BinBee Arı ve Doğal Ürünler Dergisi, 2025, 5(2),26-36
Journal of BinBee - Apicultural and Natural Products (JBANP)

The Importance of *Astragalus* Species in Bee Nutrition

Sıraç Yavuz*

Bingöl University, Faculty of Agriculture, Animal Science Department, Bingöl, Türkiye

Article info
Received: 28.10.2025
Accepted:18.11.2025

Article type: Research

Keywords: Honeybees, *Astragalus*, Bee nutrition, Beekeeping statistics, Protein, Pollen

Abstract

Honeybees (*Apis mellifera*) are insects belonging to the *Apidae* family of the order *Hymenoptera*. Hives consist of a queen bee, worker bees, and drones; foraging worker bees collect nectar, pollen, water, and resin at 21 days old. Colonies consist of 20,000-80,000 individuals, and communication occurs through a waggle dance. Bee products include beewax, propolis, royal jelly, and venom. They are nourished by pollen, nectar, oils, amino acids, vitamins, and minerals; deficiencies can impair hive health. There are 33 subspecies of honeybees worldwide, reaching 111 million colonies. Turkey ranks third in the world with 9.2 million colonies. Bees provide 80% of agricultural pollination but also compete with native pollinators. According to 2023 data for global beekeeping, the number of colonies reached 102 million, honey production reached 1.89 million tons, and yield per hive reached 18.56 kg. In Türkiye, between 2018 and 2023, the number of farms increased by 22.7% to 100,399, the number of colonies reached 9.2 million, and honey production increased by 6.4% to 114,889 tons; however, yield decreased to 12.45 kg. This study examines the importance of *Astragalus*, a plant from the *Fabaceae* family, in beekeeping. Astragalus are perennial plants adapted to arid environments with their nitrogen-fixing roots. Their nectar is 70-76% carbohydrate, and their pollen is rich in protein and lipids. They support bee colonies and boost immunity. In addition to honeybees, species such as Bombus spp. also feed on this plant. *Astragalus* flowers are adapted to bee pollination and are the primary food source in the early seasons. They have a variety of uses, including cosmetics, pharmaceuticals, animal feed, and fuel. Species facing extinction due to climate change and grazing should be protected. Important species such as *Astragalus atropilosulus*, *amblolepis*, and *aureus* attract honeybees, bumblebees, and other solitary bees, encouraging mutualism.In regions experiencing food scarcity, beekeeping improves bee health, and habitat protection and planning are recommended. *Astragalus* species make beekeeping sustainable and maintain ecosystem balance.

Citation: Yavuz, S. (2025). The Importance of *Astragalus* Species in Bee Nutrition. Journal of BinBee-Apicultural and Natural Products (JBANP), 2025, 5(2), 26-36.

Geven (*Astragalus*) Türlerinin Arı Beslemesindeki Önemi

Makale bilgileri
Geliş Tarihi:28.10.2025
Kabul Tarihi:18.11.2025

Makale türü: Araştırma

Anahtar kelimeler: Bal arıları, Geven, Arı beslenmesi, Arıcılık istatistikleri, Protein, Polen

Özet

Bal arıları (*Apis mellifera*), *Hymenoptera* takımının *Apidae* familyasına ait böceklerdir. Kovan yapıları ana arı, işçi arı ve erkek arılardan oluşur; yiyecek arayan işçi arılar 21 günlük iken nektar, polen, su ve reçine toplarlar. Koloniler 20.000-80.000 birey içerir ve iletişimleri sallanma dansı ile gerçekleşir. Arı ürünleri arasında balmumu, propolis, arı sütü ve arı zehri bulunur. Beslenmeleri polen, nektar, yağlar, amino asitler, vitaminler ve minerallerden karşılanır; eksiklikleri kovan sağlığını bozar. Dünya çapında 33 alt arı türü bulunan bal arıları 111 milyon koloniye ulaşmıştır. Türkiye 9,2 milyon koloni ile dünyada üçüncü sıradadır. Arılar tarımsal tozlaşmanın %80'ini sağlarlar, ancak yerli tozlayıcılarla da rekabet halindedirler. Dünya arıcılığında 2023 yılı verilerine göre koloni sayısı 102 milyona, bal üretimi 1,89 milyon tona ve kovan başına verim 18,56 kg'a ulaşmıştır. Türkiye'de ise 2018-2023 yılları arasında işletme sayısı %22,7 artarak 100.399'a, koloni sayısı 9,2 milyona, bal üretimi ise %6,4 artarak 114.889 tona ulaşmış; ancak verim 12,45 kg'a düşmüştür. Bu çalışma, Fabaceae familyasından geven (*Astragalus*) bitkisinin arıcılıktaki önemini incelemektedir. Gevenler, azot sabitleyici kökleri ile kurak ortamlara adapte olmuş çok yıllık bitkilerdir. Nektarları %70-76 karbonhidrattır ve polenleri protein ve lipit açısından zengindir. Arı kolonilerini destekler ve bağışıklığı artırır. Bal arılarına ek olarak, Bombus spp. gibi türler de bu bitkiden beslenir. Geven çiçekleri arı tozlaşmasına adapte olmuş ve erken sezonlarda ilk besin kaynağıdır. Kozmetik, ilaç, hayvan yemi ve yakıt dahil olmak üzere çeşitli kullanım alanları vardır. İklim değişikliği ve otlatma nedeniyle nesli tükenmekte olan türler korunmalıdır. *Astragalus atropilosulus*, *amblolepis* ve *aureus* gibi önemli türler bal arılarını, bombus arılarını ve yalnız gezen diğer arıları çekerek mutualizmi teşvik eder. Gıda kıtlığı yaşanan bölgelerde arıcılık, arı sağlığını iyileştirir; habitat koruma ve planlama önerilmektedir. Geven türleri, arıcılığı sürdürülebilir kılmakta ve ekosistem dengesini korumaktadır.

