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Conservation and Management of the Carniolan Honey Bee (Apis mellifera carnica) in Slovenia

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Abstract

The Carniolan honey bee (*Apis mellifera carnica*) is an indigenous Slovenian subspecies with a long tradition and considerable importance for agriculture and ecosystem functioning. In Slovenia, it is legally protected, as only this subspecies may be bred, ensuring the preservation of its genetic integrity. It is characterized by gentleness, high productivity and adaptability, traits that have contributed to its widespread use worldwide. Beekeeping is an important agricultural activity in Slovenia; more than 12,000 beekeepers manage approximately 210,000 bee colonies, evenly distributed across the country. The number of colonies and queens has increased in recent years, suggesting positive population trends and potential effectiveness of breeding and conservation measures. Beyond the production of honey and other bee products, the principal contribution of honey bees is pollination, a vital ecosystem service that supports biodiversity and agricultural productivity. Consequently, the conservation of the Carniolan honey bee is essential for sustainable agriculture, ecosystem stability, and food security.
This article examines the status, population trends, and conservation of the Carniolan honey bee (*Apis mellifera carnica*) in Slovenia based on national statistical data and registry records. Particular attention is given to its spatial distribution, breeding practices, and honey production dynamics during the period 2010–2025.

Keywords: Carniolan honey bee (*Apis mellifera carnica*); beekeeping in Slovenia; honey production; pollination; ecosystem services

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Introduction

Bees are among the most important animal pollinators and play a crucial role in agricultural production, biodiversity conservation, and ecosystem functioning. It is estimated that approximately one-third of global food production depends directly or indirectly on animal-mediated pollination, with honey bees constituting one of the most significant pollinator groups. In addition to supporting crop yields and quality, pollination services are essential for the reproduction of many wild plant species and the maintenance of ecosystem stability. The economic value of pollination substantially exceeds the market value of all bee-derived products combined, underscoring the critical importance of bees for both natural and agricultural systems. Slovenia is recognised as one of the leading beekeeping countries in Europe, characterised by a rich and long-standing apicultural tradition. Historical records indicate that beekeeping was already well established in the Slovenian territory by the seventeenth century, as documented by Janez Vajkard Valvasor in *The Glory of the Duchy of Carniola* (1689). The scientific significance of Slovenian beekeeping was further strengthened in 1770, when Giovanni Antonio Scopoli described the Carniolan honey bee in his work *Dissertatio de Apibus*. The currently accepted taxonomic designation, *Apis mellifera carnica*, was subsequently established by Pollmann in 1879. The Carniolan honey bee (*Apis mellifera carnica*) is one of Slovenia's most important indigenous animal genetic resources and represents a distinctive component of the country's natural and cultural heritage. Owing to its gentleness, strong foraging behaviour, excellent orientation abilities, and adaptability to diverse environmental conditions, it is widely regarded as one of the most valuable subspecies of the western honey bee (*Apis mellifera*). These characteristics contributed to its extensive dissemination throughout Europe during the nineteenth century and later to other parts of the world. Recognising its ecological, economic, and cultural significance, Slovenia has granted the Carniolan honey bee special legal protection and designated it as the only honey bee subspecies permitted for breeding and management within the country. Nevertheless, despite comprehensive conservation and breeding efforts, the subspecies is increasingly exposed to multiple environmental and biological pressures, including infestations by *Varroa destructor*, climate change, fluctuations in nectar and pollen availability, habitat degradation, and agricultural intensification. These factors may adversely affect colony health, productivity, and the long-term preservation of genetic diversity. Against this background, the present paper examines the role and significance of the Carniolan honey bee in Slovenia. Particular attention is given to the characteristics of its breeding and conservation programmes, population trends, beekeeping activities, and honey production. The paper also evaluates the contribution of the Carniolan honey bee to pollination services, biodiversity conservation, and food security, while discussing the principal challenges affecting its long-term sustainability and management.

