BEE AND BEEKEEPING

II

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PREFACE

Nature offers countless gifts to this day with its unique balance and productivity. One of the most important of these gifts is bees and their products such as honey, propolis, and bee bread. Bees play an indispensable role not only with these products but also for the order and management of the ecosystem. Beekeeping is an art shaped by these miraculous creatures. Beekeeping, which is blended with human labor, knowledge, and deep respect for nature, has been important both individually and collectively throughout history.

This book in your hands covers a wide range from the basic policies of beekeeping to special applications. This study, which is intended to be a reference source for those interested in beekeeping, offers information that will benefit both beginners and beekeepers in the region.

This book examines important bee products such as propolis and bee bread in detail, while the importance of this unwanted for both bees and people is supported by informative and practical information and taken from both an academic and commercial perspective.

Wintering studies, one of the most critical challenges in beekeeping, are also one of the focal points of the book. The techniques required for the colonies to survive healthily in winter conditions are conveyed in detail with modern applications. In addition, effective performances in combating varroa parasite, one of the most common bee colonies, and detailed new approaches on this subject are also included.

Honey harvesting is the most exciting but also a delicate stage of beekeeping. In one section of the report, the effects of local factors on honey production and how these effects change in different geographies are emphasized. The effects of local flora, climate conditions and other natural features on the quality and quantity are detailed.

In addition, different programs, beekeeping practices and the results of bee products are considered according to their characteristics, and suggestions for contributing to productivity increase are presented with the techniques applied in this calendar. This storage is done both to share the knowledge and experience of local beekeepers and to enrich general beekeeping information.

Beekeeping is a great value for humanity, as well as an effort that shows knowledge and care. This book aims to guide beekeepers and further improve this root connection established with bees by shedding light on the formal and practical dimensions of beekeeping.

We hope you enjoy reading it and benefit from it…

Aralık 2024 / Bayburt/TÜRKİYE
Assoc.Prof. Dr. Yaşar ERDOĞAN
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CHAPTER 1

GEOGRAPHICALLY INDICATED LOCAL HONEYS IN TÜRKİYE

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1. INTRODUCTION

Food symbolizes a community's rich history and contains cultural expressions and traditional knowledge. Consumers purchasing behaviors and consumption patterns of food products have changed due to reasons such as the increase in standard products with globalization and the decrease in natural product production with climate change, and the tendency towards regional products has increased because they are natural, healthy and high-quality.

The increasing demand of consumers for local and regional foods causes the food trade to turn to local brands rather than international brands. A growing consumer group is concerned about food safety and quality and considers the origin of foods as a useful quality signal (Teuber, 2011). Changing consumer preferences and environmentally friendly practices as people attach importance to healthy living have increased the production and certification of healthy products. Consumers who want to eat healthily want to know where their food comes from and how it is produced (Ilbery and Kneafsey, 2000).

Different types of product labels exist to inform consumers about the product'sspecific features and to protect manufacturers from fraud (Rupprecht et al., 2020). Among these labels, the geographical indication system, which guarantees food safety and quality and explains the relationship between the origin of the product and its specific characteristics, has an important place (Castro and Giraldi, 2018).

2. The concept of geographical indication

A geographical indication is a sign indicating a product that is identified with the region, area, region, or country where it originates due to a distinctive feature, reputation or other characteristics. Geographical indication defines products that have all or some of their characteristic features from a certain region and have become known to the consumer with the quality they have created. Geographical indications are registered as a name of origin or source indication. Food, agriculture, mining, handicrafts, and industrial products can be subject to geographical indication registration (TPE, 2017).

The product diversity provided by very different geographical structures and climate conditions, the potential that contains important genetic resources and ancient agricultural culture, the market liveliness provided by the increasing population and income and the proximity to countries with import-dependent food consumption provide significant advantages to Turkish agriculture. By emphasizing these advantages, having a say in the international food market beyond ensuring the country's food security, creating a brand in the international food market in addition to ensuring food safety from farm to table, healthy nutrition of the society, and improving living and working conditions in rural areas that constitute the agricultural environment are among the inevitable priorities of the agricultural sector (Şahin and Meral, 2012).

In recent years, one of the most dynamic sectors in food consumption all over the world, and especially in Europe, is the local products sector. Local products protected by geographical indications constitute an important potential for our country's economy. The employment and added value that will develop with the protection and production of these products play an important role in the economic development of the regional population (İloğlu 2014). The added value created is important due to the closing of the income gap between rural and urban areas and its positive effects on the income distribution between regions. While the number of products receiving geographical indications in Türkiye is increasing, the awareness of increasing the number of food products receiving geographical indications valid at the international level is also increasing.

The reason for the preference for geographical products is that they are equipped with superior quality, taste, aesthetics, and other specific features. At the same time, it is seen that there is a close connection between product popularity and geographical region. The pioneers in the emergence of geographical indication protection were the Bourgogne and Bordeaux wine producers in France. Legal regulations were made in France thanks to the long and organized struggle of the producers against unfair competition caused by the sale of many low-quality wines under their names in the market. The first international regulation regarding geographical indication was the Paris Treaty of 1883 on industrial property rights and the treaty brought special protection to geographical indications. However, the practice could only be implemented with the new regulation in 1925 (Goldberg 2001).

Local food and beverages have an important place in the cultural heritage of societies. The tendency towards local values has caused these products to be imitated. In order to protect local products against imitations, local products must be registered and receive geographical indications. Geographical indications help to convey reliable signals to reduce information gaps between producers and consumers by providing official quality certification based on geographical origin (Yin et al., 2024). Geographical Indications indicate products with a specific geographical origin and qualities, characteristics or reputations that primarily derive from the place of origin. Registration of Geographical Indications protects the product's name and acts as a collective marketing tool for producers and processors of regional products. Protecting geographical indications encourages producers to maintain the common quality standard of their products (Sautier et al., 2018; Markos et al., 2023).

The necessary legal regulation for protecting this rich regional product asset was carried out on the Protection of Geographical Indications, which entered into force on 27.06.1995. The law has assigned the Turkish Patent Institute (TPI) to grant registrations. With the "Industrial Property Law" published in the Official Gazette dated January 10, 2017, the name of the TPI was changed to the Turkiye Patent and Trademark Office, and the registration of geographical indications is still carried out by the Turkiye Patent and Trademark Office (TPE, 2017).

3. Our Country's Hive Presence

Türkiye has significant potential for developing beekeeping with its mild winters and rich flora in spring (Engindeniz et al., 2015). Although there have been decreases in production due to seasonal losses in some years, an increasing trend has been observed in the last decade. The number of hives in the world increased by 1.1% in 2022 compared to the previous year and reached 101 million. According to 2022 data, India ranks first with a share of 12.5% in the total number of hives in the world, while China ranks second with a share of 9.2% and Türkiye ranks third with a share of 8.9%. In 2022, the total number of hives increased by 0.8% in India, 0.3% in China, and 2.9% in Türkiye compared to the previous year (TEPGE, 2024).

The beekeeping sector in Türkiye has generally developed in geographies where industrialization is low and rural areas cover a large area. Thanks to the suitable climate conditions and floral resource diversity in Türkiye, beekeeping has become an important economic sector. In parallel with the spread of beekeeping activities in Türkiye, the beekeeping sector has developed in recent years. Beekeeping has become an alternative source of income for producers living in rural areas who do not have agricultural land for plant production.

In addition to beekeeping, Türkiye is among the top five countries in the production of beeswax, which is used in the metal cosmetics, textile, pharmaceutical, and candle-making. When the beeswax production is examined by years, it is seen that the amount of beeswax production increased by 0.6% in India, 1.6% in Ethiopia, 0.3% in Argentina, and 8.7% in Turkiye in 2022 compared to the previous year.

The total number of colonies in Türkiye reached 9 million in 2022. Muğla, which has 817 thousand beehives, ranks first with an 8.9% share in the total number of beehives in Türkiye, Ordu with 612 thousand beehives and 6.6% share, and Adana with 495 thousand beehives and 5.4% share, is in third place. The total number of beehives increased by 2.7% in 2023 compared to the previous year. When examined on a provincial basis, the number of beehives decreased by 7.6% in Muğla, increased by 0.3% in Ordu, and there was no significant change in Adana. The Aegean Region is the leader in the number of beehives with 1.7 million in 2023, and it alone hosts 18.3% of Türkiye's hives. The Aegean Region, where extensive pine honey production is also important, has an important place in Turkiye's beekeeping. 48.5% of the beehives in the region are in Muğla. The Mediterranean Region ranks second with 1.5 million hives, accounting for 15.9% of Türkiye's hives, ın comparison, the Eastern Black Sea Region ranks third with 1.2 million hives, accounting for 12.7% of the number of colonies in 2023 (TEPGE 2024).

4. The Composition of Honey Varies by Region

Honey is the sweet substance that honey bees collect from flowers or living parts other than flowers and ripen by adding their enzymes. (Mendes et al., 1998). Türkiye is one of the countries that will have a say in beekeeping in the twenty-first century with its suitable ecology, rich flora and genetic variation in bee material. Our country is one of the twelve most important gene centers in the world. There are over 10,000 natural flowering plant species and bee races and ecotypes adapted to regional conditions in our country. The richness in plant species and bee populations stems from the fact that geographical regions exhibit very different ecologies in terms of climate and fauna. This situation also causes a great difference between the potential and problems of beekeeping according to regions (Erdoğan, Dodoloğlu and Zengin, 2005).

Honey is a thick foodstuff prepared by honeybees collecting the nectar found in the flowers of plants or the sugary secretions of living parts of plants and some insects living on the plant, changing the composition in their bodies, mixing some substances into it, storing it in the honeycomb cells and evaporating the water there. Honey is one of the oldest foods of mankind and is produced in almost every region of the world. It is a food that can be used completely as it is produced in nature and can be stored without microbial spoilage thanks to its low water activity and high sugar concentration (Erdoğan, Dodoloğlu and Zengin, 2005). Honey is a very important source of energy and is used as a raw material in the production of food due to its taste, color, aroma, smell and viscosity (De RodríGuez et al., 2004). Honey contains approximately 80% carbohydrates (35% glucose, 40% fructose and 5% sucrose) and 20% water. It also contains more than 180 substances, including amino acids, vitamins, minerals, enzymes, organic acids, and phenolic compounds (Cengiz et al., 2018) and pH is approximately 4.0 (Ouchemoukh et al., 2007). Honey contains some amino acids, the most important of which is proline (Serra Bonvehi and Escolà Jordà, 1997). The most important enzymes in honey are invertase, diastase (amylase), and glucose oxidase. These enzymes, secreted by worker bees and added to the nectar, enable the nectar to turn into honey.

The amount and characteristics of honey vary depending on the flora of the region where the apiary is located, the season, environmental factors, and the beekeeper's practices (Erdoğan et al., 2019; Erdoğan and Turan, 2022). The aim of beekeeping is to collect nectar, pollen and propolis from plant sources available in nature during the main nectar flow period of the region and to ensure that these are converted into various bee products in the most economical way. In order to achieve this goal, the flora in the region where beekeeping is carried out must be well known, the time and duration of flowering and nectar flow and the amount of nectar must be known. Achieving high efficiency from beekeeping depends on the variety and abundance of nectar and pollen sources as well as colony productivity, colony strength and diligence. Therefore, determining suitable production regions and their capacities will provide the highest level of utilization from plant sources and will also directly affect production and productivity (Doğaroğlu and Genç, 1995). The formation and composition of honey vary significantly from region to region. Due to its quite different ecological structure, a wide variety of honeys are produced in our country.

5. Geographically Indicated Honeys in Türkiye

There are many different types of honey in our country depending on geographical conditions. It has been determined that there are 30 numbers of honey with geographical indications among the product groups registered with the Turkish Patent and Trademark Office, 27 of which are named as origin and 3 are indicated as source (TURKPATENT, 2024).

The first registered honey is Pervari Balı, which received the origin mark for Siirt province by the Pervari Balı Producers Association in 2004. The provinces with the highest number of geographically indicated honey rafts are Rize (Anzer Balı and Ayder Balı), Artvin (Arhavi Chestnut Honey and Hatila Honey) and Muğla (Marmaris Pine Honey and Muğla Pine Honey). In terms of the number of honeys with geographical indication registration by region, the Black Sea Region stands out with ten honeys and the Eastern Anatolia Region with seven honeys (Figure 1). The Central Anatolia Region is the region with the least number of geographically indicated honeys with two honeys (TURKPATENT, 2024). According to alphabetical order, our honeys with geographical indication registration in Türkiye are as follows:

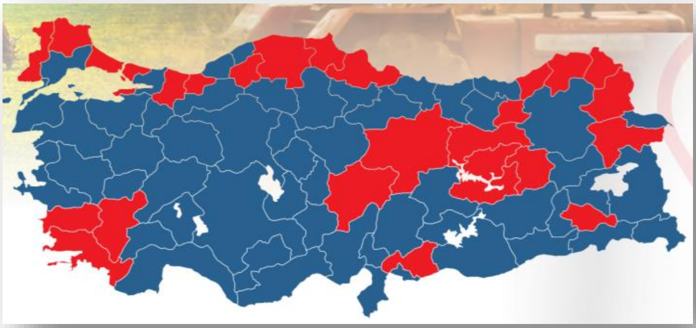

Figure 1. Provinces in Türkiye that have received geographical indication for their honey (TURKPATENT 2024).

1. Antep/Gaziantep Zahter Balı: It is a monofloral honey with a dominant Zahter aroma. It is obtained from Zahter plants growing in the mountainous areas of Gaziantep and is produced by Anatolian and Syrian bee colonies (TURKPATENT, 2024).

*Application date: 28.10.2021

*Registration date: 24.03.2022

*Type of geographical indication: Origin Name

*Registering Institution: Gaziantep Chamber of Commerce

*Geographical Limit: Gaziantep

2. Anzer Balı: Anzer Balı is a flower honey produced in the U-shaped Anzer Valley, where 450-500 types of flowers are found and 80-90 of them are endemic. This region offers a favorable environment that improves the quality and characteristic features of Anzer Honey thanks to its natural ecosystem. It is produced using Caucasian and Caucasian hybrid bee races (TURKPATENT, 2024).

*Application date: 02.12.2019

*Registration date: 16.02.2021

*Type of geographical indication: Origin Name

*Registrar Institution: Rize Provincial Directorate of Agriculture and Forestry

*Geographical Limit: Anzer Plateau (Ballıköy and Çiçekli Village) in İkizdere district of Rize province

3. Ardahan Çiçek Balı: Ardahan Çiçek Balı is generally light amber in color and has a fluid consistency. Obtained thanks to the rich flora of the city, this honey reflects the natural aroma and flavors of the flowers. While leaving a light taste on your palate, it also has a refreshing effect. The natural sugars in its content have an energizing feature and help strengthen the immune system (TURKPATENT, 2024).

*Application date: 02.08.2013

*Registration date: 01.06.2017

*Type of geographical indication: Origin Name

*Registering Institution: Ardahan Province Beekeepers Association

*Geographical Limit: Ardahan province and districts

4. Arhavi Kestane Balı: Arhavi Kestane Balı is produced with nectar collected by bees from chestnut trees and other flowering plants. It can be prepared as filtered or combed (TURKPATENT, 2024).

*Application date: 16.12.2021

*Registration date: 10.11.2022

*Type of geographical indication: Origin Name

*Registration Institution: Arhavi Chamber of Agriculture

*Geographical Limit: Arhavi district of Artvin province

5. Ayder Balı: There are two types: chestnut honey and multi-flowered flower honey. It is produced using Caucasian hybrid bees and has the ability to collect nectar from deep-tubed flowers that enrich its characteristic features (TURKPATENT, 2024).

*Application date: 28.10.2021

*Registration date: 24.03.2022

*Type of geographical indication: Origin Name

*Registrant Institution; Limited Liability Ayder Kaplıca and Aşağı Şimşirli Agricultural Development Cooperative

*Geographical Limit: Ayder Plateau, which starts from the northern slopes of the Kaçkar Mountains in the Çamlıhemşin district of Rize province and ends in the Ardeşen district, and covers the Fırtına Valley and the Kavron, Hala, Çat, Tunca, Durak and Çayırdüzü basins.

6. Ağrı Geven Balı: Monofloral strained honey obtained from astragalus plants. It offers a unique taste with its color ranging from light yellow to orange and its slightly fragrant aroma (TURKPATENT, 2024).

*Application date: 09.11.2020

*Registration date: 17.03.2022

*Type of geographical indication: Origin Name

*Registering Institution: Ağrı Province Beekeepers Association

*Geographical Limit: Ağrı

7. Babadağ Kekik Balı: Babadağ Kekik Balı is a unique honey obtained from the nectar of the thyme plant. Its aroma is quite strong and has a characteristic taste. Its color usually varies from light gold to dark brown. It is known to be beneficial for health thanks to its high antioxidant content and helps strengthen the immune system (TURKPATENT, 2024).

*Application date: 13.03.2019

*Registration date: 23.12.2020

*Type of geographical indication: Origin Name

*Registration Institution: Denizli Province Beekeepers Association

*Geographical Limit: Babadag district of Denizli province

8. Bayburt Balı: Bayburt Balı is a flower honey that has a transparent and shiny appearance, and can be yellowish or sometimes khaki depending on the season and the color of the flowers of the plants that the bees use. It has a pleasant taste, leaves a slight burning sensation in the throat and has a pleasant smell originating from the nectars of the honey plants growing in the region. Bayburt Honey, which has a fluid consistency, can crystallize in two months at room temperature, while this period is even shorter at low temperatures (TURKPATENT, 2024).

*Application date: 10.10.2019

*Registration date: 20.07.2020

*Type of geographical indication: Geographical Sign

*Registration Institution: Bayburt University

*Geographical Limit: Bayburt

9. Bingöl Balı: Bingöl Honey, which is a polyfloral flower honey, reflects the vegetation of the region with its color ranging from light amber to dark amber. It is produced as comb, black hive and filtered honey (TURKPATENT, 2024).

*Application date: 16.12.2020

*Registration date: 07.10.2022

*Type of geographical indication: Origin Name

*Registration Institution: Bingöl University

*Geographical Limit: Bingöl

10. Dikmen Çiçek Balı/ Dikmen Kekik Balı: Dikmen Çiçek Balı/Kekik Balı carries the aroma of thyme and other flowers. Its color usually varies from light yellow to dark amber. It attracts attention with its unique taste and aroma, and is frequently preferred in daily life thanks to its energizing properties (TURKPATENT, 2024).

*Application date: 10.10.2019

*Registration date: 21.12.2020

*Type of geographical indication: Origin Name

*Registration Institution: S. S. Yeniköy-Dikmen Balkoop Agricultural Development Cooperative

*Geographical Limit: Karacasu district of Aydin province

11. Düzce Kestane Balı: Monofloral Düzce Kestane Balı is obtained from chestnut flowers and has a unique bitter taste profile. Its color is dark brown and has a chestnut-specific taste and smell (TURKPATENT, 2024).