Atıf: Yavuz, S. (2025). The Importance of *Astragalus* Species in Bee Nutrition. Journal of BinBee-Apicultural and Natural Products (JBANP), 2025, 5(2), 26-36.

* Sorumlu yazar, Sıraç YAVUZ, Bingöl University/Faculty of Agriculture/Animal Science Department, Bingöl, Türkiye, siracyavuz@bingol.edu.tr, ORCID: 0000-0001-5878-8994

1. Introduction

Honeybees (*Apis mellifera*), social insects belonging to the *Apidae* family of the *Hymenoptera* order, are extremely important in terms of their roles in ecosystems and their position in human nutrition. *A. mellifera*, a social member of the *Apidae* family, is a species that provides critical pollination services in agricultural and natural ecosystems. The biological, ecological, and behavioral characteristics of this species are closely linked to human activities and play an indispensable role in global food security. In terms of hive structure, it consists of three groups: the queen, worker bees, and drones. Foragers are worker bees that live for more than 21 days, and at the end of this period, they move on to perform extra-colonial tasks such as collecting water, nectar, pollen, or resin [1]. A hive typically consists of 20,000 to 80,000 bees and is characterized by social behavior. The anatomy of bees includes legs, antennae, and mouthparts adapted for collecting pollen and carrying nectar. Beewax is a substance secreted by abdominal glands, used for comb construction, food storage, and temperature regulation; its composition consists of alkanes, fatty acids, and esters. Propolis, a material collected from plant resins, seals the hive and provides antimicrobial protection; its composition includes 50% resin, 30% beewax, and essential oils. Royal jelly, on the other hand, is a nutrient secreted by the hypopharyngeal glands of worker bees, which regulates caste differentiation; it contains water (60-70%), protein (9-18%), and sugars (7-18%). Bee venom is a toxin containing polypeptides like melittin, and its composition varies depending on ecological factors. Bees travel over 3 km to discover food and can cover an area

of 100 km². Their communication is achieved thru a waggle dance, which informs the hive of the location of food sources [2]. Feeding bees is critically important for their nutrition, hive health, reproduction, and productivity. Pollen is a major source of protein in bee feed. The crude protein content varies from 2.5% to 61%. Feeding with multi-floral pollen optimizes hive growth and increases resistance to pathogens. Carbohydrates are taken in the form of sucrose, glucose, and fructose, which are also obtained from plant and flower nectars. The ideal sugar concentration is in the range of 35-65%. Fats are provided by bees from pollen at a rate of 0.8-18.9% and are necessary for cell membranes and metabolism. Foods containing 4-8% fat in their composition have a positive effect on increasing pup production. Amino acids, vitamins, and minerals are obtained from pollen and royal jello. Water is needed for osmotic balance, feeding, honey production, and hive cooling. Nutritional deficiencies in food reduce hive longevity and increase parasitic susceptibility [3]. There are 33 different subspecies of honeybees in Europe, Africa, and Western Asia and the Middle East [4]. Honeybees have a strong foraging orientation and exhibit high performance in the production of honey and other bee products. It is estimated that there are approximately 111,515,297 colonies of honeybees in the world. The number of countries providing these figures to FAO thru their official statistical institutions is 47. The others were determined based on values reported for the number of colonies in previous years and estimated [5] . With 9,224,881 colonies, Türkiye ranks third after the People's Republic of China and India. So, globally, they have approximately 8.27% of the world's beehives. Astragalus, a plant from the Fabaceae family, in beekeeping. Astragalus are perennial plants adapted to arid environments with their nitrogen-fixing roots. Their nectar is 70-76% carbohydrate, and their pollen is rich in protein and lipids. They support bee colonies and boost immunity.

Honeybees as general pollinators, they interact with hundreds of plant species in natural areas; they account for 13% of floral visits in natural ecosystems and pollinate 5% of some plants. They provide 80% of agricultural pollination globally, resulting in a 20% increase in almond yield and an 80% increase in kiwi yield. However, they compete with native pollinators in natural areas and can affect biodiversity [6]. The current study focuses on the importance of the astragalus plant, which belongs to the Fabaceae family and has approximately 439 species in Türkiye, in the field of beekeeping and nutrition.