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Characteristics, Legal Protection, and Breeding Management of the Carniolan Honey Bee

The Carniolan honey bee (*Apis mellifera carnica*) is distinguished by the characteristic greyish hairs covering its thorax and is widely recognised as one of the most valuable subspecies of the western honey bee (Apis mellifera). Its principal characteristics include a gentle temperament, excellent orientation ability, rapid spring population development, efficient utilisation of available forage resources, strong adaptability to diverse environmental conditions, and high honey production potential. Owing to this combination of favourable traits, the Carniolan honey bee has gained international recognition and has been widely disseminated beyond its native range (Gregori, 2012). The introduction of non-native honey bee subspecies has led to the decline or loss of indigenous honey bee populations in many parts of the world. In Slovenia, however, the native Carniolan honey bee has been successfully preserved through long-term conservation efforts. The first formal initiative aimed at protecting its genetic integrity dates back to 1920, when the Memorandum of the Museum Society for Slovenia highlighted the importance of maintaining the genetic purity of the Carniolan honey bee (Skoberne, 2020). Conservation of the subspecies has subsequently been reinforced through national legislation and international commitments. Slovenia's accession to the European Union further strengthened the institutional framework for its protection, while the Resolution on the Protection of the Carniolan Honey bee reaffirmed the country's commitment to implementing measures necessary for its long-term preservation. Today, the Carniolan honey bee is protected under the Livestock Breeding Act, which recognises it as an indigenous breed of special national importance. Accordingly, the breeding and management of honey bees in Slovenia are restricted exclusively to the Carniolan honey bee, and the introduction of other honey bee subspecies is prohibited (Livestock Breeding Act, Official Gazette of the Republic of Slovenia No. 18/2002, as amended). A central instrument for the conservation and sustainable development of the Carniolan honey bee population is the Breeding Programme for the Carniolan honey bee (Kozmus et al., 2023). The programme aims to preserve genetic integrity and diversity, maintain a viable population size, improve economically important traits, and ensure the production of high-quality breeding queens. Since 2004, a studbook (pedigree register) has been maintained as a key tool for monitoring pedigrees, evaluating breeding stock, and managing selection activities. The breeding programme is implemented through cooperation between the recognised breeding organisation, beekeepers, research institutions, and governmental authorities, thereby ensuring the long-term conservation, genetic improvement, and sustainable management of the Carniolan honey bee population in Slovenia (Figure 1 and 2).

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Figure 1: Queen bee on a honeycomb surrounded by worker bees (Photo: Tratnjek)



Figure 2: Slovenia is home to more than 10,000 architecturally distinctive apiaries, a unique feature not found elsewhere in the world, reflecting the country's rich beekeeping tradition and cultural heritage (Photo: ČZS)

Material and methods

Data on honey bee colonies, apiaries, beekeepers, queen production, pedigree queens, honey production, and honey self-sufficiency were obtained from the Central Register of Apiaries and Beekeepers maintained by the Administration of the Republic of Slovenia for Food Safety, Veterinary Sector and Plant Protection. Data on queen production and pedigree queens were obtained from the Agricultural Institute of Slovenia. Honey production and self-sufficiency data were retrieved from the Statistical Office of the Republic of Slovenia (SURS). Descriptive statistics and graphical analyses were performed using Microsoft Excel.

Results and discussion

The Carniolan honey bee population in Slovenia

According to the Central Register of Apiaries and Beekeepers, Slovenia has more than 12,000 registered beekeepers, each managing an average of 18.7 honey bee colonies. The predominant hive type is the Albert–Žnideršič hive (AŽ, 2020), which accommodates approximately 93% of all managed colonies in the country. Under the Rules on bee houses and bee yard identification (Official Gazette of the Republic of Slovenia, No. 117/2008), beekeepers are required to report the number of colonies they manage to the Central Apiary Register twice annually, on 15 April and 31 October. During the period 2015–2024, the average number of honey bee colonies recorded in Slovenia was 191,548 (Agricultural Institute of Slovenia, 2025). Honey bee colonies are distributed throughout the national territory; however, their spatial density exhibits considerable geographic variation. Higher colony densities are

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typically observed in valleys and foothill regions, whereas lower densities occur in remote and extensively forested areas. With an average density of approximately 7.5 colonies per square kilometre, Slovenia ranks among the European countries with he highest densities of managed honey bee colonies (ČZS, 2025). Maintaining a sufficiently large and spatially well-distributed population of honey bee colonies therefore represents one of the principal objectives of the Resolution on the Protection of the Carniolan honey bee (*Apis mellifera carnica*) (Official Gazette of the Republic of Slovenia, No. 18/2014, as amended).

