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INFLUENCE OF CLIMATE CONDITIONS AND BEE GRAZING ON THE STRENGTH AND PRODUCTIVITY OF BEE FAMILIES

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Abstract

Honey bees are extremely intelligent creatures that form an indispensable segment of the planet's ecosystem. Their lives are closely linked to environmental conditions. Mostly with climatic conditions, honey-bearing vegetation in the area of the apiary in which they are grown, cultivation technology and many other factors. Good knowledge of honey resources and proper organization of their use are crucial for the development of beekeeping and increase the productivity of bee colonies. The leading factor for the life and development of bees are the environmental conditions - climate, flora and fauna, food base, useful and harmful to bee colonies living organisms. Most of these conditions one cannot make an impact, this can be achieved through large unjustified costs. Another group of factors that determine the development of the bee family are created inside the nest as a result of the vital activity of individuals in it. These include the collection, processing and preservation of food supplies, regulation of temperature, humidity and gas exchange within the bee colony, beneficial and harmful organisms associated with the bee colony, microorganisms involved in digestion and preservation of perga and others. These factors are related to the productivity of the bee family and in them it is possible, to some extent, altered by man. Climate change affects the development and productivity of bees to varying degrees, with weak families and higher mortality. The aim is to trace the influence of climatic conditions and bee grazing on the strength and productivity of bee colonies.

Key words*: bee family, bee grazing, climatic factors, honey bees, productivity, strength of bee colonies.*

INTRODUCTION

Bees are a bioindicator of climate and human activity. The bee organism reacts to various external factors, which allows them to be used as an indicator for biomonitoring in terms of environmental quality. For the purposes of biomonitoring can be monitored: the development of bee colonies, changes in bee behavior and periodically report mortality or apply a comparative analysis of indicator characteristics of bees (heavy metals, pesticides, radionuclides and other pollutants in the bee organism), reared in areas with varying degrees of anthropogenic impact. Background environmental monitoring is conducted in areas with small sources of pollution, with insignificant anthropogenic impact. It aims to obtain complete, objective and comprehensive information about the current state of the biosphere and its individual components at the background level. It allows solving not only national tasks, but also a number of international problems related to the negative, global effects of anthropogenic activity - climate change, ozone depletion, acid rain, the spread of harmful substances over long distances. Many scientists warn that climate fluctuations and changes today are reflected now and, in the future, to significantly affect all areas of human activity. Conservation of the species diversity of a number of pollinators, including bees, is becoming a serious problem.

According to Shopova (2021), the main factor responsible for the biological development of insects is solar radiation. Of the main meteorological elements, the average values of which determine the climate of a place, solar radiation is considered the most conservative and poorly variable factor. The beginning of egg-laying by the queen bee in honey bees is associated with an increase in the length of the day. The orientation in space and during the honey harvest happens thanks to the light. Temperature changes are also responsible for the behavior of bees and their habitats. Variations in humidity, droughts and droughts

have a direct effect on vegetation and nectar production.

In recent years, agriculture in our country is losing its diversity due to the lack of an efficient irrigation system and the risk of losses in the cultivation of plants requiring higher humidity. All abiotic factors have a complex effect on the development and behavior of bees.

According to Alexandrov (2011), the last two decades of the last century and the beginning of the present show an increase in average air temperature. In our country, scientists have found an increase of up to 0.8°C compared to the period 1961-1990. The different climate models show an increase in the average value by 2050 by between 1.6°C and 3.1°C. For the region of Struma and South-Eastern Bulgaria the annual temperature should increase by between 0.9°C and 1.3°C by 2025, distributed by seasons as follows: winter - 0.6°C; spring - 1.2°C; summer - 0.9°C and autumn - 1.2°C.

Some of the models expect an increase in solar radiation in the cold half of the year by no more than 10%. Precipitation shows a declining trend at the end of the last century and an increase since the mid-1990s in many parts of the country. The model expectation regarding the annual amount of precipitation by 2025 is to decrease by between 2% and 5%, with a tendency to increase to 10% at the end of the 21st century.