2. Global Beekeeping

The global spread of beekeeping dates back to ancient times, with some species being exported worldwide in the 18th-19th centuries, creating a commercial boom. Beekeeping represents an integrated agricultural and economic activity encompassing the raising, management, production, trade of bee products, and related ecosystem services. The global beekeeping sector is of critical importance in terms of ecosystem services, agricultural productivity, and biodiversity. In developed countries, it shows that it plays a role as an industrial sector. It contributes to global food security by impacting agricultural production thru pollination services. It is integrated with the sustainable development goals. The data presented in Table 1 reflects key indicators such as the number of colonies worldwide, honey production, beewax production, and honey yield per hive, covering the period from 2019 to 2023. This data is compiled from reports by the Food and Agriculture Organization of the United Nations (FAO) and can be evaluated in the context of beekeeping sustainability, climate change impacts, and economic dynamics.

The number of colonies is an indicator that directly represents the scale and capacity of the beekeeping sector. According to the data, the global hive count, which was 93,495,376 in 2019, increased to 102,058,674 in 2023. This indicates an increase of approximately 9.2% over the five-year period. The slight decline observed, especially in 2020, can likely be attributed to supply chain disruptions caused by the COVID-19 pandemic and the impact of bee diseases. However, the recovery and steady increase observed since 2021 can be interpreted as a reflection of improvements in beekeeping policies, bee population protection programs, and developing beekeeping investments. Honey production is a key metric for measuring the economic output of beekeeping, and in 2019 it was 1,766. Global production, which was 420 tons, reached 1,893,805 tons in 2023. This indicates an annual compound growth rate of approximately 1.8%. The steady increase in production is linked to a parallel rise in the number of colonies. However, the slight fluctuations in the 2020-2021 period reflect the impact of climatic factors and fluctuations in pollinator populations. Beewax production, as a byproduct of beekeeping, is important in cosmetic, pharmaceutical, and industrial applications. The data shows that production increased from 62,621 tons in 2019 to 65,036 tons in 2023, with the overall trend indicating a slight increase. However, a decline to 62,166 tons in 2020 and an unstable recovery in subsequent years have been observed. These fluctuations are highly correlated with honey production and are caused by variations in hive health and nectar flow. The relatively low growth rate of beewax production reflects the honey-focused

commercial structure of the beekeeping sector and necessitates the development of sustainable resource management strategies.

Honey yield per hive, as an indicator of beekeeping efficiency, measures the effectiveness of management practices, genetic improvements, and environmental factors. The value of 18.89 kg/hive in 2019 showed a slight decrease to 18.56 kg/hive in 2023, with a five-year average of approximately 18.57 kg/hive. Fluctuations in this metric indicate the negative effects of climate change on bee foraging behavior. The yield decline is particularly evident in 2021 and is likely associated with stress factors caused by global warming. This situation highlights the importance of adaptation strategies in beekeeping and should be considered in long-term modeling. It shows that the global beekeeping sector is generally trending toward growth, but there have been slight fluctuations in productivity metrics. While the increase in hive numbers and honey production demonstrates the sector's resilience, yield declines reflect the growing impact of environmental threats. In conclusion, sustainable beekeeping practices are an indispensable element in the preservation of global biodiversity and food systems.

Table 1. Worldwide beekeeping statistics [5]

Year	Number of Colonies (Units)	Honey Production (Tons)	Wax Production (Tons)	Honey Yield (Kg/hive)
2023	102.058.674	1.893.805	65.036	18.56
2022	100.996.303	1.830.768	65.063	18,13
2021	101.624.052	1.771.944	65.046	17,44
2020	93.999.656	1.770.119	62.166	18,83
2019	93.495.376	1.766.420	62.621	18,89

2.1. Honeybee Nutrition

Bees like all living species, also need essential nutrients to survive and reproduce. The natural food sources of honeybees consist mainly of nectar, honey, and pollen. After being collected from flowers by worker bees, nectar undergoes physical and chemical transformations in the bees' enzymatic digestive systems and in the honeycomb cells within the hive, turning into honey; this honey is stored in the honeycomb cells for long-term storage. Nectar and honey are consumed to meet the energy requirements of the bee hive. Adult bees can sustain their vital functions by consuming honey alone. However, pollen consumption is essential for rearing young in the hive and for the full development of newly emerged young bees.

Adult honey bees need approximately 4 mg of usable sugar per day to survive [7] and meet their carbohydrate requirements from flower nectar [8]. They obtain their water needs from water sources around the apiary or from nectar. Worker bees, which are the most numerous in the hive, consume approximately 3.4-5.4 mg of pollen per day, depending on their age and task, which corresponds to a daily protein intake of 0.7-1.2 mg based on the protein content in pollen (20-23%). The average protein requirement is approximately 0.7 mg per day [3-9].