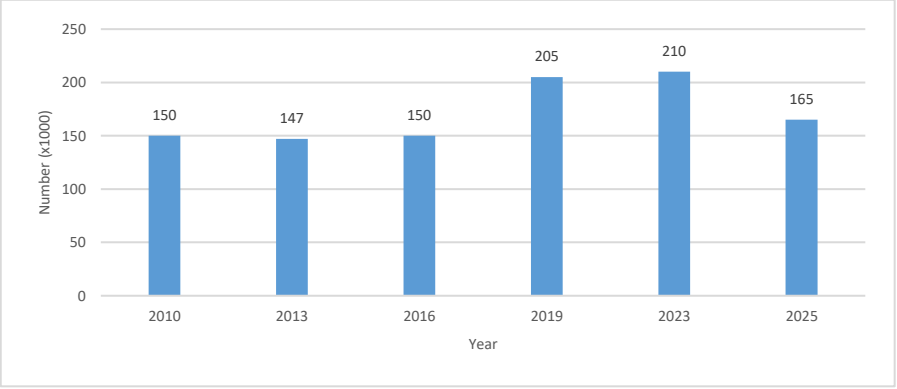


Figure 3. Number of Carniolan honey bee colonies in Slovenia, 2010–2025 (Register ..., 2025).

Figure 3 presents trend in the number of Carniolan honey bee colonies in Slovenia between 2010 and 2025. The data reveal a clear long-term upward trend, with colony numbers increasing from approximately 150,000 in 2010 to more than 210,000 in 2023. This increase reflects the strong tradition of beekeeping in Slovenia, the successful conservation and management of the Carniolan honey bee, and the continued interest of beekeepers in maintaining and expanding their apiaries. The fitted trend line further corroborates the overall growth of the population throughout the study period. A pronounced decline is apparent in the 2025 data. However, this decrease should not be interpreted as evidence of an actual reduction in the Carniolan honey bee population. Rather, it is primarily attributable to a lower reporting rate to the Central Apiary Register (Administration…, 2025). As substantially fewer beekeepers submitted colony records in 2025 compared with previous years, the reported number of colonies is likely underestimated and therefore not directly comparable with earlier observations. When this reporting-related artefact is taken into account, the data indicate that the Carniolan honey bee population in Slovenia has remained stable and has generally exhibited positive growth over the past decade.

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Queen breeding and registered pedigree queens of the Carniolan honey bee in Slovenia

Queen breeding constitutes a fundamental component of modern apiculture and plays a crucial role in preserving the desirable phenotypic characteristics and genetic integrity of the Carniolan honey bee (*Apis mellifera carnica*). In Slovenia, queen breeding is conducted at officially approved breeding stations operating within the framework of the national breeding programme. At present, 36 registered breeding stations are actively involved in queen production.