Bees are a bioindicator of both climate and anthropogenic activity. Reducing them threatens the stability and sustainability of both our food and farm animal feed. The group of external factors includes: climatic and atmospheric conditions; the variety, duration and strength of bee grazing; the presence of beneficial or harmful organisms for bees. Climatic and atmospheric conditions are a result of the geographical location and relief of the area where the apiary is located. Includes: seasonality; average daily and average annual temperatures; air humidity; direction and strength of the prevailing winds; length of daylight, etc. The life of the bee family takes place depending on the changes that occur in the surrounding nature.

However, reactions to these changes are different in strong and weak families. The strong family makes better use of the favorable changes and absorbs the unfavorable ones more easily than the weak one.

The productivity of bee colonies is directly dependent, in addition to grazing, on the number of bees and their hereditary qualities. Only strong, healthy, and active bee colonies can produce a lot of honey, wax and new colonies and most effectively participate in the pollination of crops. In winter and spring, strong families retain heat better in the nest and spend less food to maintain the necessary heat (calculated per 1 kg of bees). Therefore, they overwinter more successfully and use the saved food for their better development. In addition, strong families enter the spring with bees exhausted from overwintering, which live longer and therefore better support their spring development (Terzieva, 2016).

Strong families overwinter much better than weak ones, consume less food in winter, grow much faster in spring, participate fully in the main grazing, build many cakes, and build viable, durable, and resistant to infectious diseases bees.

Many researchers in the field of beekeeping place honey plants (bee grazing) as the first factor influencing the productivity of bee colonies. Every beekeeper must know very well the area in which he is beekeeping in terms of the honey base: to know the strength of the pasture and its species composition; to know the beginning and duration of flowering of the main honey plants. In this regard, it is recommended that the beekeeper make a honey balance in the area where he raises bee colonies to get an idea of its honey potential. According to recent research, bees may not be able to adapt to changing climates by shifting their range of habitats. While other species, such as butterflies, can migrate easily, bees do not adapt to rapid change as easily, which means that they are particularly vulnerable to the unexpected effects of climate change. Unless we stabilize or reduce climate change, bees may one day disappear altogether.

Increased CO_2 in the atmosphere, heat stress, longer droughts and more intense rainfall associated with global warming continue to affect bee populations. In recent decades, there has been a drastic decline in both wild and domestic bee species worldwide. Growing disorders in bees, unusually high winter losses

of families and reduced life expectancy of queen bees have been common in recent decades. Climate change is a factor in the destruction of habitats. Climate and hydrology determine the general conditions for the emergence and prosperity of wild species. With global warming, changes are taking place in the Earth's climate zones. Climatic conditions and the condition of the honey-bearing vegetation are the main factors that determine the vital activity of bees during the different seasons and seasons (Taranov, 1987; Bilash, 1999; Nenchev, 2002).

The productivity of bee colonies is directly dependent not only on grazing, but also on the number of bees and their hereditary qualities. Only strong, healthy, and active bee colonies can produce a lot of honey, wax and new colonies and most effectively participate in the pollination of crops (Zhelyazkova, 2004).

In winter and spring, strong families retain heat better in the nest and spend less food to maintain the necessary heat (calculated per 1 kg of bees). Therefore, they overwinter more successfully and use the saved food for their better development. In addition, strong families enter the spring with bees exhausted from overwintering, which live longer and therefore better support their spring development (Radoev, 2003).

