Resistance of Carniolan (Krajina) bees to changing weather and honey flow conditions

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Abstract. The observation data for the favorable honey flow conditions of 2024 indicate the intensive development of Carniolan (Krajina) bee colonies. By the peak of the honey flow, colonies occupied 12.8±0.98 frames, with an average of 1.7 supers per hive. Over the season, each of the 10 experimental colonies yielded 24.6±8.41 kg of commercial honey. In the fall, 10.9±0.83 frames were left in the hives. No queen replacement or colony culling was carried out during the summer of 2024. The colonies survived the fall-winter dormancy period successfully, with a 100% survival rate. In the spring of 2025, an abnormally warm period was recorded for the Kaluga region. The bee colonies developed actively, and nucleus colonies were made from five of the families. However, subsequent cold, rainy weather slowed the development of bee colonies; two colonies were culled. By the start of the main honey flow, the hives contained 11.5±1.54 frames, with an average of 0.5 supers per hive. Commercial honey yield per colony was 6.9±5.58 kg. The increase in colony population during the 2025 season, including culled colonies, was 30%. At the end of the season, 11.2±0.95 frames remained in the hives. The study results showed that the Carniolan (Krajina) bee breed is resilient to changing weather conditions. Commercial honey production from bee colonies decreased significantly due to unfavorable weather conditions in the summer of 2025.

1 Introduction

The honeybee (*Apis mellifera*) is widely used to produce valuable beekeeping products, the most important of which is honey. Bees' primary role in nature and agriculture is pollination of entomophilous crops. Thus, they directly impact the conservation of natural biodiversity and crop yields. In recent decades, global warming has been noticeable on our planet, significantly affecting the habitats of living organisms, including honeybees. Unfavorable climatic and environmental conditions negatively impact the productivity and sustainability of bee colonies, as confirmed by research conducted in many countries around the world [1-5].

Over the past 30 years, the number of bee colonies in the Russian Federation has decreased by 1.5 times, and this trend continues. Furthermore, there are regions within the country with elevated radionuclide levels. Research has shown that bees and bee products

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can be effectively used as biological indicators of radioactive contamination of the environment [6]. In recent years, strategies for preserving the population of honeybees and other pollinating insects have been developed worldwide. Therefore, great importance is attached to monitoring factors influencing the vital functions of bee colonies and changing habitat conditions [7, 8].

During the honey flow period, the development of bee colonies and the amount of honey they produce directly depend on weather conditions and the quality and quantity of food sources for bees – nectar and pollen [9, 10].

The greatest number of bee colonies perish during the winter, which is the most dangerous period for bees. Monitoring of bee colony survival conducted in the Czech Republic and Austria revealed that in the Czech Republic, between 8.1 and 28.4% of bee colonies perished during the winter; in Austria, between 6.4 and 19.4%. The authors note that the density of apiaries and bee colonies in the Czech Republic is higher than in Austria [11].

In this regard, research is being conducted to explore the feasibility of monitoring the temperature in bee colony nests using specialized sensors. This approach makes it possible to predict colony losses and improve their survival [12, 13].

A large number of bee breeds, or races, as well as different populations, are used worldwide. For breeding, plant pollination, and the production of beekeeping products, local bee populations (races) are mainly used, as they are better adapted to the climatic and honey flow conditions of specific regions. At the same time, changing climatic conditions facilitate the spread of bee breeds and species that were not previously native to or used in a given area [14, 15].

Beekeepers face the challenge of selecting a particular breed (race) of bees for breeding and harvesting bee products. Therefore, scientists are faced with the task of assessing specific bee populations to identify the most productive ones. For this purpose, comprehensive studies are conducted on the condition of bee colonies, their biological characteristics, and productive traits, and methods for effective bee monitoring are substantiated during different seasons of the year.

The Kaluga Region is located in central Russia and enjoys a temperate continental climate. In recent years, as elsewhere, the region has experienced changing weather conditions: average temperatures are rising, and the number of cloudy days is increasing, directly impacting bees' food supply. The Kaluga Region's overall honey resources are insignificant, so beekeeping is practiced primarily by hobbyists and a few farmers. The average apiary size is 15-16 bee colonies. The region primarily produces honey, along with a limited amount of other bee products. Until recently, beekeepers used the Central Russian (*Apis mellifera mellifera*) and Carpathian (*Apis mellifera carpatica*) bee species.

In recent years, beekeepers have increasingly begun to acquire other bee breeds adapted to warmer climates, such as the Carniolan (Krajina) bee (*Apis mellifera carnica*). The Carniolan (Krajina) bee is similar in appearance to the Carpathian bee, but is more peaceful, tends to replace queens through quiet supersedure, and does not exhibit robbing behavior. Preliminary studies conducted in the Kaluga region showed that, under favorable weather and honey flow conditions, Carniolan (Krajina) bee colonies develop intensively, actively search for food sources, and produce commercial honey within the first year of use, the sale of which fully offsets the cost of purchasing bee packages.

The objective of the study was to evaluate the development and productivity of Carniolan (Krajina) bee colonies over two consecutive summer seasons and after wintering in 2024-2025.