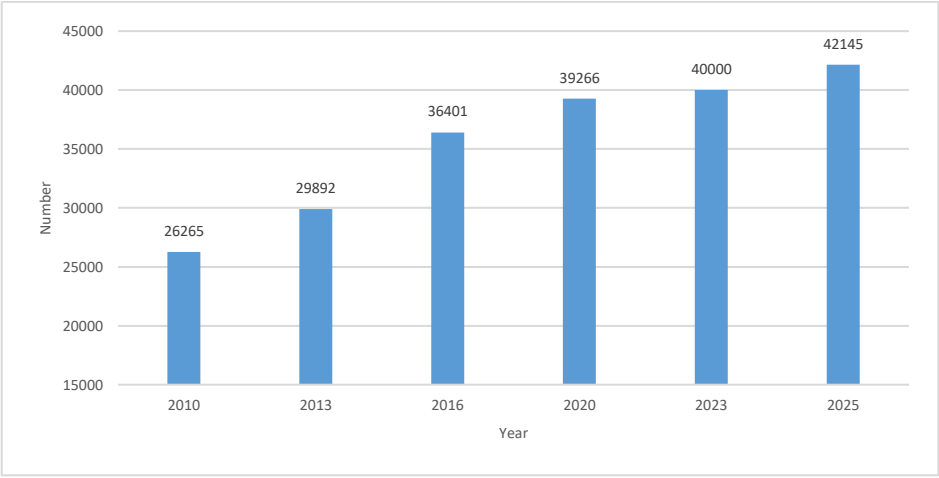


Figure 4. Trends in the production of Carniolan honey bee queens in Slovenia, 2010–2025 (Agricultural…, 2026)

Figure 4 illustrates temporal trends in the production of Carniolan honey bee queens in Slovenia between 2010 and 2025. The data reveal a pronounced long-term increase in queen production, despite several short-term fluctuations. Following a production peak in 2019, the number of queens produced temporarily declined before recovering in subsequent years. Nevertheless, the overall positive trend indicates the sustained success of organised queen-rearing activities and underscores the importance of structured breeding programmes for the conservation, genetic improvement, and long-term sustainability of the Carniolan honey bee population in Slovenia. Registered pedigree queens constitute the cornerstone of both genetic improvement and conservation efforts. Their production is based on the rigorous selection of breeder colonies exhibiting desirable morphometric, behavioural, and production-related characteristics. The selection process is coordinated and supervised by the Slovenian Beekeeper`s Association (ČZS, 2025) in cooperation with the Agricultural Institute of Slovenia (Agricultural…, 2025)

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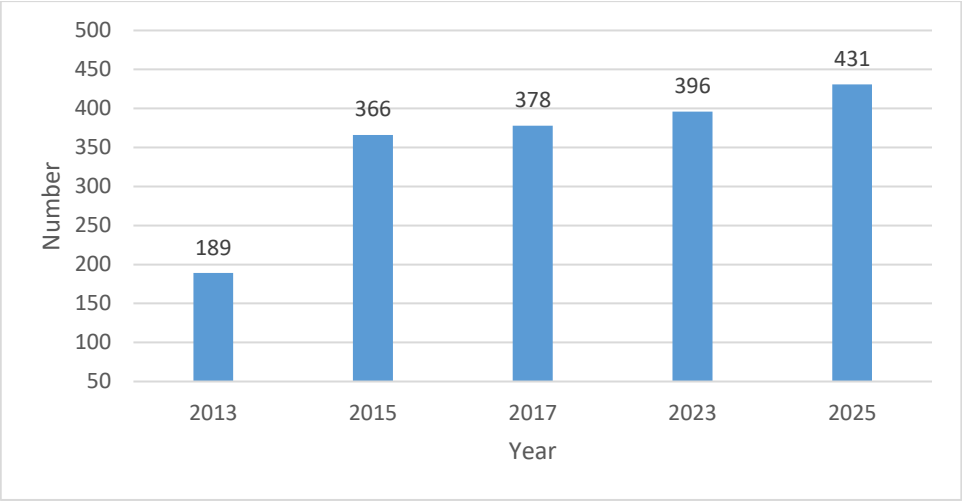


Figure 5. Number of registered pedigree queens of the Carniolan honey bee in Slovenia, 2013–2025 (Agricultural…, 2026)

Figure 5 presents the number of registered pedigree queens between 2013 and 2025. Although substantial interannual variation was observed throughout the study period, the overall trend indicates a gradual increase in production, culminating in 2025. This development reflects the continued strengthening of organised breeding activities and the growing emphasis placed on the conservation and genetic improvement of the Carniolan honey bee.