*Application date: 11.12.2017

*Registration date: 06.09.2021

*Type of geographical indication: Origin Name

*Registering Institution: Düzce Provincial Directorate of Agriculture and Forestry

*Geographical Limit: Düzce

12. EIazığ Geven Balı: It is a product offered to the consumer as filtered and comb honey obtained from astragalus and other flowering plants (TURKPATENT, 2024).

*Application date: 15.02.2021

*Registration date: 21.09.2022

*Type of geographical indication: Origin Name

*Registering Institution: Elazığ Province Beekeepers Association

*Geographical Limit: Elazığ

13. Hatila Balı: Hatila Balı is produced in the Hatila Valley and the rich vegetation in the region provides the necessary nectar resources for the bees to feed. It is produced using Caucasian and Caucasian hybrid bees (TURKPATENT, 2024).

*Application date: 31.12.2020

*Registration date: 17.09.2021

*Type of geographical indication: Origin Name

*Registrant Institution: Limited Liability Taşlıca Village Agricultural Development Cooperative,

*Geographical Limit: Hatila Village and National Park in the Central District of Artvin Province

14. Kars Balı: Kars Balı attracts attention with its light odor and sweet aroma. Produced in the winter months, this honey is usually enriched with nectars collected from flowers. The color of the honey usually varies from light yellow to dark amber tones. It has very high nutritional values and helps strengthen the immune system (TURKPATENT, 2024).

*Application date: 23.12.2016

*Registration date: 10.08.2018

*Type of geographical indication: Origin Name

*Registration Institution: Kars Province Beekeepers Association

*Geographical Limit: Kars Center, Akyaka, Arpaçay, Digor, Kağızman, Sarıkamış, Selim, Susuz districts, villages, plateaus and hamlets connected to these units

15. Kastamonu Kestane Balı: It is a dark brown monofloral honey. It is obtained during the period when chestnut flowers produce nectar intensively, so it contains a high amount of chestnut pollen (TURKPATENT, 2024),

*Application date: 20.12.2018

*Registration date: 12.08.2022

*Type of geographical indication: Origin Name

*Registration Institution: Kastamonu Province Beekeepers Association

*Geographical Limit: Kastamonu

16. Keşan Korudağ Çiçek Balı: Keşan Korudağ Çiçek Balı is a flower honey with a multifloral raw honey quality. It starts to crystallize approximately 2-4 months after harvest. Due to the easy crystallization feature of the honey, it has a high fluidity and is sticky. Keşan Korudağ Flower Honey is bright yellow and light colored and has a light lavender, thyme and linden flower scent, a light fruit taste that does not leave a bitterness in the mouth and does not burn the throat. It does not leave a burnt, caramel or smoke odor.

*Application date: 20.12.2022

*Registration date: 18.11.2024

*Type of geographical indication: Origin Name

*Registration Institution: Keşan Municipality

*Geographical Limit: Edirne province Keşan district Danişment, Mecidiye, Gökçetepe, Sazlıdere, Bahceköy, İzzetiye, Yenimuhaçir, Küçükdoğanca, Altıntaş, Beğendik, Paşayiğit, Türkmen, Orhaniye, Şabanmera, Yaylaköy, Beyköy, Suluca, Mercan, Yeşilköy, Kılıçköy, Büyükdoğanca, Hacıköy, Erikli, Kozköy, Mahmutköy, Kadıköy, Şükrüköy, Seydiköy and Çamlıca villages

17. Kocaeli Çam Dağı Kestane Balı: Kocaeli Çam Dağı Chestnut Honey is produced by collecting nectars secreted from chestnut trees and other flowering plants by bees. The vegetation in the region consists of forests consisting of chestnut trees, pine, plane, beech, linden and alder species. This rich vegetation contributes to the unique taste and aroma profile of the honey (TURKPATENT, 2024).

*Application date: 29.06.2020

*Registration date: 12.09.2022

*Type of geographical indication: Origin Name

*Registration Institution: Kocaali Municipality

*Geographical Limit: Kocaali district of Sakarya province

18. KırkIareIi Meşe Balı: Kırklareli Meşe Balı has a dark color, viscous and fluid structure, and has a low moisture content. It attracts attention with its throat-free feature and high antioxidant capacity (TURKPATENT, 2024).

*Application date: 10.12.2019

*Registration date: 12.02.2021

*Type of geographical indication: Origin Name

*Registering Institution: Kırklareli Provincial Directorate of Agriculture and Forestry

*Geographical Limit: Kırklareli province center, Pinarhisar, Vize, Kofcaz and Demirkoy districts

19. Marmaris Çam Balı: Marmaris Çam Balı is a secretion honey obtained especially from pine trees. It is easily distinguished from other honeys with its dense consistency and rich aroma. It is usually dark amber in color and leaves a long-lasting taste on the palate. This honey, which is beneficial for health, helps strengthen the immune system and gives energy (TURKPATENT, 2024).

*Application date: 13.01.2017

*Registration date: 06.11.2019

*Type of geographical indication: Origin Name

*Registration Institution: Muğla

*Geographical Limit: Marmaris district of Muğla province

20. Munzur Balı: Munzur Balı is a flower honey with yellowish and khaki tones produced by Anatolian bee (*Apis mellifera anatoliaca*) colonies. It has a thick consistency and varies according to the harvest period; It is more fluid in early harvests in August and more viscous in intensive harvests in September (TURKPATENT, 2024).

*Application date: 28.11.2022

*Registration date: 19.02.2024

*Type of geographical indication: Origin Name

*Registering Institution: Tunceli Provincial Directorate of Agriculture and Forestry

*Geographical Limit: Munzur Valley in Tunceli Province

21. Muğla Çam Balı: Muğla Çam Balı is a type called secretion honey and is obtained from the leaves of pine trees. It has a characteristic taste and an intense aroma. Its color varies from dark amber to brown. Muğla's natural beauties and pine forests increase the unique properties of this honey. Known for its healthy properties, this honey has antibacterial properties and is a natural source of energy (TURKPATENT, 2024).

*Application date: 24.09.2007

*Registration date: 15.08.2018

*Type of geographical indication: Origin Name

*Registration Institution: Muğla Province Beekeepers Association

*Geographical Limit: Bodrum, Dalaman, Datça, Fethiye, Kavaklıdere, Köyceğiz, Menteşe, Milas, Ortaca, Seydikemer, Ula and Yatağan districts of Muğla province

22. Pervari Balı: Pervari Balı stands out with its thick consistency and rich aroma. The color of the honey is usually dark amber and is produced in the mountainous areas of Pervari, which has a dense flora. The fact that it is produced by bees that carry the pollen of the natural flowers and plants in the region creates the unique taste and smell of this honey. The taste of the honey has a slightly bitter and sweet balance and leaves a lasting aroma in the mouth (TURKPATENT, 2024).

*Application date: 27.05.2003

*Registration date: 19.08.2004

*Type of geographical indication: Origin Name

*Registration Institution: Pervari Villages Service Union

*Geographical Limit: Siirt, Pervari

23. Refahiye Balı: Refahiye Balı has an aromatic taste thanks to its rich flora. It usually has a color structure ranging from light yellow to dark amber tones. The unique taste of this honey is the effect of the pollen of the natural plants and flowers in the region. This honey, which is thought to have vasodilator properties, also has energizing and immune system supporting effects (TURKPATENT, 2024).

*Application date: 21.12.2018

*Registration date: 18.09.2019

*Type of geographical indication: Origin Name

*Registration Institution: Refahiye Chamber of Agriculture

*Geographical Limit: Refahiye district of Erzincan province

24. Salıpazarı Kestane Balı: Salıpazarı Chestnut Honey is a special honey produced in the Black Sea Region of Türkiye, especially in the Salıpazarı district. It is produced by processing the nectar obtained from the flowers of chestnut trees by bees. It is known for its dark color, thick consistency and strong aroma. It also draws attention with its slightly bitter taste. It is produced under completely natural conditions and does not contain chemical drugs (TURKPATENT, 2024).

*Application date: 28.10.2021

*Registration date: 11.10.2023

*Type of geographical indication: Origin Name

*Registration Institution: Samsun Metropolitan Municipality

*Geographical Limit: Salipazari district of Samsun province

25. Sinop Kestane Balı: Sinop Kestane Balı is obtained from natural and ungrafted trees. It is obtained from pure chestnut forests dating back to the 14th century (TURKPATENT, 2024).

*Application date: 06.03.2020

*Registration date: 13.01.2021

*Type of geographical indication: Origin Name

*Registration Institution: Sinop University

*Geographical Limit: The following villages of Erfelek, Ayancık and Türkeli districts of Sinop province

26. YaIova Kestane Balı: Yalova Kestane Balı plays an important role in the agricultural economy with its long history in the region. It contains a small amount of linden pollen, which makes it a preferred honey for breakfasts. It has reinforced its reputation with geographical boundaries (TURKPATENT, 2024).

*Application date: 23.06.2020

*Registration date: 23.01.2024

*Type of geographical indication: Geographical Sign

*Registering Institution: Yalova Province Beekeepers Association

*Geographical Limit: Yalova

27. Yenice Ihlamur Balı: Yenice Linden Honey is a flower honey produced in the rich flora of broad-leaved forests and shrub transition habitats. It is prepared with nectars collected especially from linden trees and other flowering plants. It is offered as filtered or comb honey according to the production and marketing method (TURKPATENT, 2024).

*Application date: 14.12.2022

*Registration date: 22.08.2023

*Type of geographical indication: Origin Name

*Registering Institution: Yenice District Governorship

*Geographical Limit: Yenice district of Karabuk province

28. Zara Balı: Zara Balı is a flower honey produced by Caucasian race and hybrid bees that feed on plants grown in the flora within the geographical border. The harvest process starts in mid-August and continues until mid-September. It is offered to the market in two different forms: comb and filtered honey. Zara district is an important beekeeping center where beekeeping activities are carried out on the plateaus at an altitude of 1350-1800 meters. The rich flora determines the unique character and quality of the honey (TURKPATENT, 2024).

*Application date: 27.11.2020

*Registration date: 26.04.2022

*Type of geographical indication: Geographical Sign

*Registration Institution; Zara Chamber of Agriculture

*Geographical Limit: Zara district of Sivas province

29. Özvatan Çiçek Balı: Özvatan Çiçek Balı is a natural honey obtained from various flowers. This honey, which has a refreshing and sweet aroma, is usually in light yellow tones. The natural sugars in its content provide energy to the body and support the immune system (TURKPATENT, 2024).

*Application date: 18.09.2018

*Registration date: 16.11.2020

*Type of geographical indication: Origin Name

*Registration Institution: Özvatan District Governorship

*Geographical Limit: Kayseri ili Özvatan ilçesi

30. Şile Kestane Balı: Şile Kestane Balı is obtained from the flowers of chestnut trees and is a thick, dense honey. It attracts attention with its unique bitter and sweet balance. It is known for its rich content in terms of health and has antibacterial properties. It leaves a lasting taste in the mouth and has an energizing effect (TURKPATENT, 2024).

*Application date: 30.12.2020

*Registration date: 03.09.2021

*Type of geographical indication: Origin Name

*Registering Institutions: Şile Beekeeping and Bee Products Agricultural Development Cooperative, Şile Municipality

*Geographical Limit: Şile district of İstanbul province

6. CONCLUSION

Türkiye has a very rich product range in terms of geographical product diversity due to its special location. The production of honey with different aromas and flavors in various regions depends on the eco-diversity of the region. Honey acquires a characteristic feature specific to the region with various pollens collected by bees from different trees, flowers and plants. In this respect, honey with various characteristics is produced in many regions of our country. The production of honey with different aromas and flavors in various regions depends on the eco-diversity of the region. Honey acquires a characteristic feature specific to the region with various pollens collected by bees from different trees, flowers and plants. In this respect, honey with various characteristics is produced in many regions of our country. In geographical indication registration, the most basic purposes are the quality that the region-specific characteristics give to the product and the subjectivity that allows it to be distinguished from similar products. With this registration method, it is possible to protect the products in question. Thanks to geographical indication, honey with very different characteristics can be registered, and these products must be protected due to these characteristics. These valuable products registered with geographical indications have a very important place in the sustainability of local heritage and the development of the regional and national economy. Local producers should be supported in this regard and the production of these products should be continued. The protection of these products and their registration with geographical indications play an important role in terms of transferring this heritage to future generations. Authorized units should work to increase the interest and recognition of these products in protecting and registering local products. Honeys produced in our country and having very valuable characteristics should come from these regions and become a worldwide brand. In geographical indication registration, the most basic objectives are the quality that the region-specific characteristics give to the product and the subjectivity that distinguishes it from similar products. As a result, honeys produced in our country and having very valuable characteristics should come from these regions and become a worldwide brand.

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CHAPTER 2

CLIMATE CHANGE, THE FUTURE OF DRONES AND HONEYBEE COLONIES

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1. INTRODUCTION

Global climate change is one of the biggest environmental problems of the modern world and deeply affects natural and human-induced ecosystems (Uralovich et al., 2023). Rising temperatures, seasonal shifts, changes in precipitation patterns and an increase in extreme weather events due to atmospheric greenhouse gas accumulation pose significant threats to the balance of natüre (Balaram, 2023). These changes greatly affect the life cycles, health status and population dynamics of pollinating organisms, especially known as pollinators. Among pollinators, honey bees (*Apis mellifera* L.) play a critical role in agricultural production and ecosystem services (Malav et al., 2022). However, the challenges created by climate change have serious effects not only on queens and worker bees, but also on drone bees, which are carriers of genetic diversity.

Drones are critical individuals that increase the genetic diversity of honey bee colonies and strengthen the species' adaptive capacity. The genetic material they provide during mating with the queen determines the colonies'resistance to environmental stress factors. Drones develop from unfertilized eggs and are genetically haploid. Their production in the colony is closely related to environmental conditions and the status of colony resources. They are produced for mating purposes, especially in spring and summer, and participate in mating flights during these periods (Tarpy et al., 2023). However, climate change observed in recent years has put pressure on the developmental processes, life spans and mating abilities of drones. This puts both the performance of individual drones and the overall colony health at risk.

The effects of global climate change directly and indirectly shape the life cycle of drones. Increased temperatures can disrupt the developmental processes of drones in the larval stage, causing physiological defects (Medina et al., 2023). In particular, a decrease in sperm quality negatively affects the mating success rate of the queen bee and therefore the long-term health of the colony. In addition, seasonal shifts and changes in flowering cycles can lead to a decrease in pollen and nectar resources needed to meet the energy needs of drones. In addition, the spread of parasites such as Varroa destructor and viral diseases are among the indirect effects of climate change and weaken the immune system of drones (Lin et al., 2024).

These negative effects on drones directly threaten the reproductive success and genetic diversity of honey bee colonies (Tarpy et al., 2023). When queens cannot store enough sperm during mating flights, the productivity and life span of colonies can decrease (Amiri et al., 2017). This poses a serious threat not only to the sustainability of colonies, but also to the continuity of agricultural production. Pollination services provided by honey bees, especially in monoculture agricultural areas, are one of the cornerstones of global food security (Imran et al., 2023). However, the negativities observed in drones can disrupt these ecosystem services by disrupting the general balance of the colonies.

These threats to drones and honeybees in general increase the importance of research and conservation studies. Understanding and coping with the effects of climate change requires approaches that increase genetic resilience, optimize hive management strategies, and environmental regulations. Furthermore, supporting drone health and reproductive success is a critical step in securing the future of colonies.

This book section aims to discuss the potential consequences for the future of honeybee colonies by addressing the direct and indirect effects of global climate change on drones. In addition, recommendations for research and conservation strategies specific to drones will be presented. A better understanding of the effects of climate change is a critical step for both bee conservation and agricultural production and ecosystem sustainability.

2. The Role Of Drones In Honeybee Colonıes

Drones develop from unfertilized eggs through parthenogenesis. They are the largest individuals in the colony; their body weight varies according to race, but they are 180-200 mg and their length is 15-17 mm. The plump drones are not as tall as the queens. However, they are wider and larger than the worker bees and the queen bee. They have large compound eyes that almost completely cover the head. Their wings and scent perception abilities are very well developed. Their wings extend to the end of the abdomen. Drones do not have pollen baskets, poison glands, stingers, Nasanov gland, beeswax glands, hypopharyngeal glands, Koschevnikov and Dufour glands. Since drones have a very short tongue, they cannot get nectar from flowers. However, they can get food from worker bees or honeycomb cells (Genç & Dodoloğlu, 2017).

From April-May onwards, depending on environmental conditions and the number of bees, it is possible to see drones in colonies. The number of drones in the colony depends on the season and conditions inside the hive, and their numbers during the swarming season are between 500-3,000. Colonies start raising drones in spring or early summer. Under normal conditions, there are no drones in colonies during late autumn and winter (Güler, 2017).

While there are about 600 drone cells on each side of a square decimeter of honeycomb, 790-800 worker bee cells can fit into the same area. The number of drones in a colony should not exceed 1,000. A thousand drones consume approximately 7 kg of honey throughout their lives. The main task of drones, which are extremely lazy and voracious, is to mate with infertile queens that go on mating flights. Since they are formed from the infertile eggs of the queen, they are her hereditary representatives (Genç & Dodoloğlu, 2017).

Honey bees regulate the number of drones in colonies by limiting the amount of drone-eyed comb production, regulating the production of drone offspring, and expelling adult drones. The presence of drone-eyed combs in the hive encourages drone production. However, even in this case, bees can limit drone production. Drone eggs, larvae, and sometimes some of the pupae are destroyed by worker bees. Only 50-56% of drone eggs are allowed to develop into adult bees. In this way, the number of drones is prevented from exceeding a certain limit. The age of the queen, her productivity, and whether she has an anatomical defect also affect drone offspring production (Genç & Dodoloğlu, 2017).

Although there are quite different opinions about their lifespan; it is reported that it varies between one and two months and their average lifespan is 54-59 days. However, if the seasonal conditions are good and the nectar and pollen continue to come to the colony, they can live even 4-5 months. Worker bees; during the swarming period, when they are left without a queen and in colonies with an infertile queen, they raise more drones and feed the existing drones by keeping them for a longer period. The number of drones also increases in colonies with old and disabled queens. However, in autumn and when nectar is scarce, worker bees throw drones out of the hive and leave them to die, thus limiting their numbers. The number of drones expelled from a colony in a day is not more than 10-15. In autumn, the expulsion of drones from queenless colonies is delayed (Güler, 2017).

Drones start flying when they are 4 days old. However, they usually make their first flights when they are 5-7 days old. Most of the drones fly to a specific place called the gathering area at the same time of the day in the afternoon. The most intense flight activity in drones is between 14-16 o'clock. Drones generally do not fly unless the temperature rises above 18-20 °C. The purpose of the flight may be to get to know the environment, defecate or mate.

The average daily flight number is 2-4, and can go up to 17. They can fly 7 km away from the apiary and find their own hive again. It is not known exactly what kind of signals they use to find their way during flight. When they are not flying, they stay on the combs with brood in the hive and contribute to the brood temperature (Genç & Dodoloğlu, 2017).