Research shows that bees raised in strong families have 5-8 days longer lives, their proboscis is 8% longer, their muscles, legs and wings are better developed, and the honey stomach is more voluminous. That is why they fly farther and carry about twice as much nectar in flight as bees raised by weak families. In the spring, the strong families accumulate an increasing number of flying bees, which use the main pasture and collect a lot of honey. Weak families continue their development during the main grazing, as most of them are engaged in raising offspring. As a result, they have few flying bees and miss grazing without collecting enough honey, even for their own feeding. Strong families build more combs, produce more wax, and their brood and bees are more resistant to disease. They are also less likely to be attacked by bee thieves and easier to deal with enemies and pests. The assessment of the development of bee colonies in the hive was determined by two criteria - the strength of the bee colony (in kg of bees) and the number of bees and the number of sealed brood.

Honey production is influenced by the season and the type of hives (Tsvetanov, 2016; Tsvetanov 2017).

MATERIALS AND METHODS

Strength of the bee family. This feature is determined by the number of frames occupied by bees in kilograms (kg). The strength of each bee colony is determined by the main spring inspection (in early April, when there are still no young bees in the family) and the autumn inspection (in early November, when egg-laying is suspended). There are differences in the weight of beekeepers in different types of hives, in Dadan-Blatt the number of beekeepers in the beehive is multiplied by 0.250 kg; at Dadan-Blatt it is multiplied by 0.250 kg;

Quantity of bee brood. It is determined by measuring the number of sealed cells with a measuring frame. In addition to the number of frames occupied by bees, the amount of sealed brood is recorded every 12 days, which is one of the indicators of the egg-laying capacity of the mother and the strength of the bee colony. The quantity is determined by means of a measuring frame, inside of which a thin wire is stretched, forming squares with a wall size of 5 by 5 cm or occupying an area of 25 cm^2. The area of each of the squares corresponded to the area occupied by 100 bee cells (4 cells per square centimeter). The measuring frame is placed on the frame with a file and the squares that cover the bee brood are counted. The measuring frame is superimposed on the bee brood frame and the squares are counted.

Honey productivity of bee families. We determined the honey productivity of bee families, individually for each hive. As the combs from each hive are removed, placed in a portable box, and weighed again with the empty combs. The difference between the two draws was used to determine the amount of honey from each hive. The determination of the individual honey productivity for each hive was performed once at the end of the honey harvest season in the year of the study.

The most important of the controlled indicators in bee colonies is honey productivity. Combined with the evaluation on all other

grounds, it is essential because it affects the efficiency of grazing and gives a definitive idea of the suitability of the bee family for tribal use. The assessment of productivity was performed on two indicators - extraction of honey and wax. The amount of honey is determined at the end of the season, taking into account the records kept for the respective family. The total honey production of the bee family was determined by summing the centrifuged honey with the honey left for winter and the honey stored outside the hive. In determining the amount of honey in the combs, we assumed that 1 dm2 of the area filled on both sides contained 350 g of honey. After determining the area of sealed honey, we calculated the total amount of honey in the honeycomb, as one filled on both sides with sealed honey 12 Dadan-Blatova pita contains 3.6 kg, sealed to the middle - 2 kg and filled to 1/3 - 1 kg. (Nenchev, 1990).

Experimental apiary 1.
The town of Ihtiman is located in the Ihtiman valley, which is surrounded by Ihtiman middle forest. The eastern part is occupied by a distinct ridge. The Ihtiman valley has an average altitude of 650 m. The Mativir River passes through the land. The climate is temperate continental (Figure 1).

Experimental apiary 2.
The town of Koynare is located in the northwestern part of Bulgaria in the Pleven region. The altitude is 78 m (Figure 1).

