largest number of eggs, then productivity decreases. With age, she loses her drone semen and lays more and more unfertilised eggs, from which drones are hatched, thus, it is impractical to keep the queen bee in industrial apiaries for more than two years. Annually, it is necessary to change at least half, and preferably 80-100% of all queens.

According to the method of obtaining, queen bees are divided into 4 groups. Bees that feed the queen bee constantly lick it. After licking the queen bee, the bee immediately begins to share the licked queen bee's substance (pheromones) with other bees. The queen bee's substance is secreted by the maxillary glands. When the queen bee cares for herself, it spreads it all over the body. If worker bees receive a sufficient amount of royal jelly, they do not lay queen cells on the eggs and larvae of worker bees.

The queen bee's substance has been learned to be obtained artificially. Bee colonies, in which queens were removed but given the queen bee's substance in the form of drops on paper, continued to function normally.

In an old queen bee, very little of this substance is produced, and the bees begin to rebuild the bowls, and the queen bee lays eggs in them. After 16 days, the young queen bee is born from an egg. After mating with drones, the young queen bee begins to lay eggs. This change in the queen bee is called quiet. With this change, young and old queens live and lay eggs jointly without expressing hostility to each other.

In a colony where a quiet change of the queen bee is planned, the old queen bee secretes about 1/4 of the queen bee's substance produced by the young fertile queen bee. If placed in a weak colony, the bees will not lay queen cells to change the queen bee. Practice demonstrates that if in the summer in a colony preparing for a quiet change, the queen cells are broken, then such a colony often does not lay them and stays to spend the winter with the old queen bee, which usually dies in the winter. The quiet change of the queen bee depends on the breed of bees. Mountain Grey Caucasian honey bees change 40% of their queen bees annually. Carpathian bees frequently change queens.

If the bee colony loses the queen bee, the bees begin to raise the queens from the eggs and young larvae of the worker bees. Such queens are named fistulous. Biologically, they are complete and frequently better than a swarm.

In normal colonies, the quality of the fistulous queen bee depends on the age of the larvae from which the queen bee will be raised. Larvae up to 3 days old give full-fledged queens, and larvae older than 3 days (at least 6 hours) produce transitional forms of queens with varying degrees of development of signs of worker bees (wax mirrors, baskets), with fewer ovaries and a small ovary. Larvae older than 90 hours are not able to develop into queens, they grow only as worker bees. When the colony prepares for swarming, the bees make bowls, in which the queen bee lays eggs. After the appearance of larvae, bees complete the bowls, turning them into queen cells. Queen bees obtained from such queen cells are called a swarm.

Swarm queen cells are laid, as a rule, on the side, bottom, and middle of the cells. They are similar to a ripe acorn or a thimble. Swarm queen bees are not the same. They grow best in

the queen cells, which are located at the top of the cell (frame). Here they get more food, more temperature, and more humidity. In the lower part of the cell, the temperature frequently fluctuates, as warm and cold air passes through the cell. In addition, there are fewer nursing bees at the bottom, thus, they feed the larvae worse, and queen bees are born smaller. Queen bees from such larvae lay fewer eggs, die more often in winter, and are less durable.

Nurseries produce fistulous queens, which are commonly called artificial. For this, firstly, to prepare the queen bee family: to remove the queen bee and open brood and give the larvae of worker bees of one-day age, etc.

The queen bees were removed at the beginning of the main foraging season, and instead, the bees produced fistula queens. Young queen bees were weighed after fertilisation and yielded comparable findings (Table 2, 3).

Table 2. Live weight of fertile queen bees depends on the growth environment

Origin	Number of queen bees	Weight, mg
Artificial queen bees from the nursery	9	237.9 ± 7.1
Their daughters were raised in their colonies during the main forage period (fistulous)	9	272.9 ± 5.9
Their granddaughters were raised in their colonies at the end of the main forage period (fistulous)	9	230 ± 9.7

Table 3. Live weight of fertile queen bees

Origin	<i>Apis mellifera carpatica</i> , mg	<i>Apis mellifera sossimai</i> , mg
The queen bee from the nursery	277.1 ± 6.0	223.6 ± 2.8
Their daughters (fistulous)	288.5 ± 5.4	238.7 ± 4.3

During the egg-laying period, the queen bees were weighed. The queen bees were not related but belonged to the same Carpathian

breed. According to the data in Table 4, the queen bees from the nursery are smaller than the queen bees from their colonies.