The main task of drones is to mate with infertile queens that have gone on a mating flight. They catch the infertile queen in the air and mate with her. The mating flight lasts for 20-30 minutes. Drone that mate with the queen lose their copulatory organs and die (Güler, 2017).

Drones reach sexual maturity when they are 8 days old (Jaycox, 1961). In other words, an 8-day-old drone can mate. However, the most suitable drones for mating and artificial insemination are those that are 12-15 days old. Semen taken from drones that are 25 days old cannot be used in artificial insemination. Because the semen of drones of this age is very sticky and prevents work by sticking to the tools. However, drones that are 25 days old can mate with the queen.

The nutrition of drones in colonies affects the amount and quality of sperm. If there are more drones than necessary in a colony, they may not be fed enough and the quality and quantity of sperm decreases. Under normal conditions, a queen bee mates with 8-18 drones and receives an average of 10 million sperm from each. The queens can only transport 5-7 million of the sperm cells she receives from drones to her spermatheca and store them (Güler, 2017).

3. How Clımate Change Impacts Drones

Drones play a specialized yet critical role in reproduction honeybee colonies. Their primary purpose is to mate with virgin queens, ensuring genetic diversity and the colony’s long-term survival (Brutscher et al., 2019). However, climate change poses significant challenges to drone production, development, and functionality, with far-reaching consequences for honeybee colonies (Ahmed, 2023). The effects of climate change on drones are multifaceted, encompassing direct physiological impacts, disruptions to reproductive dynamics, and broader ecological disturbances. This section provides a detailed exploration of these issues, highlighting the vulnerability of drone bees to a changing environment.

Drone development is highly sensitive to environmental factors, particularly temperature, making it a critical area of concern in the context of climate change. Scientific studies provide compelling evidence of how temperature extremes and other climate-related factors affect drone development, morphology, and fertility, with profound implications for colony reproduction (Neves et al., 2011; Stürup et al., 2013;Reyes et al., 2019).

Drone brood requires a stable temperature range of 33–36°C to develop properly (Kleinhenz et al., 2003). Deviations from this optimal range can impair development at both cellular and systemic levels. A study by Czekońska & Tofilski, (2020), demonstrated that prolonged exposure of drone brood to temperatures exceeding 35°C resulted in smaller adult drones with reduced wing span and body mass. These deformities compromise their ability to compete in mating flights, reducing reproductive success. Wang et al. (2016) found that short-term exposure of capped brood of drone brood to temperatures 20°C delayed development and increased mortality rates. Surviving drones exhibited lower sperm production, directly affecting their mating efficiency.

Sperm quality is one of the most critical factors for the reproductive success of drones. High temperatures, especially during development, have been shown to drastically reduce sperm viability

(Rangel & Fisher, 2019). According to Zhao et al. (2015), drones exposed to temperatures above 38°C during the pupal stage had a 50% reduction in sperm viability. This finding underscores the vulnerability of drones in regions experiencing frequent heatwaves, a growing consequence of global warming. A study by Czekońska et al. (2013) revealed that cold exposure during development reduces the size and functionality of drones' seminal vesicles, resulting in lower sperm counts. This effect becomes particularly problematic during unseasonal frosts exacerbated by climate change.

The timing of drone development is synchronized with seasonal cues, but climate change-induced variability disrupts this synchronization. Boes (2010) reported that warmer springs trigger earlier drone production in colonies. However, if queens are not simultaneously ready for mating flights, the produced drones may age and become nonviable before mating can occur. Abou-Shaara et al. (2017) reported that the effects of erratic temperature patterns and inconsistent warming and cooling cycles disrupt the timing of drone and queen reproductive cycles. This desynchronization reduces the likelihood of successful mating events.

Temperature extremes during development can also impact the metabolic and morphological traits of drones, affecting their ability to fulfill their reproductive role. Studies by Czekońska & Tofilski (2020) showed that drones exposed to suboptimal temperatures during development had lower energy reserves, reducing their stamina for long-distance mating flights.

Research Czekońska & Tofilski (2020) identified that drones reared under extreme temperatures exhibited deformities in antennae and wing structures, which are critical for locating and pursuing queens.

The physiological and morphological impairments caused by temperature stress have broader implications for the genetic diversity and resilience of honeybee populations. A study by McAfee et al. (2021) concluded that colonies experiencing frequent temperature fluctuations produced fewer viable drones, leading to a reduction in genetic diversity within populations. McAfee et al. (2021) demonstrated that colonies with queens mated to a low diversity of drones were less resistant to diseases and environmental stressors, emphasizing the cascading effects of impaired drone development on overall colony health.

The scientific evidence clearly indicates that climate-induced temperature extremes significantly impact the development and reproductive viability of drone bees. From reduced sperm quality to morphological deformities, these effects compromise the reproductive success of honeybee colonies, highlighting an urgent need for mitigation strategies. Future research must continue to investigate the mechanisms underlying these impacts to inform conservation and management practices that support honeybee resilience in a changing climate.

4. Resource Scarcıty And Nutrıtıonal Stress

Resource scarcity, driven by climate change, significantly affects the nutritional availability and quality for honeybee colonies. Since drones depend entirely on colony resources for development and maintenance, nutritional stress directly impacts their health, survival, and reproductive success. Scientific studies highlight the interplay between resource availability, colony nutrition, and the viability of drone bees, emphasizing the profound implications of climate-induced floral resource declines.

Floral resources, including nectar and pollen, are essential for honeybee colonies. Climate change disrupts these resources through shifts in flowering times, prolonged droughts, and habitat degradation. A study by Aizen et al. (2009) documented a 66% decline in plant-pollinator interactions over 120 years, driven by climate-induced habitat changes and reduced flowering. Such declines force colonies to reduce resource allocation to non-essential members, including drones, during times of scarcity.

Czekońska et al. (2015) demonstrated that colonies experiencing limited pollen resources during the reproductive season produced significantly fewer drones. Those drones that were produced exhibited smaller body sizes and reduced vigor, compromising their reproductive performance.

The quality of pollen, which serves as the primary protein source for honeybees, is critical for drone development. Climate change alters the nutritional composition of available pollen, affecting drone health. Research by Descamps et al. (2021) showed that the protein content of pollen varies by plant species, and climate change-induced shifts in floral composition reduce the availability of high-protein pollen. Drones reared on low-quality pollen had reduced body weights and lower sperm production. Drones reared in colonies with nutrient-poor diets showed a 25% reduction in sperm viability compared to those fed nutrient-rich pollen (Rangel& Fisher, 2019). Climate change alters the timing of flowering events, often creating mismatches between colony needs and resource availability. Villagomez et al. (2013) reported that warmer springs led to earlier blooming of plants, while honeybee colonies emerged too late to fully exploit these resources. This mismatch results in reduced pollen intake during critical periods for drone rearing.

A study by Malfi et al. (2019) found that colonies subjected to early-season floral resource scarcity prioritized worker production over drones, reducing reproductive output. During periods of nutritional stress, colonies often cull drones to conserve resources for workers and brood. Boes (2010) reported that colonies experiencing drought-induced pollen shortages culled up to 50% of drones during stress periods. This adaptive strategy, while beneficial for short-term colony survival, limits long-term reproductive capacity.

Research by Boes (2010) highlighted that drones represent a significant energetic cost to colonies, requiring disproportionately high food intake compared to workers. As floral resources become scarce, colonies prioritize feeding workers over drones, leading to increased drone mortality. Nutritional deficits during larval and pupal stages have cascading effects on adult drone health and reproductive success. Czekońska et al. (2010) found that drones reared in colonies with limited pollen access exhibited a 40% reduction in sperm quality, significantly impairing their reproductive potential.

Drones with poor larval nutrition also showed reduced flight endurance and success in mating flights, as demonstrated by Castellanos-Zacarías et al. (2024). Poor flight performance lowers the probability of successful mating with queens, further compromising colony genetics.

Habitat loss and fragmentation, exacerbated by climate change, further reduce the availability of floral resources for honeybee colonies. A study by Wilson et al. (2016) highlighted that climate-induced habitat fragmentation reduces forage diversity, forcing colonies to rely on monocultural crops or invasive plant species. This lack of dietary diversity negatively affects drone development and survival. As floral resources become scarcer, increased competition among pollinators limits the amount of pollen and nectar available to honeybees. Maia-Silva et al. (2021) observed that heightened competition reduces colony-wide pollen stores, leading to fewer drones being reared.

The scientific evidence underscores the critical role of floral resource availability and nutritional quality in supporting drone development and reproductive success. Climate change-induced resource scarcity forces colonies to adapt by prioritizing worker bees over drones, compromising their reproductive output and long-term viability. Addressing these challenges requires habitat restoration, the promotion of forage diversity, and mitigating the broader effects of climate change.

5. Dısruptıon Of Reproductıve Tımıng And Behavıors

Reproductive success in honeybees depends on precise synchronization of seasonal cycles, drone and queen readiness, and mating behaviors. Climate change disrupts these delicate dynamics through altered seasonal cues, extreme weather events, and habitat fragmentation. Scientific studies highlight how these disruptions impact drone bees and overall colony reproduction, emphasizing the cascading effects on honeybee populations.

Seasonal cycles play a critical role in coordinating drone and queen reproductive readiness. Climate change alters these cycles, leading to mismatches between drone production and queen mating flights. Chang (2024) documented how unseasonal warming caused plants and pollinators, including honeybees, to emerge earlier in the season. Colonies often respond by producing drones prematurely. However, queens may not be ready for mating, leading to reduced reproductive success. Boes (2010) reported that erratic weather patterns, including sudden cold snaps, delayed drone maturation in some colonies, reducing the pool of viable drones during queen nuptial flights. This delay forces queens to mate with fewer drones, resulting in diminished genetic diversity.

Mating flights are crucial for honeybee reproduction but are highly sensitive to weather conditions. Drones and queens require specific environmental parameters, such as calm winds and moderate temperatures, to successfully complete mating flights. Ayup et al. (2021) found that high temperatures during the mating season led to dehydration and reduced flight endurance in drones. These conditions resulted in fewer drones reaching drone congregation areas (DCAs) and a decline in mating success.

Research by Karbassioon et al. (2023) highlighted how sudden storms and heavy rainfall interrupted mating flights, forcing drones to return to the hive before completing mating. Such interruptions can prevent queens from obtaining sufficient sperm, reducing their reproductive lifespan. El-Niweiri et al. (2011) demonstrated that under windy or rainy conditions, drones were less likely to reach DCAs, and queens had to travel longer distances to find suitable mating partners. This increases the energy cost of mating and reduces its efficiency.

DCAs are critical for drone mating behaviors, serving as fixed locations where drones gather to mate with queens. Climate change-induced habitat fragmentation and degradation reduce the availability of these critical areas. Koeniger et al. (2005) reported that urbanization and agricultural expansion, both exacerbated by climate change, have led to a decline in suitable DCAs. This forces drones to travel greater distances, increasing energy expenditure and reducing their chances of successful mating. Studies by Koeniger et al. (2005) showed that fewer DCAs lead to overcrowding, increasing competition among drones. This dynamic often favors larger or stronger drones, potentially limiting genetic diversity within colonies.

Climate change disrupts the timing of reproductive cycles, leading to temporal mismatches between drones and queens. Czekońska and Tofilski (2020) observed that fluctuating temperatures caused by climate change delayed drone development in some colonies while accelerating it in others. This variability results in fewer mature drones being available during the optimal mating window for queens.

Queens mated under conditions of low drone availability received fewer sperm, which reduced their egg-laying capacity and shortened their lifespan. This effect is directly linked to colony instability and increased swarming behavior (Rangel and Fisher, 2019). Climate-induced stress affects the physiological and behavioral readiness of drones, reducing their success during mating flights.

Drones exposed to fluctuating environmental conditions showed decreased flight performance and altered navigation behaviors, reducing their chances of successfully locating and mating with queens. Environmental stress caused by erratic weather resulted in drones with impaired flight capabilities and lower stamina, leading to decreased mating success (Neves et al., 2011). This effect compromises the reproductive health of the colony.

Scientific evidence underscores the critical role of synchronized reproductive timing and behaviors in honeybee colonies. Climate change disrupts these processes through phenological mismatches, extreme weather events, and habitat fragmentation, leading to reduced mating success and genetic diversity. These disruptions highlight the urgent need for habitat conservation, climate mitigation strategies, and ongoing research to support honeybee resilience.

6. Effects Of Clımate Change On Dıseases And Parasıtes In Drones

Rising temperatures and changing climate patterns enhance the reproduction and survival rates of honey bee pathogens, such as Nosema apis and Nosema ceranae. Higher temperatures can boost the development and transmission of Nosema spores, which negatively affect drone health, reducing their lifespan and fertility (Martín-Hernández et al., 2009).

The parasitic mite Varroa destructor, a major threat to honey bees, thrives under warmer conditions. Varroa mites preferentially infest drone brood due to their extended developmental period, leading to increased parasite loads in drones. This results in weakened drones with impaired sperm quality and reduced mating success (Conlon et al., 2010). Additionally, warmer winters allow Varroa populations to remain active year-round, compounding their impact on colonies (McAfee et al., 2024).

Climate change can disrupt the balance between drones and their associated microbiomes, making them more vulnerable to infections. Environmental conditions can stress drones, impairing their immune responses and increasing their susceptibility to viral infections, such as Deformed Wing Virus (DWV) and Black Queen Cell Virus (Morfin et al., 2020).

Longer active seasons due to climate warming result in prolonged reproductive periods for parasites and pathogens. This increases the exposure of drone bees to these threats over time. Research by Yañez et al. (2012) highlights that higher temperatures can amplify DWV replication, especially in drone bees, which are more prone to Varroa-mediated virus transmission.

Extreme heat events can interfere with the normal development of drone bees, including those in parasitized brood cells. Heat stress may compound the effects of parasitism, resulting in drones with reduced body size and lower mating competitiveness (Rangel & Fisher, 2019). Climate change facilitates the spread of diseases and parasites into new regions. For instance, Tropilaelaps mites and Varroa destructor, which primarily affect drones in brood, are expanding their geographic range due to warmer climates, posing new challenges for drone survival and colony sustainability (de Guzman et al., 2016).

7. What Should Be Done To Alleviate The Pressure Of Climate Change On Drones And Honey Bee Colonies

The profound impacts of climate change on drone bees and honeybee colonies demand immediate action to mitigate threats to global pollinator health and ecosystem stability. Addressing these challenges requires a multi-faceted approach involving research, conservation efforts, and policy reforms. Scientific studies provide a foundation for actionable strategies to safeguard honeybees against the consequences of climate change. We can list these strategies as follows:

***Promoting Climate-Resilient Beekeeping Practices**

Adaptation strategies in beekeeping can help mitigate the effects of climate change on honeybee colonies.

***Use of Shade and Temperature Control:** Placing hives under shade or using insulated hive designs reduced the impact of heatwaves on colony health. Temperature-regulated hives preserved optimal brood conditions, improving drone development (Al-Rajhi, 2017).

***Supplemental Feeding During Resource Scarcity:** Providing protein-rich supplements during periods of resource scarcity improved drone production and sperm viability. Supplemental feeding can help offset nutritional deficits caused by declining floral resources (Rana, 2024).

***Enhancing Habitat and Floral Resource Diversity**

Conserving and restoring habitats is critical to providing the floral resources needed for honeybee colonies to thrive.

***Planting Climate-Resilient Forage Crops:** A study by Trunschke et al. (2024) highlighted the importance of diverse, climate-resilient flowering plants in supporting pollinator health. Mixed-species plantings ensure continuous pollen and nectar availability, even under variable climate conditions.

***Creating Pollinator Corridors:** Establishing corridors of native vegetation between fragmented habitats increased forage availability and supported higher pollinator densities, reducing stress on honeybee colonies (Zhang et al., 2022).

***Reducing Pesticide Use and Promoting Sustainable Agriculture**

The synergistic effects of climate change and pesticide exposure amplify threats to honeybee health. Reducing pesticide use can mitigate these combined impacts.

***Integrated Pest Management (IPM):** Implementing IPM strategies reduced colony exposure to harmful chemicals, preserving drone fertility and overall colony health. IPM also promotes the use of biological pest control methods, which are less disruptive to bees (Somerville & Laffan, 2015).

***Promotion of Organic Farming:** Organic farms supported 30% higher pollinator species richness compared to conventional farms. This enhanced biodiversity provides better forage quality and quantity for honeybees (Nicholls & Altieri, 2013).

***Advancing Research on Honeybee Resilience**

Research is critical to developing innovative solutions for mitigating climate change impacts on honeybees.

***Genetic Breeding for Resilience:** Spivak and Reuter (2005) emphasized the potential of selective breeding programs to produce honeybees with traits such as thermal tolerance, disease resistance, and improved resource utilization. Such programs can help colonies adapt to changing environments.

***Monitoring Climate Impact on Pollinators:** Research by Potts et al. (2010) called for the establishment of long-term monitoring programs to track climate-induced changes in pollinator populations. These programs enable early detection of emerging threats and inform targeted interventions.

***Policy and Community Engagement**

Policy initiatives and community action play a vital role in addressing climate change and its impact on honeybees.

***Global Pollinator Initiatives:** Advocated for international collaboration to address pollinator declines, including the establishment of protected areas and policies that promote sustainable land use.

***Mitigating Broader Climate Change Impacts**

Efforts to address the root causes of climate change are crucial for safeguarding honeybee populations and the ecosystems they support.

***Reducing Carbon Emissions:** The Intergovernmental Panel on Climate Change (IPCC, 2021) emphasized that reducing greenhouse gas emissions is critical to slowing climate change and preserving global biodiversity, including pollinators (Allan et al., 2023).

***Reforestation and Carbon Sequestration:** Research by Fargione et al. (2021) demonstrated that large-scale reforestation efforts not only mitigate climate change but also provide critical habitats for pollinators, ensuring sustainable floral resources.

The challenges posed by climate change to drone bees and honeybee colonies are urgent and multifaceted. Addressing these threats requires a combination of adaptive beekeeping practices, habitat restoration, pesticide reduction, and broader climate mitigation efforts. Scientific studies underscore the importance of taking immediate, evidence-based action to protect honeybees and the critical ecosystem services they provide. By mobilizing researchers, policymakers, and communities, we can create a resilient future for honeybee populations and the environments they support.

8. CONCLUSION

The interconnectedness of climate change, drone bee health, and the future of honeybee colonies underscores a pressing environmental challenge that extends beyond the confines of apiaries. As climate patterns shift, drones integral to colony reproduction and genetic diversity face multifaceted threats that could jeopardize their survival and, consequently, the sustainability of honeybee populations. From rising global temperatures and altered seasonal cycles to increasing disease prevalence and habitat disruption, the impacts of climate change manifest in ways that destabilize both individual drone bees and the broader colony ecosystem.