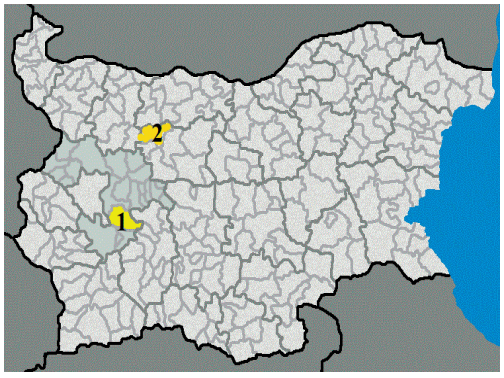


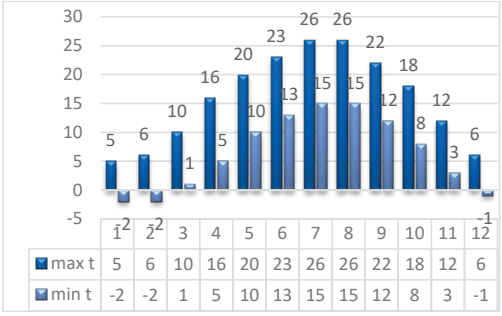
Figure 1. Map with experienced apiaries

Figure 1 shows the location of the experimental apiaries.

Number and type of hives.
For the purposes of the study, we traced 10 hives from two apiaries, system Dadan Blatt with 12 frames each.

RESULTS AND DISCUSSIONS

In terms of climate, apiary 1 falls in the temperate-continental climatic sub-region of the European-continental climatic region or in particular in the climatic region of the high fields in Western Central Bulgaria. The predominance of northwestern transport of strong ocean air masses coming from Northwestern Europe has a significant impact on climate formation. The movement of continental air masses is in the north-northeast direction and the warm tropical air masses penetrating from the south.



	1	2	3	4	5	6	7	8	9	10	11	12
max t	5	6	10	16	20	23	26	26	22	18	12	6
min t	-2	-2	1	5	10	13	15	15	12	8	3	-1

Figure 2. Minimum and maximum temperatures reported during the study period

The data in the Figure 2 show that the average annual temperature is relatively low, the coldest months of the year are January, February and December. There are also sharp drops in temperatures in spring and autumn. The warmest months are July and August. A typical spring month is April, and a typical autumn month is October. In the area of Apiary 1, there is a danger of late spring and early autumn frosts - in the second half of May and in the first ten days of September. The main reason for this is the nature of the relief. The distribution of precipitation during the year by months and seasons is uneven - a pronounced continental climate. The amount of precipitation is highest in May and June, and the lowest - in February and September. The average annual amount of precipitation is below the national average. The snowfall is in

the period November - April. This distribution of precipitation emphasizes the typical temperate-continental character, with a winter minimum and a secondary one at the end of summer and a maximum at the end of spring and the beginning of summer.

Apiary 2 falls in the temperate-continental climatic subregion of the European-continental climatic region. The continental character of the climate is very well expressed with markedly cold winters and hot summers, warm springs and sunny autumns. The average altitude of the area is about 200 m.

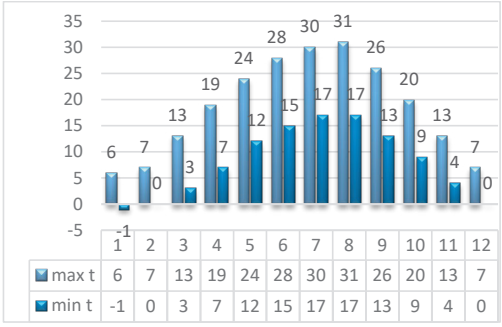


Figure 3. Minimum and maximum temperatures reported during the study period

The data in Figure 3 show that the average annual temperature is relatively low, the coldest months of the year are January and February with t -1 to 0°C. The warmest months are July and August with t 30-31°C. The highest amount of precipitation falls in March, April and May about 50 mm. The snowfall is in the period December-January.

Globally, the last 160 years have seen a trend of increasing the average temperature of the Earth by 0.5°C. Climate change is related to the general warming trend for Bulgaria, as well as the increase in the frequency of extreme meteorological and climatic phenomena, such as droughts, torrential rains, thunderstorms and hail, which greatly affect bee colonies.

The honey plants around the apiary 1 are mainly *Tilia*, less *Robinia pseudoacacia* and a variety of meadow honey plants, which are also the main source of food for bees. The cultivation of *Helianthus annuus, Brassica napus* and *Medicago sativa* in the area has also increased in recent years.