Table 4. Oviposition and live weight of queen bees depending on their origin

Origin	The mass of the fertile queen bee at the beginning of oviposition, mg	Live weight during egg-laying, mg	Oviposition, pcs.
Fistulous	247.6 ± 4.0	292.2 ± 5.0	1629 ± 113.0
Swarm	249.7 ± 6.0	300.2 ± 5.8	1206 ± 94.0

In addition to the Carpathian breed, the Ukrainian steppe breed was tested, comparing fistula queens with swarm queens. Queen bees are slightly heavier, as presented in

Table 4, although this difference is not statistically significant. Fistulous queen bees, on the other hand, produce much more eggs. The brooding quality was greater and higher

in colonies with fistulous queen bees than in swarm queen bee colonies. As a result, swarm queen bees are not worse than fistulous. Colonies with fistulous queen bees are more convenient to work with.

The data on the weighting of swarm and fistulous queens at the beginning of egg-laying is summarised in Table 4. At the beginning of oviposition, the amount of swarm and fistulous queen bees are nearly identical. Only the difference in maximum and minimum weights is significant: 85 mg in swarm and 48 mg in fistulous. As a result, fistulous queen bees have better uniformity than swarm, which has an impact on colony productivity. As swarm queen bees can be both good and harmful, their colonies emerge with variable levels of ability, complicating maintenance.

July is the most favourable month for breeding and changing queens. At this time, bee colonies reach maximum strength, the hive is constantly receiving nectar and pollen, there are no sharp temperature fluctuations. All this provides the best conditions for breeding the largest bees and queen bees. It is almost impossible to establish such conditions for the artificial breeding of queens in the nursery. Encouraging feeding (100-200 g of syrup), which is distributed to foster colonies,

does not provide the colony and offspring with proper nutrition.

The quality of queens is influenced by the method of breeding and location of the queen cell in the honeycomb, the presence of fodder base in nature during their cultivation, the strength of the colony, and the number of queen cells in the colony. The more queens the colony grows, the worse their quality.

The young queen bee should fly around. If she does not do this within a month, she loses the ability to mate with drones, and she begins to lay unfertilised eggs, from which only drones are hatched. This queen bee is called a cobweb. A colony with such a queen bee usually dies if a beekeeper does not help it.

During a strong flow, the queen bee cannot lay many eggs because the bees fill the cells with honey. As the flow decreases and the number of free cells increases, she lays more eggs. After the end of the flow season, the queen bee stops laying eggs as the bees feed them worse. In winter, they do not lay eggs.

Conclusions

1b. During the artificial rearing of queens, the foster colony does not accept eggs for rearing, thus they give her larvae. The younger the larva, the better the queen bee.

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Якість бджолиних маток за різних способів їх отримання

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Анотація. Своєчасна зміна маток є одним з основних зоотехнічних прийомів для підтримання життєдіяльності бджолиних сімей, а пошук шляхів підвищення їх якості є актуальною проблемою. Метою даного дослідження, було оцінити вплив способу отримання бджолиних маток порід *Apis mellifera sossimai* та *Apis mellifera carpatica* на їх відтворювальні функції та продуктивність бджолиної сім'ї. Для проведення досліджень в умовах пасіки медово-запилувального напрямку було сформовано три групи – контрольну та дві дослідні, по дев'ять бджолосімей у кожній. У першій (контрольній) групі були штучно виведені матки із розплідника, у другій групі – свищеві матки та в третій – ройові. Пасіка розміщувалась на точку розміром 50×50 метрів, бджолині сім'ї утримували у вуликах-лежаках. За результатами дослідження було встановлено, що бджолині матки *Apis mellifera carpatica* були важчі за бджолині матки *Apis mellifera sossimai*. Бджолині матки з розплідника найменші, а ройові бджолині матки дещо важчі ніж в інших групах, хоча різниця не була статистично значущою. Свищеві бджолині матки виробляють найбільше яєць і забезпечують кращу якість розплоду. Свищеві бджолині матки мають кращу вирівняність за масою, ніж ройові, що впливає на продуктивність сімей. Колонії з ройовими бджолиними матками характеризуються різними рівнями розвитку, що ускладнює утримання цих сімей. На якість маток впливають спосіб розведення і розташування маточника в стільнику. Чим більше маток вирощує колонія, тим гірша їх якість. Оскільки в розпліднику важко створити оптимальні умови, а кількість маточників велика, це є причиною найгіршої якості маток. Отримані результати мають практичне значення для вибору способу вирощування маток високої якості для створення добре розвинених бджолиних колоній

Ключові слова: вулик, бджолина сім'я, свищеві матки, ройові матки, розплідник, бджолиний розплід