One of the most critical challenges is the disruption of reproductive dynamics. Drone bees, whose sole biological role is to fertilize queens during mating flights, are uniquely vulnerable to environmental stressors. Temperature extremes and erratic weather patterns interfere with their development, mobility, and survival. Changes in the availability of floral resources further compound these issues, as inadequate nutrition during larval and adult stages weakens drones and reduces their reproductive viability. Such challenges may result in reduced queen fecundity, compromised genetic diversity, and diminished colony resilience factors that collectively threaten the long-term stability of honeybee populations.

The increasing prevalence of diseases and parasitic infestations exacerbates these reproductive and ecological challenges. Pathogens such as the deformed wing virus (DWV), often vectored by the parasitic mite Varroa destructor, disproportionately affect drone bees, whose compromised immune systems make them susceptible. Rising temperatures and longer active seasons for parasites intensify these risks, amplifying colony stress and mortality. As drone health deteriorates, the cascading effects on queen quality, brood viability, and colony structure become unavoidable, further highlighting the fragile equilibrium within honeybee communities.

In addition to reproductive challenges, climate-induced changes in resource availability and foraging behavior significantly impact colony dynamics. Seasonal mismatches between plant blooming periods and colony activity cycles create food shortages, affecting all members of the colony but disproportionately stressing drones due to their reliance on worker bees for sustenance. During periods of resource scarcity, colonies may prioritize survival over reproduction, often expelling drones to conserve energy. This adaptive response, while essential for short-term survival, poses long-term risks to genetic renewal and colony vitality.

Addressing the challenges posed by climate change to drone bees and honeybee colonies requires a multifaceted approach. First, enhanced research into the biological and ecological impacts of climate variables on honeybees is critical to developing targeted mitigation strategies. Improved understanding of drone bee physiology, reproductive behavior, and stress responses will enable beekeepers to adapt management practices accordingly. Additionally, habitat restoration efforts, such as planting diverse, climate-resilient forage plants, can provide consistent and high-quality nutrition for honeybee colonies, supporting drone health and overall colony stability.

On a broader scale, combating climate change itself is paramount. Reducing greenhouse gas emissions and implementing sustainable agricultural practices can help mitigate the environmental stressors that directly and indirectly impact honeybee populations. Policymakers, researchers, and beekeepers must collaborate to create supportive frameworks that prioritize the protection of pollinators as an integral component of global food security and biodiversity conservation.

In conclusion, the future of drone bees and honeybee colonies is inextricably linked to the trajectory of climate change. These essential pollinators, whose health and reproductive success are critical to both natural ecosystems and agricultural systems, face an uncertain future as environmental pressures escalate. However, through concerted efforts in research, conservation, and climate action, it is possible to safeguard honeybee populations and ensure the resilience of ecosystems and food systems that depend on them. Protecting drone bees is not merely an ecological necessity but a responsibility to secure the balance of life for future generations.

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CHAPTER 3

A GENERAL APPROACH TO PERGA (BEE BREAD)

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1. INTRODUCTION

Perga is a unique bee product formed by the fermentation of pollen by bees, commonly known as bee bread. This product, which emerges as a result of bees' survival and colony health protection strategies, draws attention with both its nutritional value and therapeutic effects. Perga has an important place in terms of human and bee health, especially because it contains many beneficial components such as phenolic compounds, biologically active substances, proteins, vitamins and minerals (Kieliszek et al., 2018). Perga, which plays a critical role as an energy and protein source for bees, is evaluated by humans in apitherapy and as a functional food.

Perga, unlike other bee products known for its use in apitherapy, is in a form where both digestibility and nutritional value are increased through fermentation. This unique fermentation process softens the wall structure of pollen grains, increasing their bioavailability and also providing them with probiotic properties (Olofsson and Vásquez, 2008). In this way, it is known that perga has positive effects on the human digestive system and supports the microflora balance (Gilliam et al., 1974).

In this review article, the formation process, chemical composition, nutritional properties, therapeutic effects and biological benefits of perga are discussed in detail. In addition, its importance in bee and human nutrition and its usability together with other bee products are also examined. Its potential in apitherapy, its role in traditional and modern medicine and its place in scientific research are emphasized as one of the core themes of this article. The increasing scientific interest, especially in recent years, reveals the applicability of this product in a wider range.

2. What Is Perga (Bee Bread) And How Is It Formed?

Perga is a bee product that bees mix the collected pollen with honey and bee secretions and place in honeycomb cells and leave to ferment. The basis of the fermentation process is the enzymes secreted by the bees and the lactic acid bacteria. In this process, the hard exine layer of the pollen softens, its bioavailability increases and perga becomes a durable food (Olofsson and Vásquez, 2008). This unique transformation is one of the main characteristics that make perga valuable for both bees and humans.

Lactic acid fermentation, pergaya It provides probiotic properties, which contribute to the microbial balance of bee colonies. Its microbial structure includes bacteria and yeasts such as Lactobacillus, Bifidobacterium and Saccharomyces. These microorganisms both preserve the pollen and enrich its nutritional value by producing lactic acid and other organic acids during fermentation (Gilliam et al., 1974).

During the fermentation process, carbohydrates, proteins and phenolic compounds, which are structural components of pollen, are transformed. The pH decreases under the influence of lactic acid bacteria, which prevents the development of pathogenic microorganisms. At the same time, as a result of fermentation, the antioxidant properties of perga increase, making bees more resistant to diseases.

During the formation process of perga, the addition of bee secretions and honey to pollen initiates fermentation. During this process, which continues for an average of two weeks in the honeycomb cells, the hard structures of the pollen soften and become more digestible. After fermentation is complete, perga has a dark brown or yellowish color and a unique aroma. This product not only meets the energy needs of the bees, but also contributes to the general health of the colony.Finally, the biochemical transformations that occur in perga increase the nutritional content of the product and ensure its long-term durability. For this reason, perga is considered a versatile and valuable food source for both bees and humans.

Perga is formed as a result of pollen being collected by bees, mixed with honey and bee secretion and left to ferment in the honeycomb cells. This process is carried out by the effect of lactic acid bacteria and the pollen becomes more durable and nutritious (Olofsson and Vásquez, 2008). Thanks to lactic acid fermentation, pergada Probiotic properties are acquired, which provides positive effects on the human digestive system (Gilliam et al., 1974).

Bacteria (such as Lactobacillus, Bifidobacterium) and yeast species (Saccharomyces, Candida) found in the structure of perga contribute to the fermentation process. During fermentation, the wall structure of pollen softens and bioavailability increases (Campos et al., 2010). At the end of this process, perga becomes a durable and nutrient-rich product.

3. Importance Of Perga In Bee Nutrition

Perga is not only a source of protein and energy for bee colonies, but also an indispensable building block for a healthy colony. Perga plays a vital role in the basic processes of the colony, such as the growth of larvae, the endurance of worker bees and the reproductive capacity of the queen bee. The essential nutrients found in perga ensure the rapid growth of young bees and support the metabolic processes of older bees. In particular, the healthy development of larvae is possible thanks to the rich protein and amino acid content of perga (Gümüs and Karslı, 2024; Kieliszek et al., 2018).

Bee colonies are known for their ability to adapt to environmental conditions, but this adaptation is based on a strong nutritional regime. Perga is an ideal source for meeting the energy requirements of bees. Thanks to its high carbohydrate content, bees meet their energy needs and perform activities in the comb (Gilliam et al., 1974). At the same time, lipids play a critical role in tissue renewal and increasing energy reserves. During the winter months, the energy provided by perga helps the colony survive low temperatures and allows the bees to maintain their mobility during the hibernation period (Pascoal et al., 2014).

The importance of perga is not limited to providing energy and protein. The phenolic compounds it contains support the immune system of bees and provide protection against pathogenic microorganisms (Markiewicz-żukowska et al., 2013). Lactic acid and other organic acids formed during the fermentation process balance the intestinal flora of bees and increase their resistance to diseases. This is an important factor that increases the survival rate of colonies, especially during stressful periods and disease outbreaks (Bakour et al., 2017).

Compared to pollen, pergada biodiversity and nutritional content are much higher. The fermentation process increases the digestibility of pollen and maximizes bioavailability (Campos et al., 2008). Enzymes and lactic acid bacteria from bee secretions break down the hard exine layer of pollen, allowing the nutrients it contains to be digested more easily. In addition, probiotic microorganisms found in perga strengthen the microflora that supports the general health of bees (Olofsson and Vásquez, 2008).

As a result, perga is not only a food source, but also a component that maintains the long-term health and sustainability of bee colonies. The effects of perga on bee health are increasingly gaining attention in modern beekeeping practices. The current increased interest in perga allows us to understand the potential of this valuable product more broadly. Future research could further explore the effects of perga on colony resilience and productivity.

4. Importance Of Perga In Human Nutrition

The nutritional benefits of perga for humans have been extensively demonstrated in various scientific studies. It is a versatile food that contributes to human health with its rich chemical composition, strong antioxidant, antimicrobial and anti-inflammatory effects. The prominent nutritional properties of perga are as follows:

• **Amino Acids**: Essential amino acids found in perga play an important role in protein synthesis and muscle repair. Branched-chain amino acids, especially valine, isoleucine and leucine, help muscle recovery after physical activity (Pascoal et al., 2014).

• **Vitamins**: While B group vitamins (B1, B2, B6) support metabolic activities, vitamins C and E show strong antioxidant effects and reduce cell damage caused by free radicals.

• **Minerals:** Minerals such as calcium, iron, magnesium, potassium and zinc are vital for bone health, blood circulation and the nervous system. Iron may reduce the risk of anemia by contributing to the production of red blood cells.

• **Phenolic Compounds:** Phenolic acids and flavonoids found in perga reduce oxidative stress through their antioxidant effects. These components may also help reduce inflammation and lower the risk of chronic diseases (Markiewicz-żukowska et al., 2013).

Perga's Its probiotic effects are another prominent feature. Lactic acid bacteria produced during the fermentation process regulate the digestive system microflora and suppress harmful microorganisms. This supports digestive health and strengthens the immune system.

In addition, carbohydrates in perga can be used quickly by the metabolism as an energy source. This feature supports energy levels in situations requiring high physical performance. Lipid content is critical for cell membrane structure and hormonal balance.

Perga, widely used in apitherapy, may be beneficial in preventing cardiovascular diseases due to its antioxidant and anti-inflammatory effects. Its immune system-supporting properties are important in protecting against infections. Its high digestibility makes perga both a food that supports general health and a functional product that can find a place in modern nutrition regimes.

5. Chemical Composition And Nutritional Content Of Perga

The chemical composition of perga has a versatile structure that distinguishes it from other bee products. Factors such as geographical region, plant diversity and seasonal differences can affect the amount of nutrients found in perga. However, in general, the main components of perga are:

5.1. Macro and Micronutrients

The chemical composition of perga is quite rich and contains macro and micro nutrients that are beneficial to human health. These nutrients have both energy-providing and metabolism-supporting properties. Here are the basic macro and micro nutrients found in perga;

• **Proteins:** The protein content in perga varies between 20-25% and these proteins are especially rich in essential amino acids. Branched-chain amino acids such as valine, isoleucine and leucine support muscle protein synthesis and increase physical endurance (Pascoal et al., 2014; Kieliszek et al., 2018). These proteins also help strengthen the immune system.

• **Carbohydrates:** Carbohydrates in perga play a critical role in providing energy. Simple sugars such as glucose and fructose, which are usually found at 35-50%, are a quick source of energy. During the fermentation process, some of these sugars are converted into organic acids by lactic acid bacteria and are added to perga. provides probiotic properties (Campos et al., 2008; Gilliam et al., 1974).

• **Fats:** Perga contains 1-5% oil and these oils are rich in unsaturated fatty acids. Omega-3 and omega-6 fatty acids protect the structure of cell membranes and provide anti- inflammatory effects (Markiewicz-żukowska et al., 2013).

• **Vitamins:** Perga contains vitamins B1, B2, B6, C and E. These vitamins support metabolic processes, provide antioxidant protection and improve overall health. Vitamin C in particular is an important component that strengthens the immune system (Bakour et al., 2017).

• **Minerals:** Among the minerals in perga, calcium, magnesium, potassium, iron and zinc stand out. While calcium supports bone health, iron reduces the risk of anemia. Zinc ensures the proper functioning of the immune system (Ciric et al., 2022).

As a result, the macro and micro nutrients contained in perga have properties that both support energy production and strengthen the immune system. This rich nutritional profile makes perga both a valuable food for human health and an important product used in apitherapy.

5.2. Phenolic Compounds and Antioxidants

In Perga Phenolic compounds are the main components that stand out with their antioxidant and anti-inflammatory effects. These components prevent cell damage by neutralizing free radicals and reduce the risk of chronic diseases. The effectiveness of phenolic compounds increases during the fermentation of pollen, which gives perga a unique antioxidant potential (Markiewicz-żukowska et al., 2013; Bakour et al., 2017).

5.2.3 Phenolic Acids and Their Effects

• **p - Coumaric Acid:** This phenolic acid, which has a high antioxidant capacity, neutralizes free radicals and plays a critical role in reducing oxidative stress. It can also accelerate the healing process in tissues by reducing inflammation (Campos et al., 2008).

• **Cinnamic Acid and Derivatives:** These compounds are lipid It contributes to the protection of cell membranes by preventing peroxidation and may reduce the risk of cardiovascular diseases (Kieliszek et al., 2018).

5.3. Flavonoids and Their Antioxidant Capacities

Flavonoids are one of the main components of perga and are known for their strong antioxidant effects. The following flavonoids stand out:

• **Kaempferol:** It has antioxidant and anticarcinogenic effects. Studies have shown that kaempferol can reduce the risk of cancer and helps reduce oxidative stress (Zerdani et al., 2011).

• **Quercetin:** This compound provides positive effects on the immune system by providing anti-inflammatory effects. It also prevents DNA damage and supports cell renewal (Pascoal et al., 2014).

5.4. Antioxidant Effects and Chronic Diseases

In Perga the antioxidant effects of phenolic compounds can reduce disorders related to oxidative stress. It is reported that pergamon plays a supporting role in disorders such as cardiovascular diseases, diabetes and neurodegenerative diseases (Campos et al., 2008; Markiewicz-żukowska et al., 2013).

5.5. Synergy of Bioactive Ingredients

phenolic compounds, other bioactive compounds found in perga with components It works synergistically and increases total effectiveness. Antioxidants such as carotenoids and vitamins C and E are important components that support this synergy (Bakour et al., 2017). This combination makes pergan a valuable product that can be used both as a functional food and in apitherapy.

5.6. Future Research

The antioxidant effects of phenolic compounds work synergistically with other bioactive components found in perga, increasing the overall effectiveness. More detailed investigation of these factors will allow perga to be developed as a more effective product for human health (Kieliszek et al., 2018; Pascoal et al., 2014).

5.7. Nutritional Content of Perga and Functional Food Potential

Perga has great functional food potential. Its antioxidant, anti-inflammatory and probiotic effects make it a unique food for human health. These properties make perga While strengthening its role in apitherapy, it also enables it to gain a wider place in modern nutritional regimes.

6. Physical And Biological Properties Of Perga

6.1. Physical Features

Perga has a hard and compact structure and is usually seen in dark brown, yellow or orange tones. Changes in the physical structure of pollen during the fermentation process give perga its unique taste, smell and texture. These unique physical properties allow perga to be easily recognized by both bees and humans (Gilliam et al., 1974).

The lactic acid that results from fermentation gives perga a slightly acidic flavor and increases its durability. This feature helps perga to be stored for long periods without spoiling and makes it suitable for consumption as food. The hard and dense texture of perga causes its shape and size to vary depending on the original source of the pollen (Olofsson and Vásquez, 2008).

The physical properties of perga play a critical role in its durability process and protection against microbial deterioration. The organic acids formed by lactic acid bacteria during the fermentation process protect the hard structure of perga and prevent the settlement of pathogenic microorganisms (Kieliszek et al., 2018). In addition, the biochemical changes that occur during fermentation make perga more physically stable.

Perga also has a unique aroma. This aroma is due to the phenolic compounds, flavonoids and organic acids it contains (Markiewicz-żukowska et al., 2013). The intensity of the fermentation process, the plant source of the pollen and the participation of bees in this fermentation are the main factors affecting the aroma and taste profile of perga.

In conclusion, the physical properties of perga increase its effectiveness as a food source for bees and its value as a functional food for humans. A more detailed scientific examination of these properties will contribute to a better understanding of the storage and usage possibilities of perga.

6.2. Antimicrobial and Antiviral Properties

Perga's Its antibacterial and antiviral effects are due to the phenolic compounds, flavonoids, organic acids and lactic acid bacteria it contains. Lactic acid bacteria produce lactic acid during the fermentation process in perga, lowering the pH and preventing the proliferation of pathogenic microorganisms (Gilliam et al., 1974; Olofsson and Vásquez, 2008). The low pH value of perga provides effective protection against bacterial and fungal infections.

Phenolic compounds, especially flavonoids and phenolic acids, have the potential to suppress microorganisms. Studies have shown that these components found in perga have an effect on Escherichia coli, Staphylococcus aureus and Candida albicans (Zerdani et al., 2011; Pascoal et al., 2014). Flavonoids can prevent microorganisms from reproducing by damaging their cell membranes. In addition, the antimicrobial effect of tannins in perga has shown that it is effective against a large part of pathogenic bacteria.

Its effects on viruses have been observed especially on RNA and DNA-based viruses. The phenolic acids and flavonoids found in perga can prevent viruses from entering the cell or suppress the replication process. These effects are effective against influenza and herpes. This has been supported by studies focusing on common pathogens such as simplex viruses (Bakour et al., 2017; Campos et al., 2008).

In Perga Another important source of antimicrobial effects is organic acids. Components such as lactic acid, acetic acid and propionic acid provide a protective effect on both bee health and humans by preventing the proliferation of harmful microorganisms (Kieliszek et al., 2018).

As a result, the perga The synergistic effect of phenolic compounds, lactic acid bacteria and organic acids makes it a natural product with both antimicrobial and antiviral potential. These properties of perga supports its wide use in apitherapy and functional food applications.

6.3. Antioxidant Properties

Perga is a versatile food that prevents cell damage by neutralizing free radicals with its rich antioxidant content. Antioxidant components such as phenolic acids, flavonoids, carotenoids and vitamin C are the main active ingredients in perga. These components play a very important role in reducing oxidative stress and supporting cell regeneration (Campos et al., 2008; Kieliszek et al., 2018).

Phenolic compounds can help neutralize free radicals in the body, reducing the risk of chronic diseases such as cardiovascular disease, diabetes, and neurodegenerative diseases (Markiewicz-żukowska et al., 2013). In addition, the anti-inflammatory effects of phenolic acids can accelerate the healing process in tissues and reduce the overall level of inflammation in the body.

Components such as kaempferol and quercetin, which are among the flavonoids, further increase the antioxidant capacity of perga. These components are lipid It protects cell membranes by preventing peroxidation and prevents DNA damage (Zerdani et al., 2011; Pascoal et al., 2014). Carotenoids are an important component that supports eye health and play an effective role in skin protection.

Antioxidants found in perga can also increase resistance to infections by supporting the immune system (Gilliam et al., 1974). The fact that antioxidant content varies depending on geographical sources and plant species emphasizes the rich bioactive potential of perga. In general, perga attracts attention as a critical component in modern nutrition and apitherapy practices.