Number of bee keepers in Slovenia

Slovenia has a long-standing and well-developed beekeeping tradition, reflected in the continuous growth of its beekeeping community. In contrast to the overall declining trend observed across the European Union, the number of Slovenian beekeepers has increased by approximately 30% in recent years, accounting for around 1.1% of all beekeepers in the EU (World Bee Day, 2018). On average, Slovenian beekeepers manage approximately 16 honey bee colonies, although a smaller proportion of professional and semi-professional beekeepers operate considerably larger apiaries.

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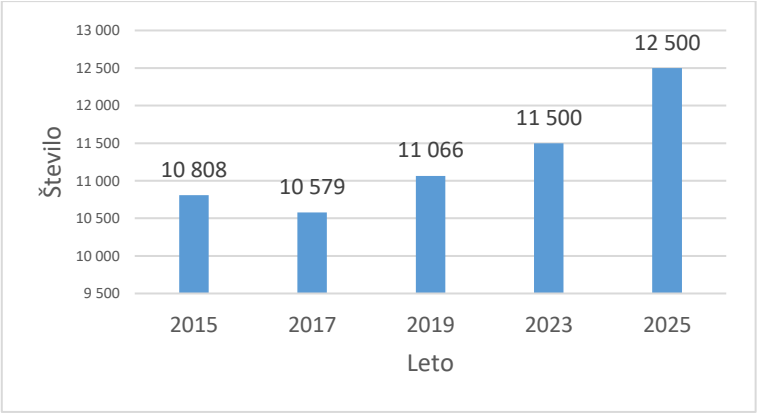


Figure 6. Number of beekeepers in Slovenia, 2015–2025 (Agricultural…, 2026)

Figure 6 illustrates trends in the number of registered beekeepers in Slovenia between 2015 and 2025. Throughout the study period, the number of registered beekeepers exceeded 12,000, corresponding to approximately five to six beekeepers per 1,000 inhabitants. The data reveal a consistent upward trend, indicating sustained interest in beekeeping and reaffirming the importance of apiculture within Slovenian society. The observed increase in beekeeper numbers may be attributed to a combination of favourable institutional support, targeted educational and promotional activities, and growing public awareness of the ecological and economic importance of pollinators. More broadly, these trends underscore the continuing role of beekeeping not only as an agricultural activity but also as a significant cultural and socio-economic component of Slovenia's rural landscape and national heritage.

Geographical distribution of the Carniolan honey bee in Slovenia

During the period 2015–2024, an average of 191,548 honey bee colonies and approximately 14,000 apiaries were registered in Slovenia, distributed throughout the country.

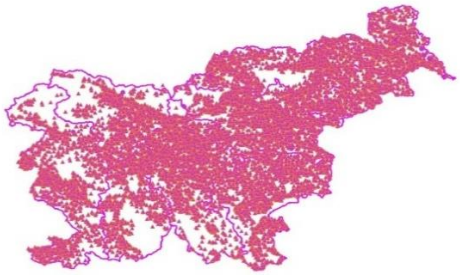


Figure 7. Geographical distribution of apiaries with the Carniolan honey bee in Slovenia (Administration…, 2025)

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Figure 7 presents the spatial distribution of registered apiaries housing the Carniolan honey bee in Slovenia. Individual points represent apiary locations recorded in the national register and reveal a dense and widespread distribution across the national territory. Apiaries are present in all regions of the country, indicating that beekeeping is a well-established and geographically extensive agricultural activity. The highest concentrations of apiaries occur in lowland, hilly, and agriculturally productive areas, particularly in central, eastern, and southeastern Slovenia. In contrast, lower apiary densities are evident in the Alpine region and in sparsely populated mountainous and heavily forested areas, where environmental conditions, land use patterns, and accessibility may be less favourable for beekeeping activities. The observed spatial pattern reflects both the long-standing apicultural tradition of Slovenia and the suitability of much of the country for honey bee management. Furthermore, the broad geographical distribution of apiaries contributes to the maintenance of a well-dispersed population of the Carniolan honey bee, thereby supporting pollination services, genetic connectivity among populations, and the long-term conservation of this indigenous subspecies. Overall, the near-nationwide distribution of apiaries highlights the ecological, agricultural, and socio-cultural importance of beekeeping within Slovenia.

