Contents lists available at *Dergipark*

Journal of Scientific Reports-B

journal homepage: *https://dergipark.org.tr/en/pub/jsrb*


***E-ISSN: 2717-8625*** ***Sayı(Number) 9, Nisan(April) 2024***

***DERLEME MAKALESİ/REVIEW ARTICLE***

*Geliş Tarihi(Receive Date): 21.07.2023* *Kabul Tarihi(Accepted Date): 07.09.2023*

# Journey to the sweet world of beekeeping: historical development, honey harvesting and overview of bee products

Ebru Halvaci[a], Teslime Kozak[b], Mert Gül[c], Hatice Kars[d], Ramazan Bayat[e], Fatih SEN[,f]*

[a]*Sen Research Group, Department of Biochemistry, Kütahya Dumlupinar University, Kutahya, Türkiye, ORCID: 0009-0003-6062-7622*
[b]*Sen Research Group, Department of Biochemistry, Kütahya Dumlupinar University, Kutahya, Türkiye, ORCID: 0009-0006-9446-8449*
[c]*Sen Research Group, Department of Biochemistry, Kütahya Dumlupinar University, Kutahya, Türkiye, ORCID:0009-0005-7215-541X*
[d]*Sen Research Group, Department of Biochemistry, Kütahya Dumlupinar University, Kutahya, Türkiye, ORCID:0009-0002-1107-0605*
[e]*Sen Research Group, Department of Biochemistry, Kütahya Dumlupinar University, Kutahya, Türkiye, ORCID:0000-0002-9763-1591*
[f]*Sen Research Group, Department of Biochemistry, Kütahya Dumlupinar University, Kutahya, Türkiye, ORCID:0000-0001-6843-9026*

**Abstract**

Beekeeping started in ancient times when the first humans naturally killed the swarms nesting in tree and stone hollows and utilized their honey. Beekeeping, which was practiced with primitive methods until a few years ago, has developed up to today's modern beekeeping in the light of scientific discoveries and developments. There are approximately 56 million beehives worldwide and 1.2 million tons of honey is produced from these hives. For this reason, honey is seen as a foodstuff that the first people meet their need for sugar, easy to digest, and quickly mixed into the blood. In addition, materials such as pollen, propolis, bee venom, and beeswax obtained from beekeeping have a very important place in health and industrial fields. However, there are not enough resources to guide today's beekeepers both for beekeeping and for bees and bee products in our country and in the world. Within the scope of this study, the historical development of beekeeping, beekeeper's calendar, hive types and sizes, honey harvesting and hive care, bee products, etc. It aims to give an overview to people interested in beekeeping.

*Keywords:* Beekeeping, Bee products, Bee venom, Pollen, Propolis

* Corresponding author.
*E-mail address:*fatihsen1980@gmail.com

## 1. Introduction

The earliest evidence of true beekeeping dates back to ancient Egypt in 2450 BC. It is also possible to find reliefs of hives and bees in the Sun Temple of the Fifth Dynasty pharaoh, Newossere Any, discovered south of the Great Pyramid of Giza in 1898. Early humans naturally killed the bees that settled in tree hollows and rock cavities and benefited from their honey. The history of beekeeping, paintings drawn in caves dating back to 7000 BC, bee fossils, and similar historical finds from very old years confirm this view [1]. In historical development, tree hives were used as hives until the Stone Age, then earthen and clay containers were used as hives and developed until the beehives used today. Real beekeeping started with people taking some honey without killing the bees nesting in the tree hives and leaving some honey to the bees. [2]. Although global stocks of managed honey bee colonies appear to be increasing, significant declines in wild and domesticated bees and colony losses have been reported in many parts of the world. Beekeeping, which is seen as one of the important branches of modern agriculture, can be successfully practiced almost everywhere in our country. The climate, vegetation, rainfall regime, and topographical and geological features of the geography we live in allow for high yields in beekeeping [3]. Beekeeping is an occupation where good results can be obtained with little capital, labor, and a conscious approach. Anyone who wants can easily take care of 2-3 hives in the garden of his/her house, or it can be increased to 20-30 hives by adding a commercial dimension to the business. Therefore, it can be the main occupation for a family's livelihood. In addition to this, it can also be easily done as an auxiliary activity that provides additional income besides the main profession [4]. Various products obtained from beehives such as honey, beeswax, pollen, bee venom, and propolis provide important inputs to the national economy. The frequent use of these products in the food and health sector and their consumption as food are of great importance for healthy living and balanced nutrition. The greatest importance of beekeeping in terms of agriculture is that it helps the pollination of plants. Many orchard owners around the world rent beehives for their orchards during the pollination period. According to research, this natural function of the bee in the pollination factor provides a 40% increase in yield. The bee travels from flower to flower to collect pollen and provides a great advantage in fertilizing plants with natural methods [5]–[7].

Traditional beekeeping is a type of beekeeping that has been going on for centuries, in the traditional system everything continues in its natural course. In our country, it is done in hives called black hives. The type and dimensions of black hives vary from region to region. There are those made by hand such as wooden crates, as well as those made by knitting in the form of baskets or plastered with mud, slime, and animal excrement. Bee colonies are not under the control of the beekeeper. At this point, the only thing the beekeeper can do is to protect the hive against negative external factors. In traditional beekeeping, it is not possible to feed the bees when necessary, diagnose and treat diseases, intervene in hive problems, replace the queen with a more efficient queen, etc. [8]. In the traditional system, the honeycomb and honey must have completely natural ingredients. For this reason, honey produced by traditional methods is more preferred in the market than honey produced by modern methods [9].