6.4. Biological Benefits of Perga

Perga attracts attention not only with its physical and chemical properties but also with its biological benefits. Thanks to its probiotic content, it supports the human and animal digestive system. With the effect of lactic acid bacteria, the number of beneficial bacteria in the digestive tract increases while the growth of harmful microorganisms is suppressed. This is important for the protection of digestive system health and the strengthening of the general immune system.

Additionally, nutrients in perga can increase physical endurance by supporting energy levels. It can play a supporting role in treating conditions such as chronic fatigue, stress, and low energy. These biological benefits make perga a unique food source for both humans and bee colonies.

7. CONCLUSION

The chemical and biological properties of perga clearly show that it is a unique food source for both bees and humans. It provides energy, protein and immune support for bees, while it has potential as a functional food and therapeutic product for humans. The lactic acid fermentation process It not only provides probiotic properties, but also strengthens antioxidant, anti-inflammatory and antimicrobial effects by increasing the effectiveness of phenolic compounds (Olofsson and Vásquez, 2008; Gilliam et al., 1974).

Scientific research, pergadaki phenolic compounds and flavonoids It has been shown that perga is effective in reducing oxidative stress and thus may reduce the risk of chronic diseases such as cardiovascular diseases, diabetes and neurodegenerative disorders (Markiewicz-żukowska et al., 2013; Bakour et al., 2017). These properties make perga a critical element in modern nutritional approaches and apitherapy applications.

The need for perga in bee nutrition becomes more evident especially in stressful environmental conditions and disease outbreaks. Research has shown that perga confirms that probiotic microorganisms support the intestinal health of bees and provide protection against pathogens (Campos et al., 2008; Kieliszek et al., 2018). However, The positive effects of bioactive components on human health position it not only as a nutritional source but also as a therapeutic product.

More research is needed to fully understand the medicinal and nutritional potential of perga, especially the geographical origin, botanical sources and fermentation process of perga. Its effects on bioactive compounds need to be studied in more depth. Additionally, more clinical studies on perga are important to understand the long-term effects of this product on human health.

As a result, perga offers a wide range of uses in both traditional and modern applications. In addition to the opportunities it offers as a functional food

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CHAPTER 4

THE IMPORTANCE OF BEEKEEPING IN TÜRKİYE'S CLIMATE POLICIES

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1.INTRODUCTION

Although the world's climate seems to have remained unchanged over the years, it does not actually have a static structure. Climate change, one of the global problems, has direct effects such as temperature increases, extreme weather events and sea level rise; in addition to indirect natural ecosystems such as agriculture, forests and animal husbandry, it also leads to far-reaching results that affect biodiversity and human life. Increasing human activities in areas such as industry, transportation, agriculture and energy increase greenhouse gas emissions into the atmosphere and strengthen the greenhouse effect. As a result, temperatures are increasing all over the world (Doğan & Tüzer, 2011). In the report prepared by the IPCC in 2018, it is predicted that global warming, which has reached 1 °C today, will reach 1.5 °C by 2040. In addition, it has been reported that this increase in global warming will cause the depletion of already scarce water resources, the rise of sea levels due to rapidly melting glaciers, the depletion of food stocks and the emergence of famine, and the migration of people (Öztürk & Öztürk, 2019). One of the most striking issues of the twenty-first century, global warming, is one of the main causes of 75% of which is urbanization, transportation, and industry due to the use of fossil fuels; the remaining 25% is agricultural activities (Houghton, 2005). Global climate change triggered by global temperature causes stress conditions in plants. Plants respond to abiotic stress conditions such as drought, heat, salinity, and excessive precipitation with physiological and metabolic changes, ensuring that their growth and development are minimally affected (Örs &Ekinci, 2015). Beekeeping has a special place in climate change discussions due to both the critical role it plays in the protection of biodiversity and the importance it carries for the sustainability of agricultural production. Our country's biodiversity and ideal climate make it one of the countries with the highest potential for beekeeping (Sakarya &Çevrimli, 2018).

Türkiye has taken a series of steps to combat climate change in recent years by creating national regulations and participating in international environmental agreements. Türkiye has demonstrated its commitment to global responsibilities in combating climate change by ratifying the Paris Agreement and adopting the 2053 net zero carbon target (Demir, 2022). However, the implementation of these targets largely depends on the establishment of sectoral adaptation policies.

2. Beekeeping and Ecosystem

Bees play a role in food security due to their role in the continuity of the ecosystem and the production of foods such as honey, pollen, and royal jelly through the pollination function of plants. When the natural structures of plants are disrupted, problems in bee products, as in many agricultural products, are inevitable. Since bees are the main actors of the pollination process in natural environments, they are very important for the protection of biodiversity and the increase in agricultural production (Özbek, 2003). However, due to the complex effects of climate change, bee populations and their life cycles are at risk. Due to factors such as seasonal changes, temperature changes and the decrease in vegetation, bees' natural habitats are shrinking. This situation makes it difficult for bees to reach food sources and has a detrimental effect on population dynamics. In addition to endangering global food security and ecological sustainability, this situation also causes financial losses for the beekeeping sector. In this context, beekeeping is considered a critical sector for rural development and biodiversity protection (Kambur & Kekeçoğlu, 2018).

It can be said that the beekeeping sector in Türkiye has some advantages compared to other sub-sectors of animal husbandry. Climate changes and globalization experienced worldwide increase the pressure on agricultural production, and the beekeeping sector is also negatively affected by this situation. Bees have been living under great stress, especially in the last few years. This situation is shown among the reasons for the decrease in honey yield despite the increase in colony numbers.

Bees are of great importance for the sustainability of ecosystems and the protection of biodiversity. Pollination is a fundamental process for the survival of our ecosystems, and approximately 90% of the world's wild flowering plant species depend entirely or at least in part on the role played by bees, butterflies, bats and hummingbirds in pollination. Pollinators not only directly contribute to food security, but are also key to preserving biodiversity (Bozkurt, 2019, Kuvancı, 2022).

Beekeeping sector has a great potential in Türkiye due to its rich flora and these activities contribute significantly to ecosystem services. However, pesticide use, habitat loss and climate change Factors such as these threaten bee populations and disrupt the ecosystem balance. In this context, policies should be developed to increase the ecological contribution of beekeeping and reduce dangers.

The mass bee deaths experienced in Canada and Austria in recent years have become dangerous. It is thought that production can be increased by using organic, sustainable farming techniques and controlling the widespread use of pesticides related to industrial agriculture. In addition to honey production, the production and trade of royal jelly, pollen, propolis, bee venom, beeswax, and package bees is a necessity in order to reduce the risks that will arise from a possible decrease in honey yield and to prevent producers from suffering losses (Yavuz & Dilek, 2019).

3. Beekeeping Policies in Our Country

Türkiye is a country with great potential in terms of beekeeping. Our country's beekeeping sector, which develops every year, is a dynamic livestock sub-sector with an increasing production volume, hives and number of beekeeping enterprises day by day. Beekeeping is a sector with an increasing economic added value for our country. The beekeeping sector in Türkiye has generally developed in geographies where industrialization is low and rural areas cover a large area. Honey production has become an important economic sector in Türkiye thanks to the suitable climate conditions and floral resource diversity.

The economic and social problems that have emerged with the population growth and globalization process in the world will significantly affect all sectors, especially agriculture. Suggestions for policy determination in overcoming these problems in the beekeeping sector in our country are listed below.

- Reducing the unit cost in the production phase, establishing a standardized production type and integrating technological developments into the activity will lead to animal welfare and an increase in yield and quality. Products produced in this way will help strengthen demand in the foreign market, and honey exports will also increase with the policies to be organized for foreign trade.

-The growth rate of the beekeeping sector, which is supported by many different institutions and organizations, is slowing down especially under the pressure of environmental factors. Increasing the growth rate can be achieved by revealing the effectiveness of the policies implemented and directing the support areas according to this effectiveness. The number of applications such as courses, grant programs, low-interest loans that will encourage and encourage young entrepreneurs and women to take part in the activity should be increased, and the sector should be supported more with new R&D projects.

-In Türkiye, it should be aimed to increase both the amount of honey consumption per capita and the share of honey in exports to strengthen the country's economy. In line with these goals, new production plans should be made and effective hive management and resource use should be ensured.

- Organizing in production and marketing within beekeeping activities is a structure that will provide great benefits. In addition, the organized production model will be a step for producers on the way to branding small businesses.

- In addition to the conscious producer concept, the conscious consumer concept must be established. The quality of the honey produced by the businesses must be controlled, food controls must be increased, and thus consumers must be protected against imitation and adulterated honey.

- The most important tool for the organization of the producer and especially for them to become effective in the market is cooperatives, as in all developed economies (Salman, et al., 2015). However, producers consider this method as the last option due to low profitability. The fact that the sales and marketing of beekeeping products are carried out with traditional infrastructure in our country causes the producer not to be able to produce products with high economic added value. In this regard, a study was conducted with beekeeping businesses in the provinces of Muğla and İzmir. Within the scope of this study, producers stated that they gained 40% profit when they marketed through wholesalers or cooperatives; 48% when they marketed to foreign sellers and 50% when they marketed to factories. Producers who bring their products directly to consumers have stated that they earn 88% from the sale of one kilo of honey. The main problems that producers experience in terms of sales and marketing are that products cannot be sold at the desired price, there is no balance between quality and price, and consumers have low awareness of the quality of honey (Çevrimli & Sakarya, 2018).

Beekeeping, as a strategic sector that supports environmental and economic sustainability, is shaped by various policies. This sector is affected by environmental and agricultural policies that aim to protect bee populations and regulate production processes. Protection of natural areas, control of pesticide use, and promotion of sustainable agricultural practices are important policy areas that support beekeeping.

In addition, national and international strategies developed to adapt to climate change aim to create adaptation mechanisms for the beekeeping sector. These policies aim to increase the role of bees in ecosystem services and strengthen the resilience of the sector against environmental threats. Supporting beekeeping makes significant contributions to both the protection of biodiversity and the provision of agricultural sustainability.

4. The Impact of Climate on the Beekeeping Industry

One of the environmental factors that has a direct impact on the beekeeping sector is climate change. The beekeeping sector is indirectly affected by Turkey's ratification of the Paris Agreement and its adoption of climate policies compatible with the 2053 net zero carbon target (Yavuz & Dilek, 2019). Sustainability of agricultural production and protection of natural resources are two goals of these policies.

Bee populations are negatively affected by the severe temperatures, unpredictable rainfall and habitat degradation caused by climate change. In addition, it is stated that human activities such as pesticide use and monoculture agriculture (Cengiz, 2013) disrupt the life cycles of bees and reduce pollination efforts (Yörük &Şahiner, 2013).

The protection of natural areas and adjustment of agricultural production to climate change are the goals of Türkiye's national climate policies. In this context, it is recommended that beekeeping activities be carried out in harmony with natural ecosystems and sustainable agricultural methods be encouraged.

Climate strategies should take into account the potential of beekeeping to reduce carbon emissions and its contribution to environmental sustainability. Therefore, beekeeping should be seen as an industry beneficial to the environment.

In order for beekeepers to benefit from state support, they must have 30 or more beehives and be a member of either the Turkish Beekeepers Central Union or the Honey Producers Central Union. Regarding the support to be provided to the beekeeping sector, there are expectations from beekeeping business managers regarding increasing the support amount paid per hive, providing support according to the quality of the honey produced, providing other beekeeping products, providing transportation support to encourage production, providing quality and cheap input to beekeeping businesses, and implementing marketing support. The expectation of beekeeping businesses is that instead of a single type of support, more than one type of support is implemented, as each beekeeping business needs support in different areas (Çevrimli & Sakarya, 2018).

Legislation has been developed with regulations in the beekeeping sector, which has significant agricultural production potential in Türkiye. The purpose of the Veterinary Services, Plant Health, Food and Feed Law No. 5996 is to protect and ensure food and feed safety, public health, plant and animal health, animal breeding and welfare, taking into account consumer interests and the protection of the environment. The Beekeeping Regulation No. 28128, prepared based on Law No. 5996, includes all kinds of production, breeding, obtaining breeding material, determination of the principles on fixed and migratory beekeeping, taking necessary measures regarding bee health and transportation, standardization of tools, machinery and materials, training, project design, development of honey plants agriculture, queen bee breeding, artificial insemination of honey bees. The Ministry of Agriculture and Forestry and provincial and district directorates are the leading public institutions related to sustainable beekeeping management. According to Article 17 of the Beekeeping Regulation, provincial and district directorates are given the authority to "take the necessary measures and conduct inspections so that beekeepers can produce honey in accordance with the relevant legislation; to have the produced bees, bee products and all kinds of tools, machines, combs, hives and beekeeping materials related to beekeeping inspected by personnel trained in beekeeping and to prepare reports". According to Article 15 of the Beekeeping Regulation; "For effective and widespread combat against bee diseases and pests, central unions, provincial unions shall carry out mass pesticide application within certain programs" is stated. The "Regulation on Identification and Registration of Bee Colonies", which entered into force in 2022, is one of the legal regulations regulated in the digital sense regarding sustainable beekeeping management, and a model has been put forward for the control and inspection of bee colonies and enterprises in this regard.

The regulation aims to effectively ensure the control of bee colony movements and diseases, to determine beekeeping enterprises in order to effectively carry out programs to prevent infection of bees, and to identify and register bee colonies. In addition, within the framework of the Regulation, the principles for which the Ministry of Agriculture and Forestry, the General Directorate of Food and Control and provincial/district agriculture and forestry directorates are authorized have been determined.

5. CONCLUSION

The world has been experiencing rapid population growth for the last two hundred years, which has increased interventions aimed at increasing agricultural products. Considering that the agricultural sector is one of the sectors most affected by global warming, effective solutions should be produced in order to prevent the increasing world population from facing hunger and famine in the coming years. In this direction, modern agricultural techniques should be developed, irrigation technologies should be developed and farmers should be made aware of water use, drip irrigation should be encouraged, excessive soil tillage should be avoided, direct planting should be done, biological control against diseases and pests should be preferred in agriculture, chemical drug use should be minimized, stubble burning should not be done, organic fertilizers should be preferred as fertilizer, renewable energy sources should be used in agriculture, breeding studies should be increased, farmers and producers should be made aware of global warming and sustainable agriculture. In addition to all these measures, the implementation of inspections and incentives by all countries for the reduction of fossil fuel use and the use of renewable energy sources will be an important step in the fight against global warming.

Honeybees are in a critical position for ensuring food security through pollination. Today, climate change has various effects on environmental elements. With changing climate conditions, it affects vegetation and living creatures, and the existence of some of them is threatened. In this respect, beekeeping activities are another area that falls under the influence of climate change. Because bees have sensitive structures, their life activities depending on vegetation and their effects from sudden temperature changes put them in the influence area of climate change.

The expected changes in global climate may change the behavior and life of honeybees. Increases in temperature and humidity in the autumn will directly affect the development of honeybees and may cause problems in wintering. The most important issue today is to reduce or completely stop the production of greenhouse gases. As of today, even if the production of greenhouse gases were completely stopped, there is currently enough greenhouse gas concentration in the atmosphere to cause sufficient warming. Due to the increasing world population and growing economy, it seems quite difficult to expect greenhouse gases entering the atmosphere to decrease. Therefore, developing international cooperation as soon as possible and ensuring that decisions taken to prevent global warming are implemented by all countries without compromise should be the primary duty of every country and its citizens.

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CHAPTER 5

IMPORTANT BACTERIAL FOULBROOD DISEASES

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1. INTRODUCTION

Declines and losses in cultivated honey bee colonies have caused considerable concern due to perceptions of pollinators worldwide for their role in pollination of agricultural crops (Biesmeijer et al., 2006).

Honey bee colonies are increasingly affected by a range of stressors, including changes in climate, habitat destruction, insufficient food resources, pesticide exposure, and the prevalence of pests and diseases. These factors pose serious risks to the health and survival of bee colonies, while also undermining their capacity to carry out vital ecological roles, particularly pollination. Given that honey bees are indispensable pollinators, playing a key role in agricultural productivity and maintaining biodiversity, their decline could lead to significant environmental and economic challenges. To safeguard honey bee populations, it is crucial to identify and mitigate these stress factors, ensuring their continued survival, enhancing their efficiency, and preserving the essential ecosystem services they provide. (Gallai et al., 2009; Smith et al., 2013).

Diseases are among the primary factors contributing to colony losses and reduced productivity in honey bees. Recognizing the diseases that threaten the health of honey bees, applying protection and control methods against diseases in the best way and managing treatment processes consciously are among the most important issues for the continuity of honey bee colonies and beekeeping activities (Ritter & Akratanakul, 2006).

Honey bee colonies face significant threats from various viral, bacterial, and fungal diseases. The colony's survival relies heavily on the development of healthy individuals. A strong colony is largely determined by the presence of a high number of robust bees. However, illnesses and mortalities during the larval stage can lead to the collapse of the colony. Among these illnesses, American Foulbrood (AFB) and European Foulbrood (EFB) are particularly harmful to honey bees and the practice of beekeeping. These bacterial infections, collectively known as foulbrood diseases, specifically target the larvae, undermining colony performance, causing colony extinction, and resulting in economic losses as well as significant challenges in the pollination of crops and agricultural products on a global scale. Managing bacterial foulbrood diseases necessitates timely detection, robust biosecurity protocols, and the use of appropriate treatment methods when required. Notably, effective sampling strategies and precise laboratory diagnostics are vital for controlling the spread of these infections. (Ratnieks, 1992; Shimanuki & Knox, 2000; Genersch et al., 2010; Forsgren, 2010).

2. Amerıcan Foulbrood Dısease

2.1.Pathogen and Pathogenesis

The causative agent of the disease is the pathogenic *Paenibacillus larvae*, a motile, flagellated, spore-forming, virulent, aerobic or facultatively anaerobic, gram-positive bacterium (Alippi & Aguilar, 1998; Genersch et al., 2006). Modern molecular techniques such as PCR and 16S rRNA sequencing offer efficient and reliable solutions for detecting *P. larvae*. These methods enable rapid bacterium identification by targeting markers specific to its genetic makeup (Ashiralieva & Genersch, 2006).

The species *P. larvae* have been classified into five genotypes: ERIC I, II, III, IV, and V (Genersch et al., 2006; Beims et al., 2020). Among these, ERIC I, II are the most commonly identified *P. larvae* genotypes globally. While ERIC III, IV have not been recovered from natural settings for an extended period, certain isolates of these genotypes have been identified in bacterial culture collections (Erban et al., 2019).

The agent is not dangerous for adult honey bees, it infects honey bee larvae. *P. larvae* spores specifically target newly hatched larvae. For larvae to become infected, larvae must be fed with food containing spores in the first 36 hours after hatching (Hoage & Rothenbuhler, 1966; Wilson, 1971).