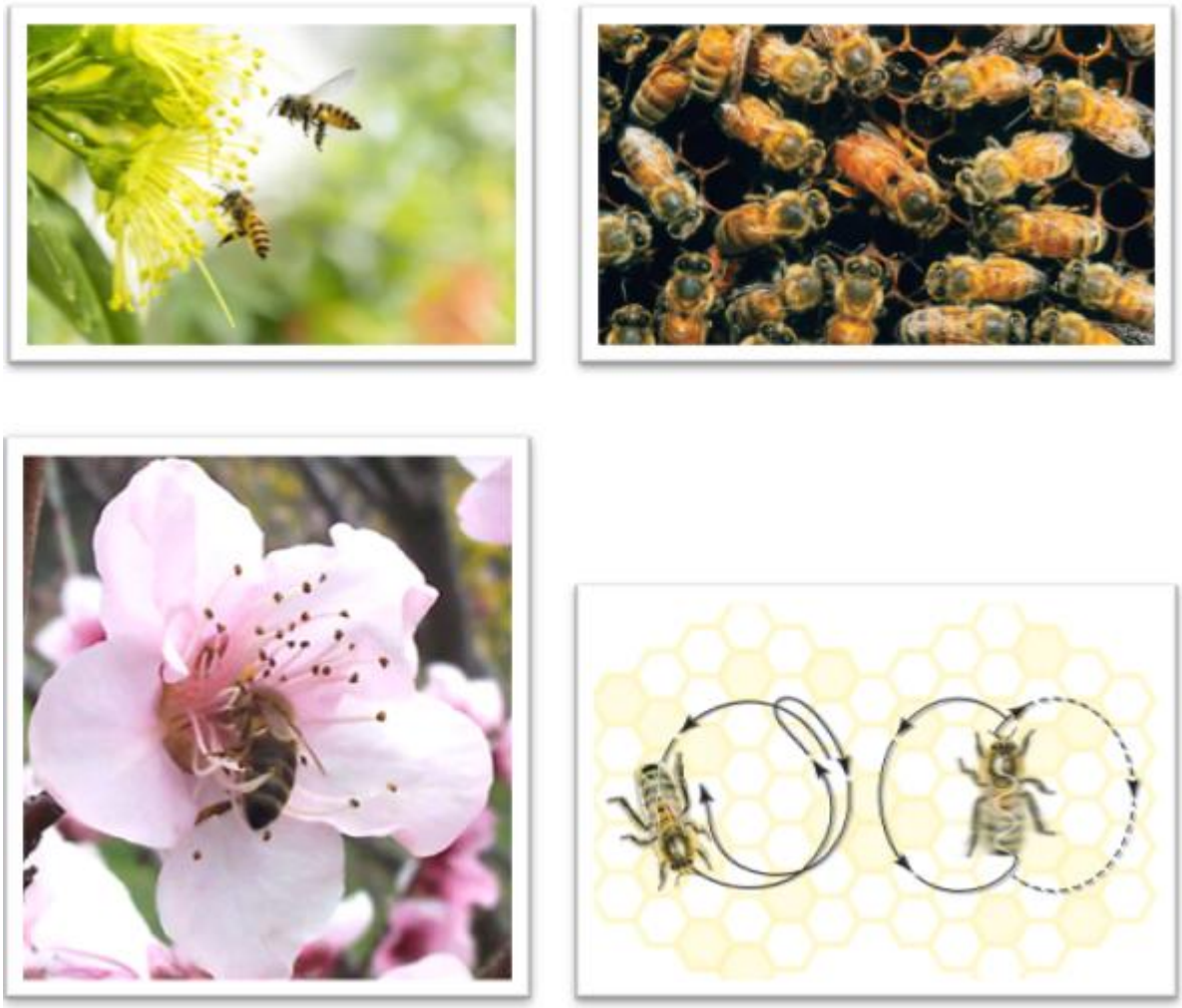

Fig. 1. The feeding of honeybees on plants and their source location communication

Pollen is a fundamental source that meets the macro and micro nutritional needs of bees, such as protein, vitamins, fatty acids, and minerals. No matter how abundant the honey supply in the hive may be, brood production is significantly limited or completely halted in the absence of pollen; this slows down or prevents the hive's population growth. On the other hand, even if pollen is abundant in the comb cells, if the honey supply is insufficient or there is no external nectar flow (if natural sources are depleted or supplemental feeding is not provided), bees face the risk of mortality due to starvation. Unlike other farm animals, honeybees do not require a continuous and regular feeding regime; natural nectar flows and existing stocks are usually sufficient. However, artificial feeding should be applied in cases requiring urgent intervention due to environmental stress factors or seasonal shortages. The main scenarios in which hive feeding is recommended are as follows [10].

Autumn Stimulatory Feeding: Autumn stimulatory feeding is implemented when it is determined that bees have not stored sufficient honey for the winter period, with the aim of enhancing the hive's survival rate. Generally, bees produce adequate honey; however, some producers fail to leave enough reserves within the hive to sustain the hive through the winter months. Consequently, supplemental feeding is applied in the autumn.

Spring Stimulatory Feeding: Spring stimulatory feeding is conducted for colonies that have survived the winter to stimulate the queen's oviposition activity prior to the main nectar flow, thereby strengthening the worker bee population and maximizing overall hive strength. Producers typically prepare syrups from sugar and water for this purpose.

Emergency Starvation Intervention: Emergency starvation intervention is applied in situations where nectar collection activities are interrupted due to spring delays, adverse weather conditions during the nectar flow (such as rainy or cold periods), or other environmental constraints, in order to mitigate the risk of hive starvation.