Modern beekeeping is a type of beekeeping that started in the 1850s with the discovery of frame hives. 3 main features distinguish modern beekeeping from the traditional system. First of all, the frame inside the hive, the ready-made combs, and the machines for extracting honey from the combs differ. For 1 kilogram of honey, the honeybee visits about 5.5 million flowers to collect nectar and transforms it into honey in the hive. If a single bee produced a 500-gram jar of honey, it would be able to fill it in 2,000 days. This corresponds to approximately 5.5 years. Honey bees, on the other hand, live for a maximum of 45 days and spend a great deal of labor to produce a jar of honey. Ready-made honeycomb makes the bee's work much easier [10]. The bee frame quickly fluffs up the finished comb and starts to store honey in the comb chambers. Thus, she is freed from the process of building the foundation of the hive and spends most of her time storing honey. In addition, the beeswax in the honeycombs emptied of honey in the honey extractor can be used again and again by the bees [11]. The main advantages that distinguish the modern system from traditional beekeeping can be listed as follows:

- Since a ready-made comb is used, the bee spends its performance on honey storage, so honey production is higher than expected.
- Hives can be opened easily, and diseases and in-hive problems can be detected.

- Honey harvesting is quite easy.
- Queen change can be made for breed breeding.
- It is under the control of the beekeeper to swarm or not to swarm weak hives.
- Artificial swarming is possible.
- Bee products such as pollen, bee venom, and royal jelly can be taken easily.
- New developments and techniques in beekeeping can be applied.
- It is much easier in modern hives to prevent the winter and spring extinction of bees when honey is scarce.

The disadvantage of modern beekeeping is the suspicion of the substances used in the production of artificial comb on the bee. Due to the lack of standards and weak controls on artificial honeycombs, beekeepers are skeptical. The way to avoid this suspicion is not to consume the artificial part in the middle of the purchased artificial honeycomb [12].

In this study, it is aimed to create the literature necessary for beekeeping to be done with the right methods and techniques. From the historical development of beekeeping to honey harvesting, bee calendar, bee care, and bee products, it is aimed to give a general perspective to people interested in beekeeping. As a result, it is envisaged to ensure the sustainability of beekeeping.

## 2. How to start beekeeping?

Before starting beekeeping, you should start beekeeping after learning basic theoretical information from the right books, magazines, and related institutions. The biggest factor that leads new beekeepers to failure is relying on hearsay information. For this reason, it is the healthiest to contact people who are successfully practicing modern beekeeping around you and learn the right starting information. It is possible to start beekeeping with modern methods by adding swarms to an empty hive that we buy, by hiving stray bees that we find in the field, or by buying a hive with bees. The best of these methods is to start by buying a hive with a strong bee population and a young queen. With this method, it is possible to approach the hive and the bee with more accurate techniques. For beginners, 3 hives are ideal, after learning the techniques, the number of hives can be increased over time and commercialized [9], [13].

The first thing the beekeeper needs to learn is undoubtedly the rules to be considered when entering the apiary. To do beekeeping safely, it is necessary to know what behaviors annoy bees and take precautions. For example, opening the hive door in windy, rainy, and harsh weather; approaching the apiary by applying pungent odors such as essence, perfume, and cologne; blowing on the bee ball, breathing directly on the bee; also, when hive maintenance is to be done, it is necessary to move calmly and quickly and not to stop on the flight paths of bees [14]. The second thing to learn is the method of opening the beehive and checking the frames. When the beekeeper looks at a frame, he should be able to recognize which cell contains honey, which cell contains brood, or which contains pollen. He should also be able to recognize the female bee, drone, and queen at first glance. From time to time, the beekeeper will be confronted with various problems in the hive and must learn to deal with them [15]. They should feed the bees when necessary, harvest the products at the end of the period, and learn the methods of bringing the apiary to the wintering position. Therefore, the beekeeper who wants to be successful should constantly research and try to follow and learn the current methods of beekeeping [16].

## 3. Hive types and dimensions

The technical characteristics, location, and types of hives in which bee colonies spend their entire lives are directly related to the efficiency of beekeeping. Various hive models are used around the world, but the most widely used are Langstroth and Dadant-type hives. Although Langstroth-type hives are mostly used in our country, intermediate models close to the Dadant type are the majority because the hive dimensions are made differently. A Dadant-type hive consists of 5 parts (Fig. 1.). These are; the bottom board, body or brood box, honey box, cover board, and cover [7].

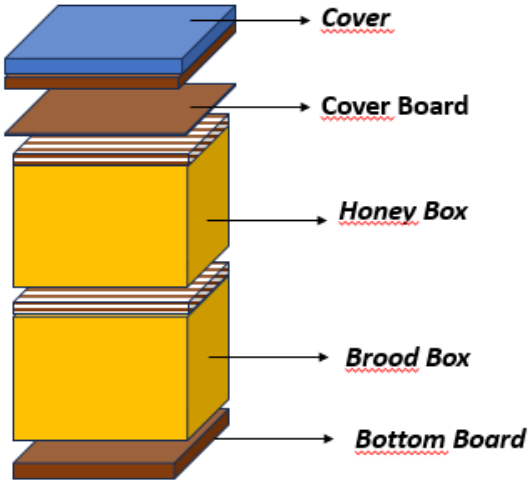


Fig. 1. Dadant-type hive consists of a cover, cover board, honey box, brood box, and bottom board.

The bottom board of the hive should be made of a single piece; if it cannot be made of a single piece, gaps should not be left at the joints of the pieces. Because every gap and crack in the bottom board provides a habitat for fungi, bacteria, and insects that may come from the environment [17]. The moth butterfly is the most common example. The body, or brood box, is the main habitat of bees. This is where the bees enter the hive. The queen is located in this section and during the brood rearing period she is on the honeycomb in the brood box. In some periods, when the bees cannot fit in the hive body, they go upstairs. Since the bee colony is in the brood chamber during the winter season, the hive body must be strong and resistant to the harsh conditions of winter. In addition, sacks or sturdy pieces of cloth can be used as cover boards, many beekeepers prefer pieces of cloth. The advantage of rags is that they do not annoy the bees by making noise when the hive cover is opened and help to ventilate the inside of the hive in summer. This helps to get rid of moisture and dampness inside the hive. There must be ventilation holes in the hive cover and these holes must be opened in summer. The cover should be made in such a way that it fits the hive well and protects the hive in adverse weather conditions. As mentioned, if the hive is to be purchased ready-made, it should be purchased from companies that are especially engaged in beekeeping and know this subject. There are various technical errors in the hives prepared by local carpenters who are not engaged in beekeeping. Therefore, no matter which type of hive is preferred, there are common rules to be considered for a good hive [18], [19].