Table 1 shows the honey plants with the most burning importance for the bees in the area, the flowering period and what the bees collect from them.

Table 1 Honey-bearing vegetation determined around an apiary 1

№	Latin name	Bulgarian name	What do bees collect	Flowering period
1	*Prunus domestica*	Слива	Abundant nectar and some pollen	IV-V
2	*Prunus cerasifera*	Джанка	Abundant nectar and some pollen	IV
3	*Malus domestica*	Ябълка	Neckar, pollen	III-IV
4	*Cerasus vulgaris*	Череша	Neckar, pollen	IV-V
5	*Prunus cerasus*	Вишня	Neckar,pollen	IV
6	*Prunus spinosa*	Трънка	Nectar, some pollen	IV-V
7	*Rubus idaeus*	Малина	Nectar	V-VI
8	*Rosa canina*	Обикновената шипка	Pollen	V-VI
9	*Lamium purpureum*	Мъртва коприва	Neckar, pollen	IV-X
10	*Brassica napus*	Рапица	Neckar,pollen	IV-V
11	*Robinia pseudoacacia*	Акация	Neckar, pollen	V
12	*Tilia spp.*	Липа	Neckar, pollen	V-VI
13	*Helianthus annuus*	Слънчоглед	Neckar, pollen, propolis	V-IX
14	*Medicago sativa*	Люцерна	Neckar, pollen	V-IX

Fruit species are of great importance for the development of bee colonies and especially on the egg-laying activity of the mother and the development of the brood in the spring. *Cerasus vulgaris* are very good honey plants with abundant flowering. From them the bees

collect nectar and pollen. *Prunus domestica* and *Prunus cerasifera* are a source of copious amounts of nectar and less pollen. These species provide the bee family with good food during the period of its intensive reproduction. The flowering period is from month March to month May, consecutively. *Lamium purpureum* is a good, honey plant with a very long flowering period of 5 or more months. It supports the continuous development of bee colonies in the spring and their preparation for grazing. The honey plants of the greatest importance for apiary 1 are the predominant plantations of linden, sunflower and meadow vegetation. From *Helianthus annuus*, bees collect abundant nectar, pollen and glue. It has a long flowering period and is one of the important honey plants around the apiary.

Natural meadows are a very good honey base for bees. There are a large number of species that bloom for a long time and emit enough nectar. In many parts of the country, meadows provide the main pasture for bees. Flowering of meadow honey plants begins in spring and ends in mid-summer. It coincides with the full development of families and the most favorable external conditions. With good grass composition in the meadows, bees collect large amounts of high-quality nectar. Table 2 shows the honey-bearing vegetation around the apiary 2.

Table 2. Honey-bearing vegetation around apiaries 2

№	Latin name	Bulgarian name	What do bees collect	Flowering period
1	*Prunus domestica*	*Слива*	Abundant nectar and some pollen	IV-V
2	*Prunus cerasifera*	*Джанка*	Abundant nectar and some pollen	IV
3	*Malus domestica*	*Ябълка*	Neckar, pollen	III-IV
4	*Cerasus vulgaris*	*Череша*	Neckar, pollen	IV-V
5	*Prunus spinosa*	*Трънка*	Neckar,pollen	IV
6	*Crataegus monogyna*	*Обикновен глог*	Nectar, some pollen	IV-V
7	*Rosa canina*	*Обикновената шипка*	Nectar	V-VI
8	*Lamium purpureum*	*Мъртва коприва*	Pollen	V-VI
9	*Robinia pseudoacacia*	*Акация*	Neckar, pollen	IV-X
10	*Amorpha fruticosa*	*Черна акация*	Neckar,pollen	IV-V
11	*Tilia spp.*	*Липа*	Neckar, pollen	V
12	*Helianthus annuus*	*Слънчоглед*	Neckar, pollen	V-VI
13	*Medicago sativa*	*Люцерна*	Neckar, pollen, propolis	V-IX
14	*Onopordum acanthium*	*Магарешки бодил*	Neckar, pollen	V-IX

From Table. 2 shows that honey plants are represented by fruit species such as plums, apples *Malus domestica* and cherries and junipers. They bloom in early spring, April, May and give the bees some pollen. *Prunus spinosa, Crataegus monogyna, Rosa canina* are important for the maintenance of grazing and the development of families.