These feeding strategies constitute indispensable components of integrated beekeeping practices, designed to optimize hive health and facilitate efficient honey production. During feeding operations, the use of controlled materials such as sugar syrup or pollen supplements must adhere to specific standards to minimize the risk of contamination. *Astragalus* species rank among the important forage plants for pollinators, particularly bees. Their nectar serves as a carbohydrate-rich energy source, while their pollen supplies essential proteins, lipids, and micronutrients that are vital for larval development and the vitality of adult bees. This is particularly evident in habitats characterized by low plant diversity or limited seasonal floral resources, such as mountainous regions, where *Astragalus* has been observed to support bee populations and biodiversity [11]. *Astragalus* provides colonies with high-quality nectar and pollen; the protein-rich pollen aids in brood growth and immunity, whereas the nectar delivers sugars. Research indicates that honeys derived from *Astragalus* nectar contain 70–76% carbohydrates and 16–21% water, along with beneficial physicochemical properties, underscoring the nutritive quality of this nectar source. In addition to honey bees, other bees such as bumblebees (*Bombus spp*.) and solitary bees like *Anthophora* and *Anthidium* frequently forage on this plant [12-13].

2.2. *Astragalus* and its species

Astragalus species are typically perennial herbs or shrubs adapted to harsh and arid environments, featuring deep roots that facilitate nitrogen fixation, thereby conferring benefits to surrounding ecosystems and pollinators. Their flowers are adapted for entomophilous pollination and generally possess mechanisms that promote pollen release during bee visitation, thereby facilitating efficient cross-pollination. Many species are dependent on bees for reproduction, exhibiting obligate or facultative outcrossing tendencies that foster mutualistic interactions [14-15].

Astragalus species hold significant value in regions such as Europe, Asia, and parts of North America, where they provide essential forage during early seasons when alternative resources are scarce. Various species of this plant are widely utilized in cosmetics, as well as in teas, coffee, herbal gums, and animal feed; they also feature prominently in folk medicine and nutritional supplements. In areas characterized by sparse vegetation and the absence of trees, such shrubby plants assume critical importance. These plants fulfill numerous stabilizing functions, including soil protection, mitigation of wind and water erosion, avalanche prevention, and overall soil conservation. In rural regions devoid of trees, *Astragalus* serves as the primary fuel source. Certain species possess taproots extending up to approximately 11 meters, which are harvested for fuel. This resource enables communities to endure severe winter conditions. From an ecological perspective, *Astragalus* provides honey bees with nectar and pollen sources via its flowers, while serving as a roughage substitute in livestock nutrition and fulfilling a fuel role through its extensive roots. Numerous *Astragalus* species are rare or endangered. They face threats from uprooting, overgrazing, and climate change, which in turn constrain bee foraging resources. Conservation of these species preserves pollinator habitats, enhances pollination services, and sustains broader ecosystems. It is known that some species contain toxins that primarily affect livestock, with minimal impact on bees [16].

The *Astragalus* species most frequently visited by honey bees [11-17-18-19]:

- *Astragalus atropilosulus*
- *Astragalus amblolepis*
- *Astragalus aureus*
- *Astragalus angustifolius*
- *Astragalus beypazaricus*
- *Astragalus cinereus*
- *Astragalus compactus*
- *Astragalus declinatus*
- *Astragalus filipes*
- *Astragalus holmgreniorum*
- *Astragalus gummifer*
- *Astragalus lineatus*
- *Astragalus longifolius*
- *Astragalus monoensis*
- *Astragalus oocephalus*
- *Astragalus onobrychis*
- *Astragalus phoenix*

The *Astragalus* plant is visited by bees during its flowering period (Fig. 2 and Fig. 3), consumed by other animals during grazing in the maturation phase, and in autumn, its stems and roots are utilized both as roughage and as fuelwood.

Fig. 2. Flowering stage of some astragalus species for bee nutrition

Fig. 3. *Astragalus beypazaricus*

3. Beekeeping Statistics in Türkiye

Türkiye, as the world's third largest honey-producing country, possesses a rich flora and favorable climatic conditions, along with a geography characterized by nectar-rich plants across its diverse regions. It produces a wide array of monofloral and polyfloral honeys tailored to varied palates [20]. In high-altitude and mountainous areas where plant diversity is limited, the *Astragalus* plant is encountered in abundance. Honey, renowned for its natural purity in human nutrition, garners substantial market demand based on consumers' taste preferences. Among monofloral honeys such as acacia, sunflower, pine, chestnut, rhododendron, citrus, thyme, and *Astragalus*; *Astragalus* honey has recently begun to establish a foothold in the market and is marketed under this designation. Derived from beekeeping operations conducted by producers in apiaries situated in regions abundant with this eponymous monofloral plant, *Astragalus* honey has emerged as a consumer favorite. Consequently, numerous producers are specializing in its production and promoting its dissemination through branding.