2 Materials and methods

Weather conditions were assessed by recording daily temperature, sunshine hours, and precipitation during the study period. The data was summarized, and the monthly and overall average values were determined. Honey flow conditions were assessed based on the species composition of entomophilous conditions and, indirectly, by the intensity of bee foraging.

The development of bee colonies was monitored during regular inspections during the warm season. For this purpose, the number of frames fully occupied by bees was recorded starting from the main spring inspection. During the summer, the date of the first supers and their total number were noted, and the number of colonies obtained from each colony was recorded. If a colony was culled, the reason for its culling was determined. Commercial honey production was determined individually for each colony by weighing the supers or brood frames containing honey. After the end of the honey flow, during a control inspection, the number of combs in the bee nests left for the autumn-winter rest period was recorded. Ten Carniolan (Krajina) bee colonies were selected for the study in May 2024. The bees were housed in standard 12- or 14-frame hives with brood frames measuring 450 x 300 mm. When the main honey flow began, supers with frames measuring 450 x 145 mm were installed on the hives.

3 Results

Data on daytime air temperature, the number of partly cloudy and sunny days (in the spring-summer seasons) and days with precipitation are shown in Table 1. Monitoring was carried out during the active period of bee activity over two years and in the autumn-winter period of 2024-2025.

Table 1. Weather conditions 2024-2025

Indicators	Spring-summer season of 2024						On average, fluctuations
	March	April	May	June	July	August	
Air temperature, °C	2.0±2.36	10.9±6.21	14.4±4.75	23.5±2.12	26.1±2.97	24.5±3.15	16.9±8.56
Min - max, °C	3.0…17.1	-0.7…21.4	5.7…23.2	20.4…32.1	20.0…32.1	18.2…29.0	-0.7…32.1
Days with precipitation	5	9	9	13	11	7	9.0±2.72
Partly cloudy and sunny days	2	8	13	8	19	19	11.5±6.18
Autumn-winter period of 2024-2025							On average, fluctuations
Indicators	October	November	December	January	February		
Air temperature, °C	12.2±4.46	3.3±3.48	1.0±2.55	1.7±3.01	-2.4±2.63		3.2±4.89
Min - max, °C	7.0…22.2	-2.0…11.1	-5.2…2.1	-4.3…7.0	-7.0…5.0		-5.2…22.0
Days with precipitation	10	9	12	9	3		8.6±3.01
	Spring-summer season of 2025						On average, fluctuations
Indicators	March	April	May	June	July	August	
Air temperature, °C	5.7±4.43	15.2±9.53	14.6±5.10	16.9±4.06	24.9±4.02	20.5±3.65	16.3±5.89
Min - max, °C	-2.5…12.5	-1.5…23.0	6.5…25.0	11.5…26.0	2.5…31.0	14.0…27.0	-2.5…31.0
Days with precipitation	11	18	17	22	16	11	15.8±3.84

Partly cloudy and sunny days	4	8	8	6	13	11	8.3±2.98

The individual development of bee colonies purchased as 4-frame bee packages during the 2024 honey flow season, as well as the amount of commercial honey obtained from them, is presented in Table 2.

Table 2. Development and honey productivity of bee colonies in the summer period of 2024.

No.	Family number	Frames of bees at the peak of honey flow, pcs.	Date of placing the first super	Number of supers installed, pcs.	Commercial honey produced, kg	Frames in hives before wintering, pcs.
1	1	12	29.06	2	18	10
2	2	12	29.06	2	24	11
3	3	12	11.07	1	13	11
4	4	14	29.06	2	32	11
5	6	12	29.06	1	9	11
6	7	14	16.07	1	23	10
7	10	14	29.06	2	29	11
8	14	12	04.07	2	35	10
9	16	12	29.06	2	33	11
10	17	14	04.07	2	30	13
Total	10	128	-	17	246	109

During the summer season of 2024, no nucleus colony production was planned from the purchased bee colonies. All colonies produced commercial honey, with individual honey yields ranging from 9 to 35 kg. No colonies were culled. All colonies had queens born the previous year.

The development and productivity of the colonies, beginning with the spring 2025 inspection, are shown in Table 3.

Table 3. Development and honey productivity of bee colonies in the summer period of 2025.

No.	Family number	Frames of bees at the peak of honey flow, pcs.	Date of placing the first super	Family number	Number of supers installed, pcs.	Nucleus colony(+); culling (-)	Commercial honey produced, kg	Frames in hives before wintering, pcs.
1	1	10	10	-	0	(-)	0	-
2	2	11	12	15.06	2	-	17	12
3	3	10	12	-	0	-	4	11
4	4	11	10/14	-	0	(+)	0/10	10/12
5	6	11	12	-	0	-	0	11
6	7	10	10/11	-	0	(-)/(+)	0	0/11
7	10	4	14	-	0	-	0	13
8	14	9	12/12	15.06	1/1	(+)	3/5	11/11
9	16	11	10/11	-	-	(+)	0/4	9/11
10	17	10	14/9	07.07/14.07	1/1	(+)	8/4	12/11
Total	10	97	173	-	6	7	55	145

The survival rate of bee colonies during the fall-winter period was 100%. The number of combs in the nests in the spring ranged from 4 to 11. During the summer season, honey yield per colony ranged from 0 to 17 kg. During the summer season, two colonies were culled,

four were divided, and one was used to produce a nucleus colony (artificial swarm). The reason for culling the colonies was the absence of a queen or poor development.