Predominant honey plants as the main food source are: *Lamium purpureum, Robinia pseudoacacia, Amorpha fruticosa, Tilia* spp., *Medicago sativa, Helianthus annuus* and *Onopordum acanthium.* In both study areas, we reported approximately the same plants, a source of food for bees with small differences.

Determining the strength of bee colonies in the spring.

The aim of beekeeping is to obtain the highest possible and constant yields. This is achieved through human intervention in the life of the bee colony, guiding and supporting it. For this purpose, it is necessary to carry out regular inspections. The size and strength of the bee colony is determined by the number of frames covered with bees. This means the number of bees that cover from top to bottom neighboring wax combs. Moreover, this number of bees in a frame is a constant number, which is the same and does not change with the seasons, the strength of the family and other factors.

The strength of the families in the spring was determined during the main spring inspection carried out on 12.03.2021 in apiary 1, the results of which are presented in Figure 4.

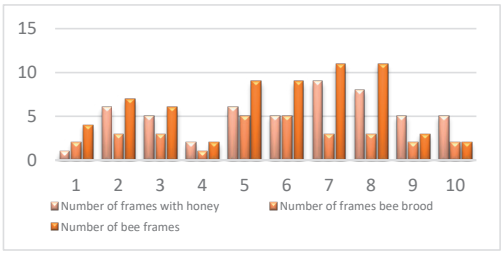


Figure 4. Number of frames with honey, bee brood and quantity of bees

In the review we found that bee colonies are relatively strong from 6 to 11 bee frames, except for three, in which we reported a smaller number of brood and frames with bees. We performed feeding in order to support and strengthen the weak bee families in order to equalize them in strength.

On apiary 2 we made the main spring inspection on March 13, 2021. The results are shown in Figure 5.

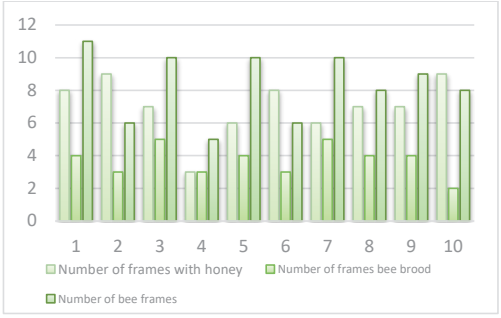


Figure 5. Number of frames with honey, bee brood and quantity of bees

The bee families in this apiary are relatively strong from 6 to 11 frames with bees, the color of the frames with a brood is from 3 to 5 pieces and a significant amount of food supplies from 6 to 9 frames with honey. We did not report weak families.

Determining the strength of bee colonies in the fall in both apiaries.

Strength of bee colonies reported in the autumn in the apiary 1. With the completion of the autumn development, the main autumn inspection of the bee families was carried out. With it we established the presence of the mother and her qualities, the amount of the pilot, the strength of the family and the health of the bees, the quality and quantity of food supplies.

Autumn inspection of apiary 1 performed on September 6, 2021. The results obtained are presented in Figure 6.