Rules to be considered in a good hive

**1.** The hive body, i.e., the brood box, should be at least 2.5-3 cm. The boards to be used for the hive body should be made of well-dried, knotless, and strong wood. Linden wood is highly preferred in hive construction, instead the most ideal is pine wood.

**2.** The hives must be made by people who are engaged in beekeeping or have knowledge in this field and their measurements must be precise. It should be ensured that all hives are the same size. If the dimensions are not taken into consideration, using frames and honey in different hives will cause various problems.

**3.** Particular attention should be paid to the joints of the hive body. It should not be perforated or hollow, and insulation should be paid attention to prevent moisture.

**4.** Hive models should be made according to previously tested and accepted measurements. The models that emerge at the end of long efforts enable the bees to live in the best way and produce products without disturbing their natural order.

**5.** Only the outward-facing sides of the hives should be painted white or beige.

**6.** Those who will do mobile beekeeping should prefer a flat hive cover, those who will do fixed beekeeping should prefer a cradle-shaped hive cover.

**7.** Hive bottom board should be made mobile if possible.

**8.** Necessary gaps should be left for the bees to move easily in the hive and for the hive to be ventilated on summer days. According to these measurements,

- 7.5 mm between the two frames on the sides and the inner surface of the shell,
- 10 mm between the frame head and the inner surface of the barrel,
- 25 mm between the bottom board and the bottom slat of the frame,
- The gap between the two frames is 36-38 mm,
- 12 mm between the top slats of the frame,
- There should be a 10 mm gap between the top slats of the frame and the cover board.

**9.** Langstroth type hive is highly preferred according to TSE 3409 standards which is the most suitable for the methods and dimensions in beekeeping ( Fig. 2.).

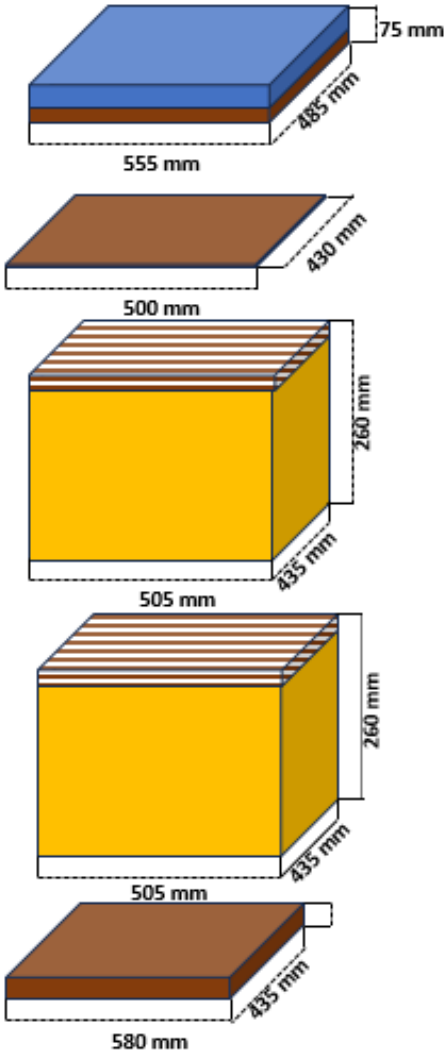


Fig. 2. Langstroth-type hive dimensions according to TSE 3409 standards.

## 4. Bee care

Beekeeping is one of the most common agricultural activities all over the world. The most important feature that distinguishes modern beekeeping from traditional beekeeping is that the bees can be easily fed when necessary. Feeding is done in the spring, when the bees start to come out of the hive, to encourage the queen to lay eggs. The queen laying as early and as many eggs as possible strengthens the colony. The queen's activity leads to an increase in yield during the honey collection season [20]. Autumn feeding is to complete the winter food of the bees and again to encourage the queen to lay eggs and to ensure that the bees enter the winter with young and healthy bees. For this reason, it is necessary to check the bee's care and nutrition status frequently. In the spring season, the sherbet is prepared in the form of water with sugar at a ratio of 1:1. In the fall season, sugar is increased in a ratio of 1:2. For example, it is prepared as a ratio of 1 kilogram of sugar to 1 kilogram of water or a glass of sugar to a glass

of water. If a spoonful of honey is added to the mixture while preparing sherbet, the tendency of bees to sherbet increases. It is possible to prepare this mixture with various ingredients. Sherbet is prepared with clean water, so first boil the water, and wait for the boiled water to cool down a little. Add sugar or honey to the water that is warm enough not to burn the finger. Stir until the sugar is completely dissolved and do not boil again after this stage. Sherbet boiled again will cause digestive tract disorders in bees. The syrup should be given in the afternoon when the weather is warm and should not be too hot or cold. There are various feeders for giving sherbet, and the amount of sherbet prepared is adjusted depending on the consumption power of the bees. However, if the beekeeper does not have a feeder box at hand, the alternative is to make a few small holes in the lid of a jar. The syrup is poured into the jar and the lid is tightly closed and placed over the feeding hole drilled on the lid. Another method is to pour the prepared syrup into the cells of the swollen comb. Care should be taken not to chill the bees in the honeycomb taken out and sherbetted, and to feed them without harming them. If for some reason the feeding of bees is forgotten, or if it is necessary to feed the bees at a time when the weather is not suitable; bee cake is a very easy method instead of sugar syrup. Because giving syrup when the hive is not opened and the bees cannot go out for food increases the possibility of diarrhea, pathogenicity, and dysentery in the colony [21], [22]. There are commercially available bee cakes, but there is also an easy recipe that anyone can prepare at home. Strained honey and powdered sugar are kneaded in a bowl to make bee cake. The cake kneaded until it reaches the consistency of dough is wrapped in a bag. Depending on the consumption power of the bees in the hive, the prepared cake is opened and placed in the feeding area. Alternative techniques are used in cake preparation according to the nutritional content of the bees. If we formulate them: 3 kg honey, 1 kg pollen, and 6 kg powdered sugar; 3 kg honey, 1 kg skim milk powder, 6 kg powdered sugar; 3 kg honey, 6 kg powdered sugar, 400 g skim milk powder, 20 g pollen or bee vitamin. With these methods, the bee care and feeding period is realized very easily and efficiently in line with the possibilities available.