An examination of Türkiye's beekeeping statistics for the period 2018–2023 (Table 2) encompassing the number of enterprises, hive numbers, honey production, beewax production, and honey yield per hive reveals fluctuations in both sectoral growth and productivity. The number of enterprises rose from 81,830 to 100,399, reflecting an approximate 22.7% increase, while hive numbers grew by 13.8% from 8,108,424 to 9,224,881; these trends suggest an expansion of beekeeping activities and a shift toward professionalization. Honey production increased from 107,920 tons to 114,889 tons, demonstrating a 6.4% rise; however, the declines observed in 2020 and 2021 may signal transient challenges, such as environmental factors or hive health issues. Beewax production exhibited an unstable trajectory, with a modest decline from 3,987 tons to 3,971 tons, potentially indicating that it receives comparatively less emphasis than honey production. Meanwhile, honey yield per hive decreased from 13.31 kg to 12.45 kg, incurring a 6.5% reduction; this underscores a productivity bottleneck despite rising hive numbers and highlights the imperative to optimize per-unit output.

Table 2. Beekeeping Data in Türkiye [5-21]

Year	Number of Enterprises (Units)	Number of Colonies (Units)	Honey Production (Tons)	Beewax Production (Tons)	Honey Yield (Kg/hive)
2023	100.399	9.224.881	114.889	3.971	12,45
2022	95.386	8.984.676	118.297	4.165	13,17
2021	89.361	8.733.394	96.344	3.766	11,03
2020	82.845	8.179.418	104.077	3.765	12,72
2019	80.645	8.128.360	109.330	3.971	13,45

Türkiye's apiculture sector holds significant economic and ecological importance, largely due to its geographical diversity and rich vegetation. Table 3 presents data from the Turkish Statistical Institute (TÜİK) for the year 2025, detailing the number of beekeeping enterprises, hive populations, honey production (tons), and beewax output (tons) by region. Additionally, honey yield per hive (kg/hive) is also considered. The analysis is structured on a regional basis, with a particular focus on the role of the *Astragalus* genus (commonly known as milkvetch) in bee nutrition.

Astragalus species, particularly prevalent in the steppe ecosystems of Eastern and Central Anatolia, are rich in nectar and pollen, thereby supporting bee hive health, enhancing honey yield, and contributing medicinal properties such as antioxidant and phenolic content to monofloral honeys.

Black Sea Region characterized by high rainfall and forested landscapes, this region supports beekeeping primarily based on chestnut trees and shrub flora. The influence of *Astragalus* is limited, as the plant prefers drier steppe habitats. While the number of enterprises and hive density is high, honey yield varies depending on floral composition. Ordu province leads the region with 3,114 enterprises, 625,110 hives, and 13,001 tons of honey, resulting in a high yield of 20.88 kg/hive, largely attributed to chestnut nectar. In contrast, Trabzon, with 2,629 enterprises and 155,829 hives, produces 781 tons of honey at a significantly lower yield of 5.01 kg/hive [22]. The reduced productivity in Trabzon may be explained by mountainous terrain and shorter blooming periods, although overall floral diversity supports production volumes.

Mediterranean Region in the foothills of the Taurus Mountains, species such as *Astragalus angustifolius* are moderately prevalent, contributing to improved bee nutrition and honey quality. The region benefits from both tourism and agricultural diversity, which collectively promote apiculture. Antalya province, with 3,497 enterprises and 242,450 hives, produces 2,024 tons of honey, demonstrating high productivity. The presence of *Astragalus* in the Taurus region facilitates early-season bee feeding, potentially enhancing beewax production. Comparatively, Isparta with 602 enterprises and 36,924 hives produces 256 tons of honey, yielding 4.53 kg/hive [22]. The lower yield may reflect the impact of mountainous topography on hive accessibility. In both provinces, *Astragalus* contributes to the honey's aromatic profile and enhances its medicinal value.

Southeastern Anatolia Region due to its arid steppe landscapes, this region serves as a natural habitat for *Astragalus*. In Adıyaman province, the production of "Golden *Astragalus* (milkvetch) Honey" has been reported to reduce nutritional stress on bee colonies, thereby increasing productivity. Ongoing irrigation projects (GAP) further support the development of apiculture. The nectar from *Astragalus* maintains bee health during dry periods and supports beewax production. Siirt, with 1,379 enterprises and 227,097 hives, produces 3,048 tons of honey with a notable yield of 13.42 kg/hive [22]. This high yield is likely linked to the abundance of *Astragalus*, which enhances pollen diversity, promotes hive proliferation, and contributes to the anti-inflammatory properties of the honey in both Siirt and Adıyaman.

Aegean Region apiculture in this region is primarily based on olive and thyme flora. However, *Astragalus* also provides nutritional support in Inner Aegean areas. High hive density is associated with export-oriented production. Muğla stands out with 4,308 enterprises, 728,913 hives, and 7,031 tons of honey, making it the region's top producer. The contribution of *Astragalus* complements the dominance of pine honey. İzmir, with 2,593 enterprises and 265,658 hives, produces 2,884 tons of honey at a yield of 10.86 kg/hive [22]. The slightly higher yield in İzmir may be attributed to coastal flora. In both provinces, *Astragalus* enhances the polyphenol content of the honey, thereby strengthening its antioxidant capacity.