The development and productivity of a group of 10 Carniolan (Krajina) bee colonies over two summer seasons are shown in Table 4.

Table 4. Evaluation of development, growth, culling of bee colonies and yield of commercial honey

Indicators	2024	2025	2025 to 2024, % (+/-)
Number of bee colonies at the beginning of the season, pcs.	10	10	100.0
Number of frames of bees in hives, pcs.:			
- at the beginning of the season	4.0±0.00	9.7±1.85	242.5
- at the peak of the honey flow	12.8±0.98	11.5±1.54	89.8
- in the autumn	10.9±0.83	11.2±0.95	102.8
Number of supers installed, pcs.: - total	17	6	35.3
- on average per 1 bee colony	1.7±0.46	0.5±0.50	29.4
Number of nucleus colonies or swarms obtained, pcs.	0	5	+5
Culled bee colonies, pcs.	0	2	-2
Number of bee colonies at the end of the season, pcs.	10	13	130.0
Yield of commercial honey per 1 bee family existing at the beginning of the season, taking into account culling, kg	24.6±8.41	6.9±5.58	28.0

4 Discussion

The spring-summer period of 2025 (Table 1) was characterized by optimal conditions for the development of bee colonies and honey flow. A gradual increase in temperature was observed in the spring, and favorable weather and honey flow conditions were observed in the summer. The number of days with precipitation from March to August averaged 9, with 11.5 sunny or partly cloudy days. Bee colonies reached biological maturity by the beginning of the main honey flow and were actively collecting nectar and pollen. The main food sources for the bees were meadow grasses, as well as entomophilous trees and shrubs. The apiary area is free of any agricultural crops, allowing for the production of environmentally friendly honey.

The average daytime temperature during the winter months of 2024-2025 (Table 1) was 0.1°C, compared to -3.6°C during the same period last year, indicating a significant increase in daytime winter temperatures in the apiary area. Warm weather and ample supplies of high-quality food allowed the bee colonies to successfully survive the winter.

The spring season of 2025 (Table 1) was characterized by high daytime air temperatures. In April, the average air temperature was 4.3°C higher than in the previous year. In May 2025, no difference in temperature was noted. However, the number of rainy days was 1.9 times greater than in 2024. Cold weather set in in June 2025. The average air temperature was 6.6°C lower than in 2024. The number of days with precipitation reached 22. In July, the average temperature was also 1.2°C lower, and the first half of the month was characterized by rainy weather. The abnormally warm spring contributed to the intensive development of colonies at the beginning of the season, with the early manifestation of the swarming instinct. Later, bee foraging activity sharply decreased due to unfavorable weather conditions - cold and rainy weather in the first half of summer. On the rare warm days, the bees brought mostly pollen to the hives; small reserves of honey in the nests of most bee families began to appear only in mid-July.

Carniolan (Krajina) honeybee packages developed rapidly in the summer of 2024 (Table 2). By the start of the main honey flow, they occupied 12-14 frames, with 1-2 supers placed per hive, depending on the colony's strength. Ten to 13 frames were left in the nests for wintering.

Bee colonies developed well at the beginning of the summer season of 2025 (Table 3), with half of them forming colonies. In all colonies except colony No.2, the queens were replaced with young queens bred in the apiary. However, due to unfavorable weather conditions before the main honey flow, bee development slowed, and supers were placed only for three main colonies and two nucleus colonies (artificial swarms). Four main colonies and four nucleus colonies produced a small amount of commercial honey. At the end of summer, the nests of bees left for the winter contained from 9 to 12 frames.

Data on the development and productivity of bee colonies over two seasons (Table 4) indicate that favorable weather and honey flow conditions in 2024 contributed to the intensive development of 4-frame bee packages of the Carniolan (Krajina) bee breed. The number of frames in nests at the peak of honey flow increased to 12.8±0.98, with an average of 1.7 supers per nest. The yield of commercial honey amounted to 24.6±8.41 kg per bee colony. In the autumn, an average of 10.9 frames of bees and sufficient food reserves were left in the nests.

At the beginning of the 2025 honey flow season, the average number of frames in the hives was 9.7, reaching 11.5 at the peak of the honey flow. Over the course of the season, the total number of bee colonies increased to 13. Honey yield averaged 6.9 kg, which is 3.6 times less than the previous year. At the end of the 2025 honey flow season, comfortable weather set in, and late honey plants such as knapweed, sow thistle, and goldenrod began blooming, providing the bee colonies with a late honey flow and a replenishment of food reserves for the winter. The average number of frames in the hives at the beginning of autumn was 11.2.

Observation of Carniolan (Krajina) bee colonies showed that their activity is directly dependent on weather conditions and, consequently, honey flow. Unfavorable external conditions significantly reduce the growth rate of bee colonies and decrease the yield of commercial honey in the apiary.

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