## 5. Beekeeper calendar

For people interested in bee care and breeding, 4 main periods are very important. These periods can be classified as spring care, honey harvesting period, fall care, and finally wintering period. Problems that follow each other during the period can be faced with problems that reduce yield, damage the hive, and negatively affect the fight against external factors. Therefore, the goal of the modern beekeeper is to make the queen bee more effective and increase the number of worker bees in the hive until the honey harvest period [23]. When the total number of bees in the harvest season reaches around 80,000-100,000, the beekeeper will have reached the desired amount of honey. During this period, the beekeeper must fulfill his/her duties with care and experience, because if the number of healthy bees in the hive increases, the amount of nectar will increase at the same rate [24].

### *5.1. Spring Care*

In the spring period, the care that the beekeeper will do on the hives has a great impact on the honey yield that year. The first thing a conscious beekeeper should do is to maximize the honey yield that year without neglecting spring maintenance. This period, which is defined by taking the days when the vegetation on the land is dense, covers 10-30 days on average. During the spring season, vegetation, climate, and geographical conditions affect the amount of nectar. Bees store the honey left over from their daily nectar needs for the hive in the hive during this season. The second work to be done in the apiary during this season is the precautions taken for winter. Also, during this period, it is to remove the items that will prevent the bees' nectar search and flight. If the hives are placed side by side and covered, it is necessary to arrange the hive positions according to the appropriate intervals given. If the hive entrance holes are closed, they should be opened, and bee dead and waste that block the flight holes should be cleaned. When we divide the beekeeper's calendar into seasons, the all-important honey-harvesting season covers a very small period [7].

### *5.2. First Care and External Intervention to Hives*

Bees do not miss the opportunity to go out for excretion, especially during the warm and fertile days of spring. During this period when the flower population increases in the environment, they start to carry pollen to the hive. However, the cold at night and the increase in temperature during the day cause the bees to get sick frequently and the brood to get cold. For this reason, it is not right to open the hive until the weather is completely warm. In addition, opening the hive in cold weather makes the bees panic and irritable, and the decrease in the hive temperature increases the honey consumption of the bees. It is the healthiest method to detect the problem by intervening from the outside of the hive and observing the movements of the bees until the weather warms up during the period [25]. The following are the conditions to be observed when externally inspecting the beekeeper:

#### 5.2.1. Efficiency of the queen

The presence or absence of the queen, which is vital for a hive, is very important. If the bees enter and leave the hive quickly on favorable days and seasons and bring nectar, this indicates the efficiency of the queen. However, if the bees are not carrying nectar and are hovering on the outer surface of the hive, the queen is most likely dead for the winter [26].

#### 5.2.2. Food status

Checking the nutritional status, it is possible to tell from the wax residue on the bottom board of the hive that the nectar is rapidly depleting and the bees are starving. Also, if the lavra sacs have started to be expelled, this may be because the brood is cold or hungry. If there are a lot of dead bees being thrown out, it is an indication of a disease in the hive or that the food supply has reached a critical level. When food becomes scarce in the hive, older bees begin to commit suicide for the sake of the young bees and the health of the hive. This suicide takes place by clamping their heads in the comb chamber and suffocating. In addition, it is not correct to give sherbet to hives with critical nutritional status because the weather has not warmed up completely. It would be more appropriate to give solid feed to hives that need nutritional support. As described in the bee cake recipe, a mixture of powdered sugar and strained honey should be prepared and given from the feeding area. However, if there is no material for bee cake, glazes are taken from the honey frame from previous periods and left on the brood frames [27].

#### 5.2.3. Hive population

It is possible to determine this number by monitoring the number of bees entering and leaving the hive. If worker bees enter and leave the hive one or two at a time, it indicates that the bee population in the hive is low and insufficient. But if the worker bee enters and leaves the hive 3-5 times in a healthy and lively way, it shows that the hive is strong. At the same time, in the evening, after the bees enter their nests when the hive is tapped lightly, strong hives react very quickly, and a strong buzz is emitted. Weak hives have a very weak buzz [28].

#### 5.2.4. Disease status

It is possible to estimate whether the bees in the hive are diseased by observing the number of bees entering and leaving the hive. If there are more dead bees on the bottom board of the hive than expected and we know that the amount of food inside is sufficient, it is first thought that the bees are diseased. Therefore, Varroa disease is seen if wingless bees are hovering at the bottom of the hive or on the floor; Nosema disease is seen if there are small groups of bees on the floor and around the flight tray and the bees are not flying [29]. If the bees are carrying pupal-looking dead brood from the hive to the flight tray, they have Lime or Stone disease. In cases of various diseases like this, it is normal for the bees to have diarrhea for the first few days they are outside. However, if this period is prolonged and lasts for weeks, dysentery should be suspected if the flight tray and the front of the apiary are dirty [10]. During

the external inspection, hives that are likely to be diseased or problematic should be marked, and when it is time for internal inspection, those hives should be serviced first. When the weather gets warmer and the temperature difference between day and night decreases, it is time for internal maintenance and inspection of the hives. It should be started in the early hours of a calm and sunny day that will not move the bees during maintenance [30]. During internal maintenance, it is necessary to perform the following operations first in order:

a) If the bees are irritable during the first maintenance, the bellows are lit and smoke is given appropriately without suffocating the hive. If the smoke is not given properly, it has the opposite effect on the bees and they become irritable and flighty. In the spring period, the insufficient amount of nectar in the field and the critical level of nutrients in the hive is also a state of stress for bees. Therefore, it is possible to see the bees irritable in the first phase of the internal examination. The bellows are lit and smoke is given 2-3 times in slow waves through the flying hole and after waiting for about 2 minutes, the noise starts to decrease. The condition of the bees is checked by opening the top cover, if necessary, smoke is given slowly several times from the edges of the cover. The top cover is not opened completely to prevent the brood from getting cold. However, if the top cover of the hive is in one piece, the maintenance should be completed as soon as possible and the top of the hive should not be left open. In addition, the top of the hive should be covered with a cloth opened as much as necessary, and move quickly [31].