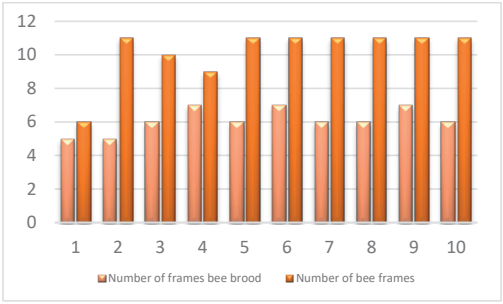


Figure 6. Strength of bee colonies reported in the autumn in the apiary 1

The results show that the ten bee families in apiary 1 are strong and values from 6 to 11 bee frames are reported. At apiary 2 we made the autumn inspection on 01.09.2021. The obtained results are presented in Figure 7.

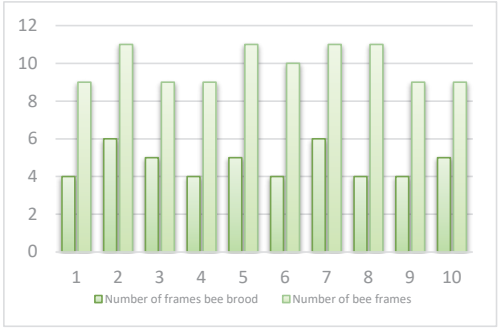


Figure 7. Strength of bee colonies reported in the autumn in the apiary 2

Figure 7 shows that in the apiary, bee colonies are strong, with values of 9 to 11 bee frames and sufficient food supplies for a good winter. Strong families overwinter much better than weak ones, consume less food in winter, grow much faster in spring, participate fully in main grazing, build many combs and raise viable, resilient and disease-resistant young bees.

Determining the honey productivity of families.

The most important of the controlled indicators in bee colonies is honey productivity. Combined with the evaluation on all other grounds, it is essential because it affects the efficiency of grazing and gives a definitive idea of the suitability of the bee family for tribal use. The assessment of productivity was performed by indicator - copper production. The amount of honey is determined at the end of the season. The total honey production of the bee family was determined by summing the centrifuged honey with the honey left for wintering and the honey stored outside the hive.

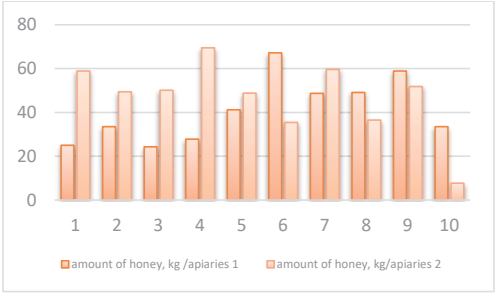


Figure 8. Determining the honey productivity of families

From the results shown in Figure 8 it can be seen that the largest amount of honey was obtained from hive № 6 and hive № 9, respectively 67.2 and 58.9 kg of honey.

The smallest quantities are obtained from beehives № 1, 3 and 4 from 24.3 to 27.8 kg of commodity honey. The other hives have relatively good amounts of honey from 33.5 to 49.1 kg. The largest amount of honey was obtained from beehives № 4, № 7, № 1 and № 9, respectively 69.5, 59.6, 58.9 and 51.8 kg of honey. The smallest quantities were obtained from beehive № 6 and beehive №8 about 17.8 and 24.3 kg of honey. The other hives have relatively good amounts of honey from 48.4 to 50.1 kg.

CONCLUSIONS

The analysis of the obtained results gives us grounds to draw the following more important conclusions:

The geographical and climatic characteristics in both regions of the apiaries are suitable for creating and raising bee families. The high temperature and humidity during the beekeeping season creates good conditions for the development of bee families and their good wintering.

The honey-bearing vegetation around the apiaries is sufficient for the development of bee families throughout the beekeeping season. There are no periods of grazing interruption. The main pasture is mainly acacia, linden and fruit species, which are a source of honey with excellent qualities. Sunflowers and meadow honey species prolong grazing and allow for the production of high-quality honey.

In both regions of the country, where the apiaries of the study are located, we found strong bee colonies during the autumn inspection. The mothers are young and very productive, which is why the strength of the families in the apiaries is due. Bee families are better developed in an apiary located in the area of the town of Koynare. Climatic conditions are more favorable and this affects development.

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