Adult bees transfer spores to the larvae, which ingest them through contaminated food during feeding. Once inside, the spores settle in the midgut, where they germinate. They then develop into vegetative cells—the active form within the larval system—and invade the hemocoel by crossing the epithelium (Yue et al., 2008). Pathogenic bacteria like *P. larvae* act as natural competitors to the probiotic bacteria in the larvae's gut microbiome. These probiotics, capable of completely sterilizing the gut microflora, are overtaken by *P. larvae*, which spreads and dominates the gut environment. By producing bacteriocins and antimicrobial compounds, *P. larvae* eliminate other microorganisms in the larval gut, enhancing the infection. During colonization of the midgut lumen, *P. larvae* use peptide antibiotics to suppress both bacterial and fungal microorganisms, ultimately establishing itself as the sole dominant bacterium in the larval gut (Stephan et al., 2020).

The presence of rapidly multiplying bacteria in the midgut causes by destruction of the epithelium. The death of larvae is caused by septicemia, infectious spores, and the failure of the immune system. When most of the larvae are infected and die, the colony's future is lost and the colony is destroyed (De Graaf et al., 2013).

2.2.Symptoms

In honeycombs with infected larvae, the lids are usually wrinkled and sunken after the death of the larvae. The honeycombs are dark brown in color due to dead larvae. Worker bees try to remove the infected and larvae from the combs, so honeycombs with punctured lids are observed. As the larvae are removed, the brood area looks disorganized and untidy. In general, when the brood area is examined, dead larvae can be seen open and closed in the honeycomb cells. This situation also creates a mosaic-like appearance on the surface of the comb with the laying of the queen. The dead larvae start from white, yellow, yellowish brown, dark brown and finally black. When the larvae in the honeycomb cells are touched with a stick, elongation is observed like a sticky thread. Dead larvae in the hive produce a characteristic bad odor. As the infection progresses, the dead larvae stick to the lower parts of the comb cells and dry out and cannot be removed by the bees. As the disease progresses, the colony weakens with a decrease in the colony population, laziness and abnormal flights are observed in the bees (Rauch et al., 2009; Genersch, 2010).

2.3.Transmission Routes

Transmission occurs in a variety of ways. Spores can be transferred to larvae by adult honey bees during the care and feeding of larvae and during cleaning of comb cells (Broodsgaard et al., 1998).

The disease can spread within and between colonies when hygienic conditions are not maintained during beekeeping activities, using contaminated beekeeping materials, using contaminated honey and pollen as food, introducing the queen of a sick colony to healthy colonies, colony exchange and transplants. The spores' durability and resistance to environmental conditions contribute to the rapid spread of the disease between colonies. Dead larvae become a dense source of bacterial spores and the risk of transmission to other colonies increases (Hansen & Brodsgaard, 1999; Lindström, 2008).

Spores exhibit remarkable resistance to extreme temperatures and various physicochemical conditions. In dried larvae and combs, endospores can retain their infectivity for as long as 35 years, while in bee products like honey, propolis, and beeswax, they remain viable for over 70 years (Haseman, 1961; Lindström, 2008).

2.4.Protection, Control and Treatment

To control the disease, it is essential to implement good agricultural practices (GAP) and good hygienic practices (GHP), which encompass all measures and procedures aimed at preventing the disease from reaching the apiaries. It is the duty and legal obligation of the competent authorities and producers to take appropriate measures and implement procedures in case of clinical symptoms and suspicion of AFB. Good practices are based on ensuring hygienic conditions in the apiary, inspection of purchased bees, daily disinfection, use of sterilized combs, control of foodstuffs, hazard analysis, and identification and inspection of critical control points (Somerville & Laffan, 2015).

When the disease is suspected, the authorities should be informed immediately, and then all necessary measures should be taken to bring the situation under control quickly. Early disease detection is one of the most critical disease control steps. After the symptoms appear, all beekeeping tools and equipment must be disinfected. The emergence of the disease, even in a single colony in the apiary, makes it necessary to check other colonies in the apiary and other nearby apiaries. In order to prevent the spread of the disease, the colonies carrying the disease must be destroyed (Mezher et al., 2021)

AFB is a very dangerous disease. Due to factors such as the resistance of the endospores of the agent to extreme conditions, its high level of contagiousness, the risks of antibiotic use, AFB cannot be cured and radical measures are taken when AFB is detected in the apiary by following legal procedures. In advanced cases, the most accurate and preferred method is to destroy the colonies carrying the disease by burning, burying the remaining residues and applying a comprehensive disinfection. For these applications, the flight hole is closed considering the evening hours when all honey bees are in the hive. The hives are moved to a point away from the apiary and burning is carried out (OIE, 2023).

If the disease is detected at an early stage, one of the commonly used treatments is shaking. The essence of this practice is to transfer adult honey bees to a clean hive (Parvanov et al., 2006). Afterwards, infected combs should be destroyed and the hive body and contaminated materials should be disinfected. The materials used in the destruction process, reusable hives are disinfected with potassium hypochlorite or alkaline hypochlorite after cleaning. After chemical cleaning, hives and materials are passed through hot water and left to dry. In the absence of chemical disinfectants, metal beekeeping equipment can be disinfected by boiling in water to which 1% ash has been added (Ratnieks, 1992).

Although some countries permit the use of antibiotics such as tylosin, lincomycin, and oxytetracycline for disease control, many others prohibit their use. Antibiotics target only the vegetative stage of the bacteria, which can lead to the development of antibiotic resistance. Furthermore, their use results in residues being left in bee products, particularly in honey (Tian et al., 2012).

Alternative methods for preventing and treating AFB are gaining increased attention. These alternatives consist of substances of natural origin that do not harm honey bee products and have no negative impact on the environment. They include, for example, probiotics, prebiotics, fatty acids, plant extracts and essential oils. These substances have been utilized for many years in preventing and treating diseases in livestock and domestic animals, and they have recently been incorporated into beekeeping practices. (Kuzyšinová et al., 2016). In the study where the effects of natural propolis extract on *P. larvae* were tested, positive results were obtained (Antúnez, et al., 2008).

The risks of antibiotic use draw attention to nanotechnology-based research as a new treatment method. Nanostructured drugs have advantageous features such as reduced side effects, slow, gradual and controlled release, and increased bioavailability (Masry et al., 2021).

Sing bacteria as preventive supplements or therapeutic agents represents a promising strategy for managing AFB. Certain bacterial species are regarded as potential biocontrol agents against AFB due to their antagonistic effects on the infectious and pathogenic characteristics of *P. larvae*. Notably, species from the genus Bacillus (*Bacillales, Bacillaceae*), known for their antibiotic production, and the genera *Lactobacillus* and *Bifidobacterium* (*Bifidobacteriales, Bifidobacteriaceae*), which produce lactic acid and other organic acids, are particularly prominent (Abdi et al., 2023).

The growing resistance to antibiotics and the effort to minimize their use have prioritized the development of alternative strategies for disease prevention and treatment. This is especially critical for diseases like American foulbrood, which cannot be effectively managed using conventional methods. One well-known approach in this context is selecting colonies where adult bees exhibit hygienic behavior toward infected larvae. While infection may still occur in these colonies, hygienic bees remove infected brood before visible symptoms of the disease develop (Spivak & Reuter, 2001).

3. European Foulbrood Dısease

3.1.Pathogen and Pathogenesis

The bacterium *Melissococcus plutonius* serves as the main causative agent of European Foulbrood (EFB) in honey bees (*Apis mellifera*), predominantly targeting them during their larval stage. *M. plutonius* is a gram-positive, microaerophilic bacterium with a coccus shape, appearing individually, in pairs, or in chains, and it does not form spores (Bailey & Collins, 1982). While *M. plutonius* is the primary pathogen responsible for the disease, secondary bacteria also accompany the infection. These secondary bacteria do not directly cause the disease but may influence the texture and odor of deceased larvae. The presence of *M. plutonius* is typically detected early in the infection, before other bacteria. These secondary bacteria include *Paenibacillus alvei, Achromobacter euridice, Brevibacillus laterosporus, Enterococcus faecalis, and Paenibacillus apiariu*s (Gaggia et al., 2015; Forsgren et al., 2018; Lewkowski & Erler, 2019). A key difference between *M. plutonius* and *P. larvae*, the causative agent of AFB, is that *M. plutonius* does not form spores. In oxygen-limited conditions, *M. plutonius* proliferates rapidly in the larval intestines, leading to death by inhibiting nutrient absorption (Forsgren, 2010). The bacterium thrives in environments with temperatures between 35-37°C and low oxygen levels. Its effects are exacerbated by stress factors such as poor nutrition, adverse weather, and high bee density in colonies (Genersch, 2010).

The toxin mtxA, which has been found to play an important role in the infectious capacity of *M. plutonius*, has been linked to pMP19, the virulence plasmid of the bacterium. This relationship explains the critical importance of the toxin in disease processes and the ways in which it enhances the effect of the pathogen (Nakamura et al., 2020).

It was observed that ***M. plutonius*** isolates were classified into 40 sequence types and grouped into three clonal complexes. The clonal complex (CC) analysis, used to assess genetic diversity among field strains of *M. plutonius*, shows that the so-called CC3, CC12 and CC13 groups are particularly prominent. All typical strains were classified into groups CC3 or CC13, which are relatively similar to one another. In contrast, all atypical strains were placed in CC12, indicating a more distant relationship from the other two groups. (Arai et al., 2012; Takamatsu et al., 2014). Studies have identified CC12 as highly virulent and with the potential to cause serious infections. In contrast, CC3 strains were found to have moderate virulence. CC13 was classified as the strain with the lowest virulence and was associated with milder infections than the other two groups (Nakamura et al., 2020).

M. plutonius infection is usually transmitted through the consumption of contaminated food in the first days after the larvae hatch. The bee larvae ingest the bacteria into their digestive tract along with food brought by feeder bees. Within a short time, the bacteria settle in the larva's stomach or midgut, where it begins to multiply between the intestinal folds. After the larva reaches the pupal stage, the pathogen is released into the comb chamber via feces. Worker bees carry this waste out while cleaning, but can infect other larvae in the process. The pathogenic bacteria rapidly deplete the larvae's food sources and gut contents, causing the larvae to enter the pupal stage in a very weak state or die at this stage. The death of sick larvae is accelerated by *Bacterium eurydice*. On the remains of the dead larvae, *Bacillus alvei* can survive for many years and form resistant spores and reproduce in the infected tissues, causing the larvae to rapidly disintegrate and the remains of dead tissues to accumulate in the comb cells. This observed situation leads to a deterioration of colony hygiene and complicates the worker bees' efforts to remove infected larvae. Infection is not always lethal and *M. plutonius* can persist in larvae and pupae without any clinical symptoms due to different degrees of virulence (Bailey, 1957; Forsgren et al., 2005; de León-Door et al., 2020).

3.2. Symptoms

Larvae are infected when they are 3-4 days old. A key characteristic of the disease is that the larvae typically die before the honeycombs are sealed. The disease is commonly seen in open honeycombs. The dying larvae first appear watery and soft and later harden. The larvae die in a curled up position and collapse to the bottom of the comb chamber. Infected larvae are initially pale and wrinkled with a dull white color, then yellowish and finally brown. This results in an abnormal appearance on the comb’s surface. A common sign of EFB is the visible deterioration of larval tissues, often manifesting as a sticky, thread-like structure. But this adhesion and elongation is minimal. Worker bees can clean dried honeycomb eyes. In infected larvae, the digestive system is disrupted during the disease process. The feces of the larvae can accumulate in the comb cells and are commonly observed as a visible yellowish-brown liquid or dried residue. During this process, a disorganization of the comb surface is noticeable compared to a healthy colony. Worker bees may perforate the lids of the comb cells while focusing on cleaning infected larvae. This can lead to a more irregular structure on the comb. Another striking feature of EFB is the characteristic odor emitted during the disease. As the dead larvae decompose, the colony develops a pungent and sour odor. This odor can be an important clue for experienced beekeepers to recognize an infected colony (Bailey, 1960; OIE, 2023; Budge et al., 2024).

Other important symptoms of the disease include general lethargy and weakening of the infected colony. EFB generally occurs when the colony's immune system is weak or when environmental stressors such as malnutrition, excessive colony density or bad weather conditions are present. This leads to reduced honey production in infected colonies and, in the long term, colony collapse. In the absence of early diagnosis, the disease can spread rapidly and infect other colonies in the vicinity (Erban, et, al., 2017).

3.3. Transmission Routes

EFB transmission occurs in various ways. Beekeepers' malpractice, lack of attention to hygiene conditions, infected beekeeping equipment and combs are important sources of infection. Giving infected combs to healthy colonies, hive transfers and honey of unknown origin, infected honey and pollen can cause the spread of the disease. Infected adult bees can carry the bacteria and the disease can also spread during swarming. Environmental factors such as unfavorable weather conditions, poor nutrition, stress exacerbate EFB outbreaks as they weaken the colonies' immune system, weakening its ability to resist infection EFB does not form spores, which means it is relatively less persistent in the environment. However, it can survive for long periods in infected combs and hive equipment, presenting challenges for eradication. The general health of the colony is important in the course of the disease. Stress factors such as inadequate nutrition or excessive bee density lead to a reduced capacity of worker bees to remove larvae, increasing the rate of disease spread (Forsgren et al., 2005; Genersch, 2010).

3.4. Protection, Control and Treatment

Since *M. plutonius* is a non-spore-forming bacterium, its ability to survive for a long time in environmental conditions becomes limited. This aspect of the situation makes it possible to control the disease with regular hygiene practices in addition to the destruction of infected material.

Early diagnosis is crucial for the control, management and eradication of the disease. *M. plutonius* is a genetically homogeneous bacterium. However, the virulence levels of different strains may vary (Haynes et al., 2013). These factors affect the infection spread rate and its impact on colonies. The most common technique for genetic identification is molecular techniques such as PCR. Molecular techniques such as PCR allow for rapid and precise identification of the bacteria (Roetschi et al., 2008).

Managing EFB requires an integrated approach combining chemical and non-chemical strategies. Historically, antibiotics such as oxytetracycline have been the primary treatment and have effectively suppressed bacterial growth. However, over-reliance on antibiotics has led to concerns about the development of resistance and residue accumulation in hive products such as honey (Reybroeck et al., 2012). Non-chemical methods such as queen replacement, shaking bees into new combs (shake swarm method) and improving colony nutrition have shown promising results in reducing EFB prevalence without creating chemical residues. Ensuring proper hive hygiene, including sterilization of tools and equipment, also plays a vital role in disease prevention.

Several methods are commonly employed to manage EFB, including the complete elimination of infected colonies, the shook swarm technique, antibiotic treatments, and specialized strategies based on integrated pest management (IPM) as outlined by the FAO. IPM, according to the FAO, involves the careful assessment of various pest control options and the integration of suitable measures to prevent pest population growth. The goal of this approach is to minimize pesticide use, promote healthy crop growth, ensure sustainable pest management, and lessen the negative effects of pesticides on human health and the environment. This is accomplished by integrating biological, chemical, physical, and cultural (crop-specific) control strategies. In the beekeeping sector, IPM strategies emphasize integrating antibiotic treatments with best beekeeping practices, particularly the shook swarm technique (Waite et al., 2003; Mosca et al., 2024).

4. CONCLUSION

AFB and EFB are major infectious diseases that result in considerable economic damage to the global beekeeping sector. AFB is a fatal illness caused by the bacterium *P. larvae*, which is spore-forming and highly resistant to harsh environmental conditions. In contrast, EFB is a less severe disease caused by *M. plutonius*, a non-spore-forming bacterium that can spread quickly when the immune system of the bee colony is compromised (Forsgren, 2010; Genersch, 2010).

Although the two diseases differ in their spread routes and susceptibility to environmental factors, they have serious negative impacts on bee health and honey production. Destruction of infected colonies, sterilization of used equipment and attention to hygiene practices are the main measures in the control of EWF. Combining antibiotic treatments with appropriate beekeeping practices is an effective method in the management of EWF (Forsgren et al., 2005; Reybroeck et al., 2012). However, overuse of antibiotics is far from being a long-term solution as it causes both the emergence of resistant bacteria and residue problems in honey products (Özüiçli, 2022).

The most efficient way to manage these two diseases is by adopting good agricultural practices (GAP), good hygienic practices (GHP), and integrated pest management (IPM) strategies. IPM regulates pest populations by combining biological, chemical, and cultural methods in a balanced manner, reducing harmful effects on the environment and human health (FAO, 2024). In addition, the development of more resilient honey bee populations and the widespread use of modern molecular diagnostic tools are of great importance for both early detection and effective control.

As a result, effective management of AFB and EFB can be achieved through beekeepers' conscious practices, compliance with hygiene rules and orientation towards sustainable methods. Additionally, enhancing research and educational initiatives will contribute to the success of combating these diseases and help ensure the long-term viability of the beekeeping industry.

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CHAPTER 6

INVESTIGATION OF FUNCTIONAL PROPERTIES OF PROPOLIS

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1. INTRODUCTION

Propolis, or sometimes called "bee glue", is produced by honeybees (e.g. Apis mellifera L.) and stingless bees (e.g. Tetragonisca Angustula It is a lipophilic, sticky, gummy and resinous substance collected by different bee species, including Illiger (Simone-Finstrom et al., 2010; Kuropatnicki et al., 2013; Pujirahayu et al., 2019). Bees use it to seal holes in their hives, smooth interior walls and protect the entrance from intruders. It also acts as a natural antibiotic to prevent bacterial, viral or fungal infections inside the hive (De Castro, 2001; Dos Santos et al., 2003; Wagh, 2013; Sanpa et al., 2015) . Bees collect resin from cracks in the bark and leaf buds of different trees, including poplar, conifers (e.g. pine and cypress), birch, alder, willow, palm, chestnut and even different species of trees such as eucalyptus, acacia, klusia. Bees add salivary enzymes to the collected resin, mix it with beeswax and use this partially digested substance in their hives. The name propolis is derived from the Hellenistic ancient Greek word meaning "suburb/bee glue" or "city defense". The use of propolis dates back to 300 BC and was used by the Egyptians, Persians, Greeks and Romans. Propolis, which was preferred by the Egyptians in the mummification process, was used as a topical cream for cuts, ulcers, wounds and other dermatological problems. However, the use of propolis was not very popular in the Middle Ages. It remained mostly in Eastern Europe, especially in Russia, where it was later known as "Russian penicillin", as an alternative herbal medicine. The use of propolis was rediscovered in the Renaissance with the increasing popularity of ancient teachings and medicine. The first scientific studies of propolis began with its distillation in the 19th century and were closely linked to the development of chemistry. The first major chemical research on propolis in the early 20th century The first components isolated from propolis were vanillin, cinnamic acid and cinnamyl alcohol. A further breakthrough occurred in the early 1970s with advances in chromatographic analytical methods, which allowed the isolation of increasingly new components from different propolis samples.