Honey Production 2010–2025

Slovenian beekeepers produce honey protected by a Protected Geographical Indication (PGI), which certifies both its geographical origin and compliance with defined quality standards. Slovenian honey obtained national protection in 2008 and was subsequently granted European Union protection in 2013. Producers participating in the PGI scheme are subject to stringent quality control procedures, and honey marketed under the protected label must comply with relevant national and European legislation governing honey quality, authenticity, and traceability (ČZS, 2025). Honey consumption in Slovenia remains relatively stable and averages approximately 1.4 kg per capita annually.

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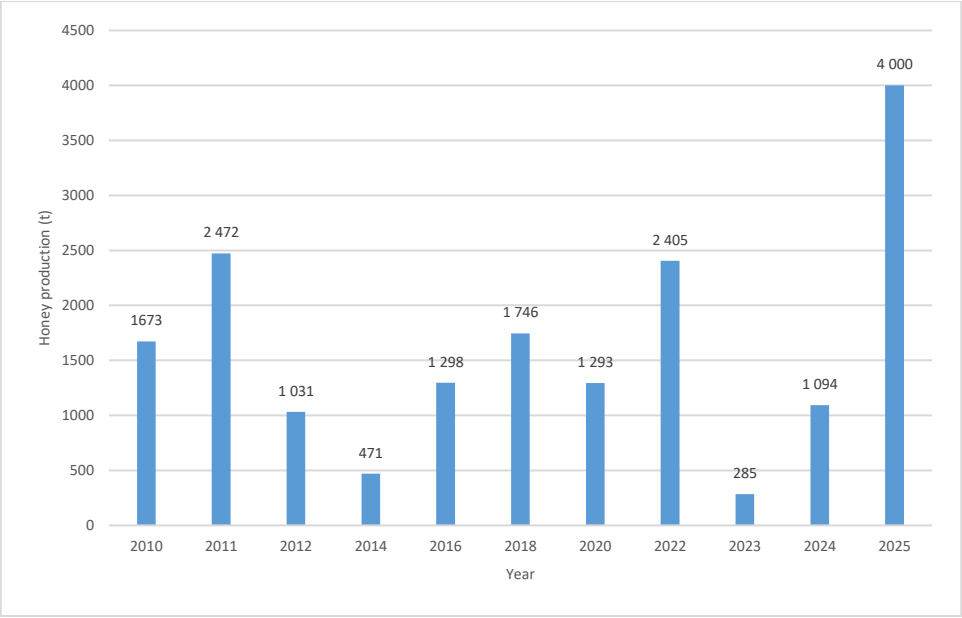


Figure 8. Honey Production in Slovenia over the period 2010–2025 (SURS, 2026)

Figure 8 presents annual honey production in Slovenia between 2010 and 2025. The results reveal considerable interannual variability, reflecting the strong influence of climatic and environmental conditions on honey yields. The highest production during the observed period was recorded in 2011 (2,472 tonnes), while the lowest occurred in 2023 (285 tonnes). Honey production was also exceptionally high in 2022, approaching the record level achieved in 2011. Following the poor harvest in 2023, production recovered substantially in 2024. According to provisional estimates of the Statistical Office of the Republic of Slovenia (SURS, 2026), honey production reached approximately 4,000 tonnes in 2025, representing one of the highest yields recorded in recent decades. This exceptional harvest was largely attributed to favourable weather conditions, abundant nectar flows, and extended foraging opportunities. However, the data for 2025 are preliminary and should be interpreted with caution. Overall, the results demonstrate that honey production in Slovenia is highly dependent on environmental conditions. Despite relatively stable colony numbers and continued growth of the beekeeping sector, annual honey yields remain strongly influenced by climatic variability and nectar availability.