b) The hive frames are checked one by one to check their condition. The frames should be kept in the hive to avoid the risk of the queen falling out and being damaged or destroyed. During this check, the number of eggs and lavra, the condition of the worker bees, and the amount of honey and pollen are reviewed. If there is a mix of lavra in different stages of growth in a frame, with occasional empty eyes, this indicates that the queen is aging and inefficient in the hive. It is normal to have brood in different lavra stages in the same frame. But a fertile queen lays eggs without any gaps between cells and it is possible to see the areas with brood in a strip. The appearance of the lavra in the different stages is uniform, not jumbled together. Bees stand in clusters, especially on cold winter days. For this reason, in the first days of the spring season, brood can be seen in the frames inside the hive where the bees are concentrated, and the number of bees and brood decreases as you move toward the edges. As the weather gets warmer and the bees start to spread in and around the hive, the number of broods starts to increase towards the frame [32].

To keep the temperature of the brood chamber constant, the frames that are not occupied by bees are taken out and the internal volume is reduced by placing a hive partition board. In the section without a partition board, straw, grass, rags, newspapers, etc. are filled with easily accessible, clean parts to provide insulation. At the same time, the top cover of the hive should be overhauled in such a way that the young do not catch cold. Honey frames left over from the previous period may have occupied too much space, leaving no space for the queen to lay eggs. These frames are removed and replaced by frames with fluffed and ready-made honeycomb. Because of the abundant nectar in the field, the bees store a lot of honey in the hive, so there may be no space left in the hive for the queen to lay eggs. In this case, the drone cells in the brood box should also be removed, and a fluffed honeycomb or ready-made honeycomb with female cells should be placed in that area [33], [34].

c) The condition of the queen in the hive should be reviewed. If the queen is present or not, if her wings are worn out, if she is old, if she is sick, or if her ability to lay eggs has decreased for some reason, she must be replaced with a new queen [35].

d) The honeycomb cell or hive is checked for diseases such as mold, honeycomb moth, foulbrood, and bee lice. Necessary measures must be taken for diseases that show symptoms in the hive. There are alternative treatment methods for all bee diseases in our country. Before using these medicines, it should be ensured that they are licensed and produced only for bees. It is necessary to use some protective medicines, vitamins, and support mixtures against disease during this period. It is necessary to make the relevant preventive and therapeutic medicines against diseases

in the early spring when the bee population is low. because the risk of finding drug residue in the honey stored in the hive is minimized because the honey harvest has not yet started [36].

e) The physical structure of the hive should be reviewed. If there is a situation that will prevent the development of bees or offspring, the hive should be replaced. Hives that are thought to have problems should be removed from the apiary and necessary maintenance should be done. In addition, moldy, moth-eaten, and rusty hives are dried by placing them in the sun. Holes, cracks, and dismantled places on the hive should be repaired with new pieces of wood. Bee wastes on the surface of the hive should be scraped and cleaned completely and then disinfected with a blowtorch or by holding it over a burning fire at regular intervals. Hive painting should be repeated without neglect during this period [37].

f) In a hive with 10 frames during the brooding period, if 2 frames have a lot of bees, this family is weak. If the number of frames is 3-4 and the queen is old and sick, this is also effective in the weakness of the hive. However, if the hive has 3-4 frames and the queen is healthy, her activity in the hive is moderate. If the number of frames in the hive is more than 4 and the queen is hardworking, it can improve itself until the honey harvest season which is an indication that it will be a strong hive. If the number of bees and brood in the hive is low, this hive should be combined with another hive. 1 strong hive produces more honey than 10 weak hives. In hives with 3-4 frames and hard-working queens, it is necessary to supplement the young comb in other strong hives. In the hives, the frame with closed eyes should be removed from its place and the cells on it should be cleaned and placed in the place to be strengthened [38].

g) For hives whose nutritional status has reached a critical level, supplements should be fed from outside. This process can also be repeated to encourage the queen to lay eggs. On days when the weather is cold and opening a hive is risky, it can be supported with various products, but after the weather warms up, sherbet can be given easily. Bees usually prepare themselves for the cold winter settings and start to die out in the spring when the weather starts to warm up. This is because bees are dormant during winter and consume very little food. But as the weather warms up, the bees become active and their food consumption is very fast. Since the flower population is high in the field, the hive that is left without food during this period is doomed to die. To prevent this situation, the nutritional status of the hives should be checked and bee activity should be increased [39]. If there are honeyed and glazed frames in the hive, it is necessary to encourage the bees by scratching over the glaze to make it easier for the bees to feed. If there is not enough food for the bees and they are weak from hunger, they will probably not eat the prepared syrup. In such cases, warm syrup is immediately prepared and sprayed into the hive without harming the bees and without getting them wet. This process saves the hive from extinction by directing the bees, which are revived during the period, towards more sherbet [40].

h) If there is no natural water source close to the apiary, the water source for the bees must be clean, clear, and changed daily [41].

## 6. Swarm of bees

A population of bees living in colonies can reproduce again in colonies by splitting into hives with the queen. This division of hives is called swarming. The new population that leaves the hive is called swarming bees. The swarming season is one of the most busy periods for the beekeeper. During this season, the hives should be well maintained and the apiary should be monitored and kept under control at certain times of the day [42]. This phenomenon is very common when the season and the flower population are very diverse. In the spring, the bees, whose numbers are increasing and no longer fit in the hive, begin to prepare for swarming. The swarming season covers the period from the beginning of May to mid-June. The beginning and end of the swarming period varies according to climate, vegetation, and geographical conditions. The swarming season ends with the start of the major honey collection season when pollen levels are at their highest. The most obvious indication that the colony is ready