At the beginning of the 21st century, Marcucci (1995) and Bankova et al. (2000) recorded more than 300 components in propolis, and between 2000 and 2012 alone, at least 241 new compounds were isolated from propolis. Later, in 2012, the number of components increased to over 500 and continues to increase every year with the discovery of new components from different regions and plant origins in propolis. Despite advances in pharmacology, the list of current preparations and uses of propolis is still very wide; mostly antiseptic, bacteriostatic, antibacterial, antimycotic, antiviral, antiprotozoal, antioxidative, spasmolytic, choleric, astringent, anti-inflammatory, anesthetic, antitumor, immunostimulating, cytostatic, hepatoprotective and other properties (Huang et al., 2014).

Propolis can be classified in several different ways. According to its “collectors”, two main types of propolis are known; the first is the “normal” propolis collected by honeybees, and the second is the so-called geopropolis collected by stingless bees that also add soil to their propolis mixture. According to the plant sources, propolis is divided into seven main types: poplar propolis (non-tropical regions of Europe, North America, Asia) (Bankova et al., 2000), which is the most common type of propolis, Baccharis or Brazilian green propolis (Alencar et al., 2007), red propolis, eucalyptus propolis (Abu -Mellal et al., 2012), Macaranga or Taiwanese green propolis (Huang et al., 2007), birch propolis (Popravko and Sokolov, 1980) and Mediterranean propolis (Popova et al., 2010). Meanwhile, Graikou et al. (2016) classified propolis into seven types based on their different properties: the poplar type (Europe, subtropical regions of Asia, New Zealand and North America), the birch type (Russia), the green type (Brazil), the red type (Brazil, Cuba and Mexico), the klusia type (Cuba and Venezuela), the Pacific or Macaranga type (Japan, Taiwan and Okinawa prefecture in Indonesia) and the Mediterranean type (Greece, Sicily and Malta). However, due to the increasing discovery of propolis types of different plant origins, the classification of propolis varies among authors. For example, Park et al. (2000) already described about 12 types of Brazilian propolis; however, a few years later, a new, red Brazilian propolis type was added.

all propolis species, poplar and Brazilian green propolis are the most commercially available and the most researched due to their potent pharmacological activities. The composition of propolis depends largely on the parent plant source, the season, and the bee species, but generally consists of 50% vegetal balsam and resin, 30% beeswax, 10% essential and aromatic oils, 5% pollen, and 5% other organic and inorganic molecules. This is especially true for poplar propolis.

of propolis depends on its age and primary plant source and varies between yellow, green, red and dark brown, although transparent propolis has also been reported. Its chemical composition is extremely diverse. Up until 2012, more than 500 components have been recorded in propolis from different plant sources and countries (Huang et al., 2014), and by 2018 this number has increased to at least 305. However, each propolis sample contains approximately 80–100 different components. These include phenolic acids and esters, many types of flavonoids and other phenolic molecules, terpenes, ketones, aromatic aldehydes and alcohols, proteins, fatty acids, waxy acids, amino acids, steroids, stilbenes, sugars, vitamins (B1, B2, B3). B5, B6, C and E), minerals (at least 35, some only in trace amounts) and even enzymes (e.g. b- glucosidase) (Walker and Crane, 1987; Cvek et al., 2008; Cantarelli et al., 2011; Zhang et al., 2012). Some groups of compounds, e.g. glycosides, were discovered rather late and some, e.g. alkaloids and tannins, were found only recently. Every year more and more components of propolis are reported for the first time, and some of them are completely new to science.

2. Chemical Content

The chemical profile of propolis is the main reason why researchers are constantly studying propolis worldwide. The chemical complexity of propolis is due to the great variability of its botanical sources. In fact, bees collect propolis from plants found in the region, and the richer the vegetation of the region, the more complex the chemical composition of propolis.

The chemical composition of propolis depends on its botanical origin, bee breeds, climatic conditions in the region, etc. The study of the chemical profile of propolis began a long time ago, but the number of molecules identified has increased significantly in recent years.This is certainly due to the development of new sophisticated analytical techniques for separation and purification, such as high-performance liquid chromatography (HPLC), thin-layer chromatography (TLC), gas chromatography (GC) and mass spectroscopy (MS), as well as gas chromatography techniques coupled to nuclear magnetic resonance (NMR) and mass spectroscopy (GC-MS). From 1900 to 1979, Ghisalberti (1979) was the first author to study the chemical compounds identified in propolis from different parts of the world. In this review, Ghisalberti (1979) reports 34 components belonging to different chemical classes, such as phenolic acids, flavonoids, etc. In fact, from 1900 to 1927, only three molecules were identified: cinnamyl alcohol, cinnamic acid and vanillin. Sixteen years later, a new compound called chrysin (flavonoid) was identified by Jaubert et al. (1926). From that time until 1969, no new molecules were reported in propolis. Ghisalberti (1979) attributed this to the lack of interest due to the recalcitrant nature of propolis and the lack of separation and analysis techniques. Since 1969, many molecules have been identified with the development of some suitable separation and identification techniques. The second interesting review article on the chemical composition of propolis is that of Walker and Crane (1987). Since 1987, 149 compounds have been identified in propolis, along with 22 mineral elements. This number has increased rapidly, and Marcucci (1995) reported that 209 compounds had been identified in propolis by 1995. From 1995 to 2000, 78 new compounds were identified in propolis.

These molecules belong to different chemical groups; aromatic compounds (8 molecules), flavonoids (7 molecules), prenylated p-coumaric acids (8 molecules), acetophenone derivatives (3 molecules), caffeoylquinic acids (8 molecules), lignans (7 components), diterpenic acids (10 mol ash), triterpenes (2 molecules), monoterpenes, sesquiterpenes and aromatic compounds (volatile compounds), sugars and sugar alcohols (10 molecules). Until 2000, at least 300 compounds were identified in propolis. In their study by Huang et al. (2014), where they reported the new components detected in propolis from 2000 to 2012, 241 new compounds were identified for the first time for this period. These molecules belong to flavonoids, phenylpropanoids, terpenes, stilbenes, lignans, coumarins and their prenylated derivatives. In total, the number of components identified in propolis increased from 300 molecules identified until 2000 to 541 molecules in 2012. After 2012, analytical techniques became available in many laboratories worldwide. Therefore, the identification of new compounds from propolis increased significantly between 2013 and 2018. In fact, 305 compounds were identified during this period (Sturm et al., 2019). Also surprisingly, propolis alkaloids were first isolated during this period (Coelho et al., 2015; Soltani et al., 2017). With these new compounds identified between 2011-2012, the total number of compounds identified until 2018 exceeded 850 molecules. Many new components have been identified in propolis so far. In fact, 36 compounds were identified in propolis for the first time between 2018 and 2021. These compounds were identified in propolis samples taken from different parts of the world and belong to different chemical groups. The search for new molecules was done using various scientific databases such as PubMed, Web of Science, Medline, Scopus, Science -Direct and Google Scholar.

Propolis mainly consists of the following components: resins and herbal balsam (50%), waxes (30%), essential oils (10%), pollen (5%) and sugars, amino acids, vitamins and minerals (5%) (Tompson, 1990). The main groups of chemical compounds found in propolis, apart from resins and waxes, are: phenols (e.g., flavonoids, polyphenols, phenolic acids and other phenolic compounds) and their esters, terpenes and terpenoids, steroids, aromatic acids, aromatic esters, aldehydes, alcohols, sugars, sugar alcohols and acids, amino acids, vitamins, fatty acids, hydrocarbons, mineral elements and alcohols (Huang et al., 2014; Pasupuleti et al., 2017; The main group of phenolic compounds found in propolis is the flavonoid group, which contributes greatly to the biological and pharmacological activities of propolis . According to the chemical structure, flavonoids found in propolis are classified as follows: flavones, flavonols, flavanones, flavanonols, chalcones, dihydrochalcones, isoflavones, isodihydroflavones, flavans, isoflavans and neoflavonoids (Huang et al., 2014) . The flavonoid group mainly includes the following substances: chrysin, pinocembrin, apigenin, rutin, luteolin, galangin, kaempferol, myricetin, catechin, naringenin, quercetin, tectochrysin, pinostrobin, acacetin and others (Volpi, 2004; Another important group of compounds found in propolis are phenolic acids, among which ferulic, cinnamic, caffeic, benzoic, salicylic and p-coumaric acids are most frequently found . Besides stilbenes and the stilbene derivative resveratrol, other phenolic compounds (e.g. artepilin

C) were also found (Volpi, 2004; Volatile compounds such as terpenes and terpenoids are reported to be present in propolis at only 10% but contribute greatly to the biological and pharmacological activities of propolis and are responsible for its characteristic odor (Huang et al ., 2014). Of these, terpineol, camphor, geraniol, nerol and farnesol have been identified to date (Volpi, 2004; It has been noticed that the presence of different types of terpenoids in propolis varies depending on the geographical origin of propolis (Volpi, 2004; Przybyłek et al., 2019; Zabaiou et al., 2017). Hydrocarbons such as alkanes, alkenes, alkadienes, monoesters, diesters, aromatic esters, fatty acids and steroids have been identified in many different propolis species to date (Huang et al., 2014) . Succinic dehydrogenase, glucose-6-phosphatase, adenosine Some enzymes such as triphosphatase and acid phosphatase are also found in propolis (Lofty, 2006; Pasupuleti et al., 2017; Volpi, 2004; Przybyłek et al., 2019; Zabaiou et al., 2017), Na, Mg, Mn, Fe, Si, Zn, Se, Cu, Ni, Al, B, Ba, Cr and Sr (Lofty, 2006; Pasupuleti et al., 2017). Trace element profiles of propolis can be used to identify different propolis samples according to their locations. Some toxic elements such as As, Cd, Hg and Pb were also found in propolis, especially in propolis samples collected from industrial and polluted areas, therefore elemental analysis of raw propolis can be used as an indicator of environmental pollution factors. Propolis contains some important vitamins such as B complex vitamins, vitamins C and E (Lofty, 2006; Pasupuleti et al., 2017; Volpi, 2004; Most of the data on the chemical composition of propolis are from different propolis The analysis of the extracts was obtained. Several different solvents can be used for the dissolution of propolis and the extraction of biologically active compounds : water, alcohols (e.g. ethanol and methanol), glycols (e.g. propylene glycol), oils (e.g. olive oil) and, to a much lesser extent and only for analytical purposes, other organic solvents such as hexane, acetone, dichloromethane and chloroform. The use of the mentioned solvents, especially water-ethanol mixtures, is also quite common (Bogdanov, 2012). Since propolis represents a mixture of polar and non-polar compounds, the most suitable extraction systems are hydroalcoholic solutions (Alberti et al., 2019). In addition, due to the lipophilic nature of some compounds and their low solubility in water, commercial propolis Their formulations are often ethanol or glycol based (Alberti et al., 2019). Despite the wide variety of chemical compounds found in different propolis samples, there are some general chemical groups that are responsible for the "basic" biological activities of propolis, regardless of the specific compounds.

3. Biological Activity

Propolis and its extracts have numerous applications in the treatment of various diseases due to their wide spectrum of biological activities. Propolis and its components have been found to possess antimicrobial (antibacterial, antiviral, antifungal), antioxidant, anti-inflammatory, immunomodulatory and antiproliferative activities (Sforcin et al., 2016; Pasupuleti et al., 2017). In addition, propolis and its components can stimulate the synthesis of extracellular matrix components (such as collagen), proliferation and migration of fibroblasts, differentiation of cells (Volpi, 2004) and may have both anti

-apoptotic activity against normal cells and apoptotic activity against some cancer cell lines, as well as proactive action. The activity of propolis depends on its chemical composition and geographical origin (Przybyłek, 2019). Some biological activities of propolis are unique, regardless of the type of propolis and its origin (e.g. antimicrobial and antioxidant); Some specific biological functions are related to the botanical origin of propolis and also to the presence of some biologically active compounds in the structure of propolis. Propolis, an important antimicrobial bee product, is effective against both Gram-positive and Gram-negative bacteria, as well as aerobic and anaerobic bacteria with slightly higher activity than Gram-positive bacteria (Sforcin et al., 2011). Propolis It shows its antibacterial effect at two levels: by acting directly on microorganisms and by stimulating the immune system, resulting in the activation of the organism's natural defense mechanisms (Sforcin et al., 2011). Due to its rich chemical profile and wide range of biological activities, propolis may have great pharmacological and therapeutic applications and can be used as a natural antiseptic, anti-inflammatory, antioxidant, antimicrobial (antibacterial, antiviral, antifungal), anticancer, immunomodulatory and wound healing agent, as well as in various preparations and as part of some drugs for the treatment of a wide range of conditions and disorders (Sforcin et al., 2016; Pasupuleti et al., 2017). So far, the following pharmacological properties of propolis have been reported: antiulcer, antacid, antihistaminergic, anti-inflammatory, antitumor, anesthetic properties, hepatoprotective, nephroprotective, cardioprotective, neuroprotective and pancreatoprotective activities

(Sforcin et al., 2016; Pasupuleti et al., 2017; Sforcin et al., 2011; Zakerkish et al., 2019). In addition, recent studies have shown that propolis has It has been shown that it has hypoglycemic activity, which may have a positive effect on diabetes complications. It also modulates the metabolism of blood lipid levels, reduces lipid peroxidation and scavenges free radicals (Zakerkish et al, 2019).

Some patents have suggested the use of propolis in the treatment of dental diseases, as an adjuvant in anti-cancer treatment, in cosmetic products, as an anti- inflammatory agent and as a natural antibiotic (De Figueiredo et al., 2014). In many experimentally created liver injury models in rats, propolis has been shown to have a positive effect on the liver. The hepatoprotective effect of Malaysian propolis against experimentally induced ischemia in rats has been reported (Madrigal-Santill an et al., 2014). The cardioprotective effect of Malaysian propolis against experimentally induced ischemia in rats has been attributed to its anti- lipoperoxidative and antioxidant effects (Ahmad et al., 2017). Its nephroprotective effect has also been shown against significant damage caused by cisplatin in the kidney tissue depending on the dose (Yuluğ et al, 2019). Since propolis and its flavonoid components have been reported to exhibit neuroprotective properties in in vitro and in vivo studies through their antioxidant, anti-inflammatory and immunomodulatory properties, it has been suggested as an effective candidate for the prevention or treatment of oxidative stress and neuroinflammation in neurological diseases (Farooqui et al, 2012).

of propolis on the liver of diabetic rats have been reported and it has been shown to reduce oxidative stress, inflammation and hepatocytes.

suppression of apoptosis, as well as hepatocytes It has been linked to completely improving liver function in diabetic conditions by increasing liver proliferation (Nna et al., 2013). propolis extract of The protective effects of propolis on the cardiovascular system and hepatorenal functions have been reported and Antihyperlipidemic and antioxidant activity of propolis has been indicated; supports its traditional use as an adjuvant agent in the form of food supplements in hyperlipidemic disorders (Orsolic et al., 2019). Due to its good oral bioavailability and immunomodulatory activity, propolis adjuvant It is reported that propolis is a good candidate for anticancer therapy (Chan et al., 2013). It is reported that it is used in the treatment of gynecological disorders due to its antimicrobial activity, especially against Candida species, as well as its anti-inflammatory activity (Pasupuleti et al ., 2017) . Propolis is used in the treatment of chronic vaginitis, improvement of vaginal health, recurrent vulvovaginal It is recommended as an alternative treatment for candidiasis and other gynecological disorders (Pasupuleti et al, 2017).

4. CONCLUSION

Propolis shows a great variety in terms of chemical composition depending on its origin and the plant sources from which it is collected and produced. Different chemical compositions may determine the specific biological activity of propolis , but despite the variety in chemical composition, the biological and pharmacological properties of propolis are basically similar. The areas of study and investigation on propolis are wide and will continue to expand in the future. Considering this situation, studies should be conducted especially on the pharmacologically active compounds found in propolis and on the determination of various content compounds that have not yet been elucidated.

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CHAPTER 7

FALL CARE AND WINTERING IN HONEYBEES COLONIES

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1. INTRODUCTION

Establishing, maintaining, caring, and managing colonies of any social bee species is defined as beekeeping. Beekeeping is a form of agricultural production carried out with little capital, is not dependent on land and, where idle labor can be utilized (Erdoğan Y, 2019c). Honey bee colonies are housed in areas called apiaries and boxes called beehives (Erdogan, Dodologlu, & Emsen, 2009; Erdoğan Y, 2019a).
Honey bees (*Apis mellifera*) live in different climates and regions and face different challenges at different times (Ruttner, 2013).
Winter is the season when honeybee colonies face the most significant challenges. Honeybees are one of the insect species that have adapted to survive winter conditions without going utterly dormant during the winter months (Winston, 1991).

Studies have shown that bee colonies emerge from winter, losing approximately 30% (Winston, 1991).

In order to ensure the pollination of fruit trees that bloom in early spring, bee colonies need to come out very strong in the spring.
While the honey bee colony moves into the wintering position, some changes occur in the behavioral and physiological characteristics of the bees. These are a decrease in the bees' activity, a change in the endocrine system, an increase in food stores (honey and pollen), an increase in their lifespan, and a complete cessation of brood rearing. When the bees move into the wintering position, they move into a cluster that regulates heat (Mahir Cengiz & Erdogan, 2017; Mahir Murat Cengiz & Erdoğan, 2023; Hepburn, 2010). The wintering period is an arduous struggle for honeybees against extreme cold.

Many studies have been carried out worldwide to minimize bee colony losses in the winter by improving the temperature conditions of the hives in which the bee colonies live (Abrol, 2002; Anderson, 1983; Büdel, 1968; MM Cengiz, 2021; Cetin, 2004.; Detroy, Erickson, & Diehnelt, 1982; Dodologlu, 2004; Erdogan Y, 2019; Erdogan et al., 2009; Furgala, 1992; Owens, 1971; Villumstad, 1974; Wineman, 2003).

According to the results of their studies, some scientists have suggested heating bee colonies with solar energy. For example, one study suggested that the hives should be painted dark and exposed to direct sunlight, but sufficient scientific studies and evidence on this subject could not be found (Morse, 1999).

Recently, interest in beekeeping has increased worldwide (Mahir Murat Cengiz, 2023; Velardi S, Leahy J, Collum K, McGuire J, & Ladenheim M, 2021). Unfortunately, wintering losses in bee colonies have also increased (Requier F, 2018). Winter losses were reported as 16.7% on average in the European Union in the winter of 2018-19, with 32% in Slovenia (Gray et al., 2020). US beekeepers reported losses of 32.2% on average in the winter of 2020-21, with losses as high as 58% in some states (Steinhauer N, 2021).

To reduce these losses, beekeepers in different parts of the world use very different methods (Caron, 2013.; Underwood, Traver, & López-Uribe, 2019).

The most common method is to wrap or cover the hives with extra material during the winter months (Lee K, Reuter GS, & Pivak M, 2020).

Honeybees spend the winter in clusters without hibernating. Worker bees in the cluster produce heat by consuming honey, and when the cluster gets too hot, they expand the cluster and cool it down (Farrar, 1943; Stabentheiner, Kovac, & Brodschneider, 2010). In the early 20th century, beekeepers covered their hives with wool insulation in cold climates, partially buried them in channels they dug, or kept them in cellars. Beekeeping books even recommended altogether abandoning wintering outdoors without cover (Currie, Spivak, Reuter, & Graham, 2015).