Marmara Region due to industrialization and urbanization, the apiculture sector faces various challenges in Marmara. Beekeeping is often supported through migratory practices. In provinces such as Balıkesir and Bursa, similar productivity levels reflect the role of agricultural diversity. Beewax production remains relatively stable in both areas [22].

Eastern Anatolia Region is home to the densest populations of *Astragalus*, and provinces like Elazığ, Erzurum, and Ağrı have gained geographical indications for their milkvetch honeys. The plant improves bee nutrition and increases honey yield, ranging between 8–15 kg/hive. High-altitude pastures promote monofloral honey production. Elazığ, with 1,406 enterprises and 93,816 hives, produces 604 tons of honey at a yield of 6.43 kg/hive. The drought-resistant nectar of *Astragalus* enhances winter survival of colonies. Erzurum, with 2,249 enterprises and 136,074 hives, yields 964 tons of honey at 7.08 kg/hive [22], a slight increase attributed to broader *Astragalus* coverage. In both provinces, the plant improves the immunostimulant effects of honey and enhances beewax quality.

Central Anatolia Region with its characteristic steppe flora, this region represents the natural habitat of *Astragalus.* In provinces such as Sivas and Ankara, the plant supports pollination and optimizes honey yield. The arid climate necessitates migratory beekeeping. Sivas, with 2,358 enterprises and 252,611 hives, produces 4,003 tons of honey making it the largest producer in the region. The abundance of *Astragalus* mitigates nutritional stress. Ankara, with 1,714 enterprises and 104,433 hives, produces 624 tons of honey at 5.98 kg/hive [22]. Sivas's relative advantage is likely due to its more expansive pasturelands. In both provinces, *Astragalus* enhances the pharmacological properties of honey and supports sustainable beekeeping practices.

Table 3. Beekeping data in Türkiye by regions [22]

Regions	Number of Enterprises (Units)	Number of Colonies (Units)	Honey Production (Tons)	Beewax Production (Tons)	Honey Yield (Kg/hive)
Black Sea	24219	1744276	20629	568	10,42
Mediterranean	12779	1423899	18218	721	8,92
Southeast	8014	968716	10275	157	8,01
Aegean	12459	1544589	15117	752	8,58
Marmara	13625	884510	10103	321	10,68
Eastern Anatolia	15201	1577522	13316	547	8,17
Central Anatolia	11687	818463	7834	252	7,43
TOTAL	**97984**	**8961975**	**95492**	**3318**	**8,88**

4. Conclusion

Globally, while hive numbers and beewax production have exhibited proportional increases, fluctuations have been observed in honey production and per-hive kilogram yields. The highest honey yield was recorded in 2019 at 18.89 kg/hive. In 2021, despite an increase in hive numbers, honey production displayed a declining trend, which may be attributed to the rise in swarming rates as well as the impacts of the COVID-19 pandemic. In Türkiye, although hive and enterprise numbers are at adequate levels, honey yields and the production of other bee products remain below the global average. It is essential to enhance beekeepers' awareness through educational programs on the production of royal jelly, bee venom, and propolis, particularly to facilitate the establishment of market mechanisms for these products.

Türkiye, owing to its rich natural diversity, varied flora, and favorable climatic conditions, features a geographical landscape characterized by nectar-producing plants across its diverse regions. Approximately 439 species of the *Astragalus* plant, which is extensively utilized in beekeeping and as roughage in animal husbandry, are prevalent throughout the country. In bee nutrition, akin to other organisms, essential nutrients such as carbohydrates, minerals, proteins, and lipids are predominantly sourced from pollen. Astragalus species, particularly in areas where bee foraging presents challenges, fulfill the nutritional requirements of colonies through their abundant pollen and nectar content, thereby emerging as a vital resource. Integrating these species into pollinator habitats could enhance bee health and foster the advancement of the beekeeping sector. To ensure the sustainability of beekeeping

operations, each apiary site must be strategically planned to restrict access by other animals. Furthermore, efforts to promote honey derived exclusively from the flowers of this plant marketed under the designation of *Astragalus* honey should be intensified. It is evident that *Astragalus* significantly enhances bee nutrition and product quality, particularly in Eastern and Southeastern Anatolia. Regional comparisons underscore the role of floral diversity in determining productivity; future studies should investigate the ecological contributions of this plant in greater depth.

Statement: This study is an expanded version of the abstract, part of which was presented orally at the *III. International Apicultural Research and Sustainable Regional Development Strategy Congress*, held in Bingöl province from October 8-10, 2025, and published in the congress booklet.

References

[1] Abou-Shaara, H. F. (2014). The Foraging Behaviour of Honey Bees, Apis Mellifera: A Review. *Veterinarni Medicina*, 59(1).