Honey self-sufficiency in Slovenia, 2005–2025

Honey consumption in Slovenia has remained relatively stable over the past two decades, averaging slightly above 1 kg per capita annually. In contrast, the honey self-sufficiency rate has shown marked interannual variability, primarily driven by

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fluctuations in domestic honey production linked to climatic and environmental conditions. Periods of favourable weather and abundant nectar availability have supported high levels of self-sufficiency, whereas adverse conditions have led to reduced domestic yields and increased dependence on imports. This was particularly evident in 2014 and 2021, when domestic production did not meet national demand. In subsequent years, honey production recovered significantly, most notably in 2022 and again in 2025, resulting in a substantial improvement in the self-sufficiency rate. The exceptionally high level recorded in 2025 indicates that domestic production exceeded national consumption requirements, generating a production surplus. Overall, these patterns highlight the strong dependence of Slovenia's honey sector on annual harvest outcomes and underscore the dominant influence of climatic variability on the country's ability to meet domestic demand through local production.

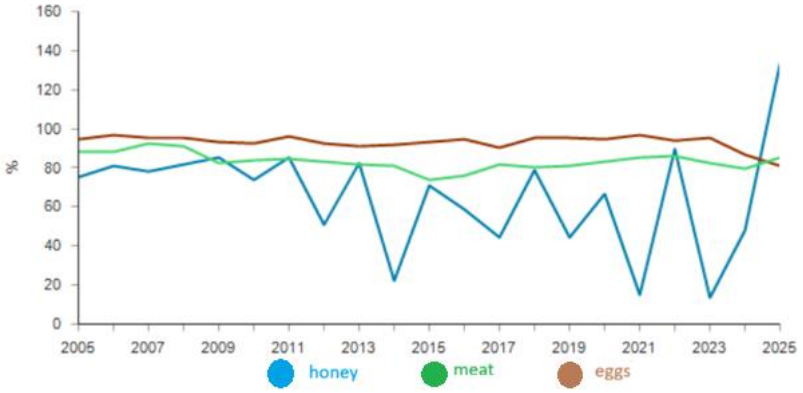


Figure 9. Self-sufficiency rate in honey production in Slovenia, 2005–2025 (SURS, 2026)

Figure 9 compares self-sufficiency rates for honey, meat, and eggs in Slovenia between 2005 and 2025. While meat and egg self-sufficiency remain relatively stable over time, honey shows considerably greater fluctuations. These variations reflect the strong dependence of honey production on weather conditions, nectar availability, and other environmental factors. Overall, the graph highlights the high variability of honey self-sufficiency compared to the much more consistent trends observed for other livestock products.

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Conclusion and recommendation

The Carniolan honey bee (*Apis mellifera carnica*) represents one of Slovenia's most valuable indigenous animal genetic resources and a cornerstone of the country's long-standing beekeeping tradition. The results of this study indicate a generally positive development of the Slovenian beekeeping sector over the past decade, reflected in increases in the number of honey bee colonies, registered beekeepers, and pedigree queen production. These trends demonstrate the effectiveness of existing conservation and breeding programmes and confirm the continued vitality of beekeeping in Slovenia. The widespread spatial distribution of apiaries across the country further highlights the extensive geographical presence of beekeeping and contributes to a well-dispersed honey bee population. At the same time, the results reveal substantial interannual variability in honey production and honey self-sufficiency, primarily driven by climatic and environmental conditions that affect nectar availability and foraging opportunities. This highlights the sensitivity of honey production to annual weather patterns, despite the relative stability of colony numbers. The exceptionally high honey yield recorded in 2025 illustrates the production potential of the sector under favourable conditions, whereas poor harvest years demonstrate its vulnerability to adverse climatic events. Future sustainability of the Slovenian beekeeping sector will therefore depend not only on continued conservation and breeding efforts, but also on adaptation to increasing environmental variability associated with climate change. Beyond its economic role, the Carniolan honey bee provides essential pollination services that support agriculture, biodiversity, ecosystem functioning, and food security. Ensuring the long-term preservation of its genetic integrity, maintaining a sufficiently large and well-distributed population, and improving forage availability and environmental resilience remain key priorities for its sustainable management.

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