The secret to success in wintering bee colonies is very good autumn care. This fact is not emphasized too much. Autumn care begins after the end of the nectar flow period and the honey harvest. Varroa control is carried out first. Then, the autumn syrup is given to encourage the queen bee to lay eggs and supplement the missing food needs so the colony can enter with young worker bees. The syrup of the colonies should be started on time. If it is too late, the colony will enter the winter with honey with a high water content, and since the queen bee cannot lay enough eggs, the worker staff will be weak.

2. Autumn Care in Beekeeping and Preparation of Colonies for the Winter Season

2.1-Providing bee colonies with sufficient food stocks for the winter

For bees to enter the winter healthy and strong, they need to be well-fed in the fall. Feeding should start immediately after the honey harvest. When feeding, syrup should not be given in large amounts at once but in small amounts. The amount of syrup to be given should be enough to be finished by morning when given in the evening. Because having syrup in the feeder during the day can lead to plundering.

Also, sugar syrup is a great way to give medicine to colonies in the fall (such as fumagillin, an antibiotic for Nosema). The sugar/water ratio of sugar syrup to be given in the fall is 2/1. This is because the weather gets cold in the fall months, so the bees cannot evaporate the water in the syrup and thicken it. The probability of disease increases in bees that enter the winter with food with a high water content.

2.1.1- Preparation of sherbet to be used in autumn feeding

First, the water to be used to prepare sherbet is boiled. The boiled water is removed from the fire and left to cool. When it cools down to 50-60 C^0, the amount of granulated sugar appropriate to the water is added and mixed. The mixing process is continued until the sugar is completely dissolved. Then, to prevent the sugar from crystallizing, one teaspoon of citric acid or one teaspoon of vinegar or a lemon is squeezed into 15 liters of syrup. The prepared sherbet is left to cool down to a temperature that will not burn your (20-25 C^0). Then, if necessary, medicines are added to the sherbet. Powdered medicines are dissolved in cold water in a small bowl before being added to the sherbet. The sherbet is mixed well again after the medicine is added. Vitamin and mineral mixture preparations can also be added to the sherbet. The prepared syrup is given to the colonies in the evening (Erdoğan Y, 2019b).

2.1.2- Preparation of bee cake to be used in winter feeding

In order to meet the protein deficiency of the bee colony and encourage brood rearing, additional feeding can be done to bee colonies using some mixtures with or without pollen. Adding pollen to these mixtures, called bee cakes, can further increase their effectiveness. Cakes can be made by adding pollen or pollen substitutes (milk powder, soy flour, brewer's yeast) or by simply mixing powdered sugar and honey.

The following mixture examples can be used for making bee cake.

*1 part honey + 3 parts powdered sugar.

* 3.3 kg soy flour + 1 kg brewer's yeast + 100 g oil (cottonseed oil) + 50 g vitamin mixture + 3.5 kg strained honey or malt.

* 4.2 kg defatted soy flour + 200 g oil (cottonseed oil) + 50 g vitamin mixture + 3.5 kg strained honey or malt.

* 2.5 kg soy flour + 1 kg brewer's yeast + 800 g pollen + 100 g oil (cottonseed oil) + 50 g vitamin mixture + 3.5 kg strained honey or malt.

* 90 kg granulated sugar + 4.5 kg honey + 15 lt soy flour + 2.5 lt brewer's yeast + 2.5 lt skim milk powder + 0.375 lt vinegar + 20 lt water.

*3 parts soybean flour + 1 part brewer's yeast + 1 part skimmed milk powder.

*2 kg dry pollen + 6 kg soy flour + 1.5 lt ½ sugar syrup + 2.5 cups water.

*23% powdered sugar + 46% (67% sugar syrup) + 10% Soy flour + 21% Brewer's yeast.

When making bee cake, first, the dry ingredients are mixed well with each other, then the liquid ingredients are slowly added and, mixed and, kneaded. Adding vitamins and minerals to the cake increases its effectiveness even more. (Erdoğan Y, 2019b).

2.2- Rules to be followed in the fall feeding of bee colonies

* Feeding should be done in the evening,

* In order to prevent plundering (honey bees stealing honey from a hive that does not belong to them), the flight hole of the hive where feeding is done should be narrowed,

* Syrup should not be spilled around,

* Instead of giving a large amount of feed to the colonies at once, it should be given little by little every day,

* The hive should not be left open for a long time in order not to chill the brood while feeding,

* Instead of strengthening weak colonies by feeding them, they should be strengthened by combining them,

* Mass feeding in the open should be avoided.

Beekeepers are divided into two regarding the wintering of bee colonies. Some beekeepers advocate that bee colonies die in the winter. Because they think that the economic value of the honey left in the bee colonies for the winter is higher than that of the bee colonies.

The other part of beekeepers think that bee colonies should be fed well in the fall, replenished their food stocks, and ensured that they emerge very strong into spring and produce plenty of honey the following season.

For a standard colony to emerge healthy and strong until spring, the total weight of the hive frame and bees should be 40-45 kg. If it is only being put into the brood for the winter, there should be at least 8 frames with honey in the hive.

On days when the outside temperature is $5C^{O}$, the hive cover is slowly lifted, and the bees are tried to be seen. If the saddle bees have climbed onto the frames, this means that the colony needs food and they want reinforcement immediately. It should be reinforced immediately with fondant sugar or bee cake. One of the most important points to be considered here is that the hive cover and cover cloth should not be left open for long.

Figure 1: During the winter season, bees are piled up on the frame, meaning the hive is out of honey (Christina, Linda, & Diana, 2024).

2.3- Methods of Combating *Varroa Destructor*

Today, the biggest threat to beekeeping is a blood-sucking mite called Varroa destructor (*Varroa Destructor*) (Figure 2). reasons for this.

1-*Varroa Destructor* is a new parasite of Apis mellifera. Therefore, honey bees have not developed an effective defense against *Varroa Destructor*.

2- *Varroa Destructor* has spread worldwide in a very short time.

3- If adequate and periodic combat is not carried out, the colony dies within 1.2 years.

4- *Varroa Destructor* combat both increases costs and causes chemical residues in bee products

5- *Varroa Destructor* is a very important factor in bee colony losses worldwide. If a much more effective combat method cannot be developed against this mite worldwide, the problem will grow even more significant in the future.

Varroa mite is considered an important factor in the decrease in the number of honey bee colonies worldwide (De la Rúa, Jaffé, Dall'Olio, Muñoz, & Serrano, 2009).

The reproduction periods of *Varroa Destructor* begin in the spring, when the brooding activities of bee colonies begin, and continue until autumn, when the brooding activities end. They spend their winter periods only on adult bees (Colin & Ball, 1999).

Varroa destructor, one of the most important pests for honey bees, is fought in three ways: chemical, biological, and herbal.

2.3.1. Chemical control with *Varroa Destructor*

Coumaphos, amitraz, lumethrin and fluvalinate are the most commonly used preparations in chemical control (Rosenkranz, Aumeier, & Ziegelmann, 2010).

Coumaphos inhibits the activity of the enzyme acetylcholinesterase (AChE), which hydrolyzes acetylcholine (ACh) into choline and acetic acid. Preparations containing the active ingredient Coumaphos are successfully used worldwide against *Varroa Destructor* infections in honey bees. (Williamson et al., 2013).

Pyrethrins such as flumethrin and fluvalinate are highly effective in controlling the *Varroa Destructor* and act by disrupting the neurological functions of the *Varroa Destructor* (Thompson, Ball, Brown, & Bew, 2003).

Using synthetic drugs to control mites leads to the development of mites resistant to these drugs. Acaricide residues may be found in bee products as a result of treatment (Tihelka., 2018).

For this reason, organic acids (lactic acid, oxalic acid, formic acid), which are the most commonly used biopesticides in the fight against Varroa Destructor, do not harm the queen, adult bee, and brood population in the colony when used at the appropriate time and dosage (Akyol & Yeninar, 2009).

2.3.2-Plant-based control

Natural treatments consisting of organic acids, plant oils, and extracts are an alternative treatment used to control Varroa Destructor. Essential oils obtained from plants are highly volatile compounds from different parts of a plant. It has been reported that many essential oils can be used as an alternative to synthetic acaricides in Varroa Destructor control (Erdoğan & Cengiz, 2020; Imdorf, Bogdanov, Ochoa, & Calderone, 1999; Tutun, Koç, & Kart, 2018).

The most commonly used essential oils for *Varroa Destructor* control in beekeeping are cinnamon oil (*Cinnamomum cassia*), eucalyptus oil (*Eucalyptus globulus*), peppermint oil (*Mentha piperita*), rosemary oil (*Rosmarinus officinalis*), spearmint oil (*Mentha spicata*), tea tree oil (*Melaleuca alternifolia*), wintergreen oil (*Gaultheria procumbens*), lemongrass oil (*Cymbopogon nardus*), neem oil (*Azadirachta indica*), thyme oil (*Thymus vulgaris*) and lemongrass oil (C*ymbopogon citratus)*(Damiani, Gende, Bailac, Marcangeli, & Eguaras, 2009; Hassan, Allam, Rizk, & Zaki, 2008; Ruffinengo et al., 2001; Tutun et al., 2018). Eucalyptol, menthol, thymol, camphor, citronellal, and citral are the most commonly used ingredients (Ellis & Baxendale, 1997; Erdoğan & Cengiz, 2020; Gashout & Guzmán-Novoa, 2009; Tutun et al., 2018).

2.3.3-Biological control methods

Biological control methods have been developed against Varroa Destructor without using chemicals.

Creating resistant colonies is the most effective and cheapest method for controlling Varroa Destructor (Zemene et al., 2015). Some of these methods;

*Using trap combs: A comb with a male eye printed on it is placed in the brood and, the queen bee is allowed to lay eggs in these cells.

After the cells are closed, the comb is removed from the hive and destroyed (Rosenkranz et al., 2010).

*Using a pollen trap: Bees coming from the field with a pollen load leave their pollen load, and sometimes the Varroa Destructor sticks to them in the trap as they pass through the trap. Although this method is not sufficient on its own, it effectively reduces the Varroa Destructor population together with other methods (Cakmak, Aydin, Camazine, & Wells, 2002).

*Using wire mesh drawer base: Thanks to the wire mesh drawers placed on the hive base, Varroa Destructor falling on the hive base are collected in the base drawer. Every two days, these drawers are removed, and the Varroa Destructor is destroyed. This method alone is not sufficient (Akyol & Korkmaz, 2006; Collins., 2024).

*Increasing the internal temperature of the hive: Female Varroa Destructors lose their reproductive abilities above 36.5 CO and die above 38 CO. However, this method is difficult and laborious (Le Conte, Arnold, & Desenfant, 1990).

By choosing the most effective and most straightforward method among these methods and combating Varroa Destructor, bee colonies can be ensured to go through the winter more comfortably and without stress and to emerge strong into spring.

Figure 2. 1.Protonymph, 2. deutonymph, 3. Deutochrysalis, 4. young molted female, 5. female *varro destructor*., 6. adult male *varro destructor* (Rosenkranz et al., 2010)**.**

3. Wintering of Honeybee Colonies

3.1. Wintering indoors.

Although closed apiaries are built to protect bee colonies from all adverse environmental conditions, if ventilation is not sufficient, humidity and carbon dioxide accumulate inside, which causes much more negative results than wintering outdoors. In regions with very cold and long winters, wintering indoors is better if ventilation is done well (Figure 3**)**(Erdoğan Y, 2019b).

Figure 3. Bee colonies wintered indoors (Koenig, 2017).

Things to consider when wintering indoors.

1-The room should not be underfoot. In other words, wintering should not be done in a place constantly entering and exiting.

2- The hives should be placed 25-30 cm above the ground.

3- A maximum of 3 rows of hives should be placed on each other.

4- When arranging the hives, the weak colonies should be in the middle, and the strong colonies should be placed at the bottom and top.

5- The hives should not be placed too close to the wall.

6- No cats, dogs or mice should be in the wintering room.

7- The temperature in the room should not rise so high that it will spoil the cluster (it should remain constant at 4-5 C^{o}*)*(Erdoğan Y, 2019b).

8-The flight hole should be covered with a fly trap, the feeding hole and the hive ventilation holes should remain open.

9-The heater should not be turned on in the wintering room.

3.2- Wintering outside.

Wintering outside is less risky than wintering inside. Bees can be wintered under a shed or outside (Figure 4). If it is snowing or raining a lot, it is better under a shed. If it is going to be wintered entirely outside, the hives are wrapped with a quilt made by putting insulated glass between 2 layers of tar paper. When doing this, it is necessary to ensurenthatbthe flight and ventilation holes are open (Figure 5***)***(Erdoğan Y, 2019b).

Figure 4: Wintering of bee colonies outdoors (Geant, 2018)

4. Factors Affecting the Survival of Honey Bee Colonies in Winter

*External weather conditions: Cold/damp, cold/dry, dry/mild, windy/icy and mild/damp weather conditions greatly affect the ability of bee colonies to survive in winter. As beekeepers, we cannot control the weather conditions, but we can intervene in the internal conditions of the hive and make the conditions more comfortable for the bees (Erdogan et al., 2009).

* It is essential to choose a suitable place for the beehive, to have strong and sufficient ventilation for our hives, and to have enough honey stock in the hive. These factors can be checked and made suitable by beekeepers. The control and intervention of these factors should be done when the outside temperature is above 10 CO. Inspecting the colonies during cold periods stresses the bees and, worse, leads to the death of the bees.

When choosing a beehive location, hollow areas should not be chosen. Because cold air tends to settle in hollow areas, build a windbreak (snow fence, wall made of straw bales, etc.) in the direction where the prevailing winds blow.

* You need to protect our hives from animal attacks. In the fall, mice look for warm places to spend the winter. Since the bees are in clusters and cannot drive the mice away, they enter by widening the hive flight holes. Mice destroy the frames in the hives and eat the clustered bees. For this reason, mouse entrance barriers should be placed in the hive flight holes. These are sold commercially. We can do this ourselves using wire mesh. Narrowing the flight holes using steel wool may be helpful. Using a trough with holes that will not obstruct the bees' entry and exit is also useful (Figure 5).

Figure 5: Covering the hive flight hole with a wide pore to prevent mouse entry (Christina et al., 2024).

A fence around the apiary prevents larger animals from entering damaging and knocking over the hives.

If there are bear pests in the area around the apiary, it is necessary to take precautions against this. Surrounding the apiary with a high-voltage electric fence is the most effective deterrent method for bear pests. This protects against bear attacks before they enter hibernation. However, considering that electricity will flow to the ground when it snows, closing the electric fence in the winter is necessary. The bear danger continues even in mild winter months. Bears can affect the electric fence system by sniffing the wires from the tip of their noses.

*The hives should be placed on the ground or stands in a solid and slightly forward-leaning manner. There should be no cracks or breaks in the hives. It should not be forgotten that bees do not heat the hive; they only try to keep themselves warm with the clusters they create. In the case of draft or wind, it fills the hive from the cracks and breaks, and it can harm the bees.

*In winter months, tightly wrapping the hives in a way that does not prevent ventilation can make it easier for the colony to cope with the winter (Figure 6). Many insulation products are developed for covering hives and sold on the market. If the beekeeper wishes, he can develop his own covering material using tar paper, tarpaulin, mulch nylon, insulation mat, rope, staples, and similar materials. The point to be noted here is that the flight hole and the hive cover ventilation holes should not be covered. After wrapping the hive with covering papers, it should be firmly fixed with staples and then tightly wrapped with a sponge or nylon rope. Otherwise, the wind will open and blow the coverings away. The covered hives can be arranged close to each other and wintering can be arranged. If there is no other precaution to prevent the hive covers from being opened by the wind, a stone or similar weight can be placed on the cover.

*Ventilation inside the hive must be excellent. In winter, bees consume honey to maintain the cluster temperature and accelerate their physiology, in which case they produce a lot of water vapor and carbon dioxide. This water vapor and carbon dioxide must be removed from the hive by ventilation. Otherwise the bees may develop diseases, and the bee colony may die. When the moisture inside the hive cannot be removed, it condenses on the cover cloth and drips onto the bees in the cluster. Bees that are wet in cold weather have no chance of survival. This situation can be eliminated by keeping the hive flight hole and hive cover ventilation hole open.

*Make sure that the hive flight holes do not face the prevailing winds in winter. Make sure that they are not blocked by snow and dead bees. Check frequently from outside without disturbing the bees.

*If the hive cover is not insulated, place moisture-absorbing insulation material under the hive cover. This material can be a pillow or sack filled with straw or wood shavings. This insulation material expects to absorb some of the moisture accumulated inside the hive and maintain its internal temperature. Make sure that the insulation does not block the hive ventilation holes.

Visit the apiary frequently in the winter (at least once a month) and clean the hive flight holes with a stick without disturbing the bees on each visit. Let's not forget that bees can spoil their winter clusters and die from the cold if disturbed.

Figure 6. Beehives are covered with insulation material and prepared for winter (Broccard-Bell, 2024).

5. Beekeepers' Winter Season Duties

-Maintenance, repair, and cleaning of the beekeeper's hut and warehouse,

-Cleaning, melting, or storing the combs in such bad condition that they cannot be reused after the honey is filtered.

-Make frames as needed, and installing frame wire and foundation combs.

-Cleaning frames that can be reused.

-Maintenance, repair, cleaning, disinfection, and external painting of empty hives.

6. Beekeepers' Early Spring Period Duties

Suppose we see bees on the frames when the hive cover is lifted and the cover cloth is slightly opened in early spring (Figure 1). In that case, it means that the colony's honey stocks are decreasing or finished and supplementary food should be given as soon as possible.

If we cannot see bees when the cover cloth is opened, two situations should come to mind. The first is that the bees' food stocks are good, which is a good situation, and the second is that the bees are dead.

It is essential for sustainable beekeeping that Sbit beekeepers winter well in cold regions. Otherwise, when colonies die, bees have to be purchased again every spring. Colonies that winter well and emerge healthy and strong in the spring both provide economic relief for the beekeeper and also create races with very high adaptation capabilities to regional conditions since the colony constantly changes its queen bees and lives in the region for years.

Dead colonies should be examined thoroughly, and a precise diagnosis should be made based on clues regarding the cause of death. Then, the necessary precautions should be taken. One of the most important issues that beekeepers should pay attention to is that Varroa Destructor is directly for a large portion of winter losses or indirectly responsible for the viral diseases they cause.

For this reason, Varroa destructor should be combated very well in the fall. In fact, when the bees come out in the spring, no time should be wasted and no varoa combat should be carried out again.

7. General Recommendations for Weak Colonies in the Spring Months

1-Provide bee cake rich in protein (pollen) and vitamins. This encourages the queen to lay eggs and also meets the colony's nutritional needs.

2-Dead bees in the hive should be cleaned. The hive bottom board should be cleaned, all combs with bee feces on them should be removed and replaced with clean combs.

4. Disease-free but weak colonies should be combined with strong ones.

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