for swarming is the appearance of queen udders on the hive frames. Normally there is only one queen in each hive and when a second queen is encountered, war between colonies begins. The queen in the hive cannot even tolerate the new queen udders carried by the worker bees and tries to damage them. However, during the swarming season, the queen is needed for the new hive. In this case, the worker bees place queen cells in the form of thimbles on the bottom of the combs to produce new queens and prevent the queen from damaging the cells [43]. When the queen meets the young queen, the worker bees do not allow them to fight. Angered by this, the queen stops laying eggs and feeding and becomes weak and ready to fly. One day when the weather is favorable, she leaves the hive with a few worker bees. The queen settles on a suitable tree branch in the vicinity and puts the worker bees on top of each other to form a cluster. The swarm-shaped swarm bees are duly removed by the beekeeper and placed in the new hive [44]. In this way, when the season is favorable, swarming can occur up to the second, third, or even sixth hive. However, each swarm means that the hive population decreases and hive strength decreases. The beekeeper who wants to keep the honey yield high has to prevent natural bee emergence or should not allow swarming after the first swarm. Because as the number of swarming hives increases, the swarm population leaving decreases. The last swarms cannot prepare themselves for winter and the beekeeper has to take care of them. Since the mother of the first swarm to leave the hive is fertilized, she can start laying eggs immediately. However, in later swarms, the young queen is not fertilized and leaves the hive 5-6 days after birth to be fertilized [45]. Although modern beekeeping techniques are contrary to natural methods of swarming, sometimes this cannot be avoided. Swarming bees usually leave the hive between 9 and 12 o'clock. The first swarms to leave the hive cannot fly very far because the queen is old, so they land near the apiary and in low places. The second, third, and later swarms tend to fly farther and land in high places because the queen is young. Sometimes these swarms do not even land near the hive but tend to nest further away directly. Various methods are possible to get the bees to land when swarming starts. It is therefore necessary to prepare the hive where you intend to place the swarm in advance so that the bees can live in it in a healthy way [46]. If possible, 1-2 frames should be preferred in the hive. A gap of 2 cm should be left between the raised combs, and if honey or sugar syrup is applied to the comb, it will be easier for the bee to enter the hive and accept the hive as a nest. The swarming hive should always be kept high above the ground, and if possible, it should be covered to keep it cool. In addition, when the bees leave the hive to swarm, their guts are full of honey, so swarming bees are calm and not easily harmed [47].

## 7. Honey period and harvest

Honey is 'the collection by honey bees of the sweet substances found in plant flowers, flower essences or living parts of plants and secreted by insects in the flower. The collected nectar is separated into its components in the digestive systems of the bees and stored in the honeycomb cells and is defined as a matured, sweet product with consistency [48]. Honey contains about 200 different components. The chemistry of honey and the amount of nectar varies depending on the botanical source. But honey is mainly composed of 82% carbohydrates, 17% water, 0.7% minerals, 0.3% protein, vitamins, organic acids, and free amino acids [49]. The amount of water in honey varies according to the maturity of the honey. Normally, mature honey should contain 17% water content. The high-water content in honey causes it to spoil more easily. Honey contains approximately 15 types of sugars depending on the source from which it is obtained, and the enzyme activities secreted by the glands of the bees to convert the honeydew into honey. However, fructose (levulose) and glucose (dextrose) constitute the majority of these 15 types of sugar. The total sugar content of honey is approximately 80% [50]. Besides sugar and water, honey contains valuable minerals such as iron, copper, potassium, calcium, magnesium, phosphorus, silicon, aluminum, chromium, nickel, and cobalt. Secretory honeys are richer in mineral content. They can be used for therapeutic purposes due to their high mineral content, but they may also be preferred by some consumers because they are not crystallized. In addition, honey may contain vitamins B, C, E, and K depending on the amount obtained and the amount and type of pollen it contains. Amino acids, which are the building blocks of proteins, are found in very low amounts in honey. However, 17 different amino acids have been identified in honey. Acids are the substance that gives honey its unique odor. It also ensures that honey has an acidic structure [51]. The pH value of honey varies between 3.4 and 6.1 depending on the ambient conditions, but the general average is 3.9. Some of the enzymes in honey are obtained

from plants and some from glands. Enzymes are among the most valuable substances that play an active role in the formation and storage of honey. The amount of enzymes in natural and non-heat-treated honey is quite high, such honey meets quality standards [52]. There are losses in enzyme value in heat-treated honey. Honey is a very important food that is easy to digest, nutritious, and has protective and therapeutic properties against many disease-causing factors through vitamins, minerals, organic acids, amino acids, and enzymes. Honey is classified in three ways according to production, marketing, or source. It can be classified as strained and honeycombed according to its production and marketing method and as flower and secretion honey according to its source. Flower honey is a type of honey produced by bees by collecting the nectar secreted from the nectar glands in the flowers of plants and in some cases in the petioles and stems of cherries, broad beans, cotton, and peaches. Glandular honey is a honey derivative created by bees by collecting the secretions secreted by insects living on forest trees such as pine, oak, beech, spruce, etc. The type of honey produced in our country is pine honey [53], [54]. Honeycomb honey is a type of honey made by honeybees for incubation purposes, hexagonal in shape, produced only from beeswax, and stored on a frame. Strained honey is another type of honey obtained by separating the honey from the honeycomb using straining machines. Honey harvesting should be carried out towards the end of the honey collection season before the end of the summer period before the amount of nectar in the field is exhausted. In honey harvesting after the nectar flow has stopped, the bees become very angry and aggressive, this is due to the psychology of looting the hive. Before harvesting, the beekeeper must make all preparations to avoid problems [55]. The first preparation is to prepare the environment where the honey will be placed. This area should be an environment where the beekeeper can work comfortably. In addition, all precautions should be taken to prevent bees from entering the room. The second stage of preparation is the beekeeper's self-preparation. A mask and clean overalls suitable for the apiary should be worn. In particular, to prevent bees from entering the overalls, the feet should be tied with a bag and tied with a rubber band [56]. The beekeeper should review all his equipment. He should prepare gloves, brushes, hand irons, bellows, a stand where he can put honey supplements, and a large white cover in front of the hive to be used during shaking [57]. Honey harvesting is started early in the morning to avoid the danger of marauders. On cool and cloudy days, the bees will swarm in the brood and the number of bees in the honeycombs will be minimal [58]. Therefore, the bees must be removed from the frame, for which 4 methods are used.