[2] Papa, G., Maier, R., Durazzo, A., Lucarini, M., Karabagias, I. K., Plutino, M., Bianchetto, E., Aromolo, R., Pignatti, G., Ambrogio, A., Pellecchia, M., & Negri, I. (2022). The Honey Bee Apis mellifera: An Insect at the Interface between Human and Ecosystem Health. *Biology*, 11(2), 233. https://doi.org/10.3390/biology11020233

[3] Ansaloni, L. S., Kristl, J., Domingues, C. E. C., & Gregorc, A. (2025). An Overview of the Nutritional Requirements of Honey Bees (Apis mellifera Linnaeus, 1758). *Insects*, 16(1), 97. https://doi.org/10.3390/insects16010097

[4] İlyasov, R. A., Lee, M. L., Takahashi, J. I., Kwon, H. W., & Nikolenko, A. G. (2020). A Revision of Subspecies Structure of Western Honey Bee Apis Mellifera. *Saudi Journal of Biological Sciences*, 27(12), 3615-3621.

[5] FAO, (2024). FAOSTAT. Birleşmiş Milletler Gıda ve Tarım Örgütü. Access date (08.08.2025).

[6] Aslan, C. E., Liang, C. T., Galindo, B., Kimberly, H., & Topete, W. (2016). The Role of Honey Bees as Pollinators in Natural Areas. *Natural Areas Journal*, 36(4), 478-488.

[7] Barker, R. J., & Lehner, Y. (1974). Influence of Diet on Sugars Found by Thin-Layer Chromatography in Thoraces of Honey Bees, Apis Mellifera L. *Journal of Experimental Zoology*, 188(2), 157-164.

[8] Ulucan, O. (2012). Bal Arılarının Besin Maddesi Gereksinimleri. *Arıcılık Araştırma Dergisi*. 11-13.

[9] Crailsheim, K., Schneider, L. H. W., Hrassnigg, N., Bühlmann, G., Brosch, U., Gmeinbauer, R., & Schöffmann, B. (1992). Pollen Consumption and Utilization in Worker Honeybees (Apis Mellifera Carnica): Dependence on Individual Age and Function. *Journal of insect Physiology*, 38(6), 409-419.

[10] Uygur, Ş. Ö. (2016). Bal Arılarının Beslenmesi ve Beslemede Genel Ilkeler. *Çiftçi Broşürü*, No: 122.

[11] Al-Ghamdi, A. A., & Al-Sagheer, N. A. (2023). Plant Species as Potential Forage for Honey Bees in the Al-Baha Mountain Region in Southwestern Saudi Arabia. *Plants*, 12(6), 1402. https://doi.org/10.3390/plants12061402

[12] Asma, S. T., Bobiş, O., Bonta, V., Acaroz, U., Shah, S. R. A., Istanbullugil, F. R., & Arslan-Acaroz, D. (2022). General Nutritional Profile of Bee Products and Their Potential Antiviral Properties Against Mammalian Viruses. *Nutrients*, 14(17), 3579. https://doi.org/10.3390/nu14173579

[13] Küçükaydın, S., Tel-Çayan, G., Çayan, F., Taş-Küçükaydın, M., Eroğlu, B., Duru, M. E., & Öztürk, M. (2023). Characterization of Turkish Geven Honeys According to Their Phenolic Profiles and Biological Activities with A Chemometric Approach. *Food Bioscience*, 53, 102507.

[14] Tanner, D. A., Clark, C., & Pitts, J. P. (2013). Pollination Biology of Geven Phoenix (Fabaceae) with Notes on the Natural History of its Pollinator, Anthophora Porterae (Hymenoptera: Apidae). *Western North American Naturalist*, 73(3), 373-381.

[15] Ganbarov, D. (2014). Geven Species and their Bioecological Features Spread in the Arajig Mountain of Julfa Region. *European Academic Research*. 1(10), 3258-3265.
[16] Anonim. (2021). Creating and Enhancing Habitat for Pollinator Insects. United States Department of Agriculture. Natural Resources Conservation Service. *Biology Technical Note* No. MT-20. Access date (20.07.2025).

[17] Gucker, C.L.; Shaw, N.L. 2023. Basalt Milkvetch (Astragalus filipes [Torr. ex. A. Gray] Raf.). In: Gucker, C.L.; Shaw, N.L., eds. Western forbs: Biology, Ecology, and Use in Restoration. Reno, NV: Great Basin Fire Science Exchange. https://westernforbs.org/species/basalt-milkvetch-astragalus-filipes/ Access date: (20.08.2025).

[18] Çaçan, E., Ülger, İ., Kilic, O., Yilmaz, M., Kokten, K., & Kaplan, M. (2017). Potential Nutritive Value of Astragalus Species Harvested at Three Different Maturity Stages. *Applied Ecology and Environmental Research*, 15(4).

[19] Sugden, E. A. (1985). Pollinators of Astragalus Monoensis Barneby (Fabaceae): New Host Records; Potential Impact of Sheep Grazing. *The Great Basin Naturalist*, 299-312.

[20] Kolaylı, S., Aliyazıcıoğlu, R., Ulusoy, E., & Karaoğlu, Ş. (2008). Antioxidant and Antimicrobial Activities of Selected Turkish Honeys. *Hacettepe Journal of Biology and Chemistry*, 36(2), 163-172.

[21] TÜİK, (2024). Türkiye İstatistik Kurumu. tuik.gov.tr Access date (08.08.2025).

[22] TÜİK, (2025). Türkiye İstatistik Kurumu. tuik.gov.tr Access date (08.09.2025).