### *7.1.1. Shaking and spraying method*

It is a method frequently used by beekeepers who do not have many hives. The biggest disadvantage of the shaking method, which is clean, healthy, and additive-free, is that the bees become irritable and injured. A stand on which we will put the honey we separate from the hive body is placed next to the hive we will harvest. From the duly lit bellows, smoke should be given in slow waves 2-3 times on the edge of the hive cover board. The honey bees are separated from the brood with the help of a hand iron taken on the table and covered immediately. The brooder is also covered with the cover board. At this stage, it is divided into two shaking methods. The first one is to shake the bees in front of the hive, for this a white cover is laid in front of the hive to cover the flying board. The shaken bees are directed towards the hive by blowing smoke with a bellows. The second method of shaking is to cover the brood box with the cover board but leave a hole through which the bees are directed up and down. This prevents the bees in the brood from being disturbed during harvesting and becoming irritable. A framed honey pot with 4-5 empty combs is added to the brood box and covered with a wet cloth. Bees are prevented from flying by half-opening the top honeycomb cover, shaking it on the cover, and occasionally running a bellow over the honeycomb. Some beekeepers take the frames with honey directly without taking the honeycomb on the brood and try to shake the bees into the honeycomb. This is a very inconvenient method. Because the bee that is shaken into the honeycomb is shaken again with the second frame just when it is trying to be removed. If the bee is shaken more than once, it becomes irritable and quite aggressive, which makes harvesting difficult [59]. For this reason, the most accurate method in the shaking technique is to hold the frame by both ends and make a quick downward shaking motion, or to hold the frame by one side and hit hard on the hand holding the frame with the free hand to make the bees fall. The beekeeper sweeps away the few bees remaining on the frame with a brush. The beekeeper needs

support at this stage. He hands the frame to the assistant, and it is placed in a box prepared for filtering and immediately covered with a wet cloth. In this way, the harvest is done quickly. During the process, the beekeeper must be careful not to smear the honey around and not to harm the bees. Contaminated honey will cause a marauding invasion in the hive. The harvested hive is quickly covered and the same process steps are repeated in the second hive [60].

*7.1.2. Bee Escape Method*

In this method, a bee-evading device is mounted in the center of the cover board and placed between the brood box and the honey pot. Bees can go down to the brood box with the bee-escaping device, but they cannot go up. Thus, within 2-3 days the bees leave the honeycomb, and the honey frames can be harvested easily. For this method to be applied in the hive healthily, there should be no brood in the honeycomb because the honeycomb will be full. After all, the keeper bees cannot go down. The disadvantage of this method is that in very hot weather the bees cannot go up to provide ventilation in the hive and the honey in the honeycomb starts to melt [61].

*7.1.3. Chemical Substance Methot*

With this method, very large commercial products are used in apiaries abroad. For products that bees do not like the smell of, it is applied to the hive with a special device under the lid. Bees leave the honeycomb at certain intervals and go down to the brood chamber. When the chemical materials used in this method pose a risk to human and bee health, it is necessary to pay attention to legal regulations for the use of appropriate techniques [62].

*7.1.4. Air Blowing Method*

This method is based on the principle of removing the bees from the frames by blowing air with pressure. A stand with an open bottom is placed in front of the hive. A wide cloth is stretched between the hive flying table and the stand or a ramp is placed in the flying hole for the bees to climb easily. The honey pot is placed on the stand and pressurized air is sprayed into the frame gaps. The bees falling on the cover with the pressure of the air are guided away from the frame by the bellow's smoke. The honey pot emptied from the hive is removed from the apiary very quickly by covering the top and bottom. Various models of air-blowing tools developed for this process are available for sale [63].

*7.2. Straining honey*

For honey straining, the temperature should be 25-30 °C to ensure the fluidity of the honey, ease of straining, and room temperature. The glazes on the honeycombs of the frame to be filtered should be removed with a glaze knife or glaze comb. The glazed frame is placed in a centrifuge (honey filtering) machine rotated manually or electrically and the honey is filtered. To clean the remaining honey contaminants from the combs, the frames with the drained honey are placed in the brooder in the evening and cleaned by the bees. This cleaning process must be done early in the day to avoid marauding bees. The clean and usable frames can be placed back into the hive in the spring [64]. Against the honeycomb moth, honeycombs can be suspended and fumigated by burning powdered sulfur in a fire, charcoal, or electric stove. However, the moth eggs in the combs may not die during this application, so the process can be repeated several times at intervals of 2-3 weeks. If the combs are to be used again, the risk of disease can be high. This is why in some countries honeycombs are only allowed to be used for one year. For this reason, mothballs should never be used to preserve frames. Naphthalene, a petroleum product, is a carcinogenic substance and its residues in honey and beeswax are very dangerous for human health. If too many chemicals are used, the honeycombs should be melted into wax and removed. In addition, the honey removed from the filtering machine is passed through a multilayer sieve to remove wax crumbs and foreign substances. However, small

particles and air bubbles in the honey will cloud the color of the honey [65]. For this reason, the honey is placed in a resting tank and allowed to rest. The small wax residues and air bubbles are collected at the top in the form of foam. The foamy part is stored separately as feed for the bees or for making vinegar and liqueur. When the honey has settled and clarified in the resting tank, it is packaged. As honey contains different building materials, it undergoes constant structural changes even during packaging. These changes are usually due to crystallization, darkening of color, increase in acidity, and increase or decrease in the types of sugars in the honey. In addition, increasing the storage time of honey or heating increases the HMF (hydroxymethyl furfural) value [66]. It is important to know that crystallization of honey starts at 5-7°C and deterioration starts at 10°C, so strained honey should be stored below 5°C if it is not heated. For crystallized honey to return to its original state, the honey pot should be dissolved in a container of hot water to dissolve the honey [67]. The honey pot should never be melted directly over a fire. Honey dissolved in this way will crystallize again. The beekeeper should therefore safely filter the honey from the hive through the frame and store it according to the information he has learned [59].

## 8. Bee products

### *8.1. Pollen*

Pollen is the name given to the plant dust sac in the head of the male reproductive organs of plants, which contains the genetic characteristics of the plant [64]. In addition to containing high amounts of protein and carbohydrate sources, it is a rich source of vitamins and minerals. Vitamins contained in pollen; It contains vitamins such as provitamin A, vitamin B1, vitamin B2, vitamin B3, vitamin B5, vitamin B5, vitamin B6, vitamin B12, vitamin C-D, and vitamin E. As minerals, they contain calcium, phosphorus, iron, copper, potassium, magnesium, sulfur, sodium, and iodine minerals [65]**.** Pollen is collected by pollen trapping, which is an important part of the hive. Pollen traps, which are located at the entrance of the hive and are only large enough for bees to pass through, collect the pollen carried by the bees during the passage of each bee and allow it to accumulate in the pollen trap chamber. The pollen accumulated in the hopper is collected at 1-2 day intervals. It is dried in drying tanks at a temperature not exceeding 42◦C. This method reduces the water content of pollen by 7%-8 [66]. Pollen with reduced water content is cleaned by sieving, packaged in an airtight container, and stored in a cold environment. Pollen that has been cleaned and needs to be stored for a long time can be fumigated with CO2 gas. In addition to honey production, pollen can also be used for colony feeding when necessary. Pollen can technically be dried in drying cabinets, but it can also be simply dried in an airy and shady place out of direct sunlight. As mentioned before, pollen is a natural nutrient that contains amino acids, vitamins, and minerals that are important for the growth and development of living things [67]. Thanks to these substances, it is of great importance in human health and nutrition and in maintaining general body resistance. Pollen should be collected in the morning on an empty stomach, at least half an hour before breakfast, 4 hours after dinner, 4 hours after dinner, or before going to bed with warm milk, fruit juices, or plain. The daily dose of pollen in the human body is 15-40 g for adults, 10-15 g for children aged 6-12 years, and 5-15 g for children aged 3-5 years. In addition to being a very useful bee product, pollen plays an active role in increasing mental and physical activities, eliminating anemia, liver and prostate diseases as well as various diseases such as cancer [68], [69].

### *8.2. Beeswax*

Beeswax is a liquid secreted by the wax glands in the last 4 pairs of abdominal rings of young worker bees. As it comes out of the rings, it solidifies after contact with air and is white at the moment of secretion, darkening as time passes [70]. Since beeswax is an apolar product, it is not soluble in water as it is soluble in various alcohols. The chemical structure of beeswax contains 72% alkali esters, 14% free fatty acids, 11% hydrocarbons, 1% free alcohol, and 2% unknown substances. The melting temperature of beeswax is between 62-65◦C and its density is 0.95. Since the density of beeswax is lower than the density of water, it does not dissolve in water and starts to dissolve in alcohol [66]. Beeswax can then be obtained by removing the wax layer that forms on the surface of the water when

left to rest. In addition to this process, solar melting pots can also be used. In ancient times, beeswax was used in embalming, to prevent the sarcophagus lids from breathing, and as an adhesive agent [71]. Bees synthesize wax by eating honey and from the carbohydrates contained in the honey they eat. After consuming honey, bees secrete wax in the form of a chain-like cluster at 35◦C. The wax flake from the abdominal rings is transferred to the chin with the help of the feet. The wax transferred to the jaws is processed and used in honeycombing and honeycomb making. In addition to these, it is largely used in industrial areas, honeycomb making, cosmetics, decoration, the pharmaceutical industry, and the health sector [72].

### *8.3. Propolis*

Propolis is a sticky substance collected from plants by bees. While propolis has a hard and brittle structure at 15 ◦C, it can turn into a soft, pliable structure at 30◦C. Depending on the source from which it is obtained, it has colors ranging from black to yellow. The components in the structure of raw propolis vary according to the source from which it is obtained. However, it usually contains 50%-55% resin and balsam, 20%-35% plant-derived waxes, 10%-15% ethereal and essential oils, 2%-5% pollen, and small amounts of organic and inorganic compounds. According to other sources, propolis contains 46% balsam, 27% wax of plant origin, and 15% flavones and flavonoids. In addition, flavones and flavonoids are substances that give propolis antifungal, antiviral, and antibacterial properties [73]. Honey bees therefore open and collect propolis, the protective resins of the plants, with their lower jaws. They soften it in their mouths, add various enzymes, and turn it into pellets for the hive. They carry the pellet using their front legs and place it in a pollen basket on their hind legs [74]. Bees accumulate propolis in parts of the hive such as the bottom board, frame edges, and behind the entrance hole. Since propolis is a sticky material, collection is done by scraping. After this process, propolis may not be clean and may contain various residues. After being cleaned from waste materials, the harvested raw propolis is brought to the laboratory, and 'Soft Propolis Extract' is produced. Propolis is used by bees to close cracks and open parts in the hive, to prevent the pests that enter the colony and cannot be thrown out of the colony from smelling by mummifying them through propolis, to polish and polish the honeycombs, to sterilize the hive, and as a raw material for medicine in various fields [75]. Propolis therefore has antibacterial, antifungal, antiviral, and anesthetic effects. It is used commercially to make medicines, lozenges, tablets, creams, and solutions. Propolis helps in the destruction of tumor and cancer cells, in the treatment of inflammation of the large intestine, in the treatment of wounds in the mouth caused by chemotherapy, in the treatment of asthma, and in the cleaning of cell wastes in the body thanks to its antioxidant properties [76], [77].

### *8.4. Bee Venom*

Bee venom is a product produced by the venom glands of worker bees and stored in venom bags. Bees in the egg stage have very little ability to produce venom. Bees reach their peak venom production capacity at 12 days of age. A worker bee produces around 0.3 mg of bee venom in its lifetime. At 20 days of age, they lose their ability to produce venom [78]. Overwintering bees cannot produce bee venom. Bee venom is rich in the polypeptide chemicals mellitin, and apamindin. Phospholipases, which are enzymes, are also present in bee venom at around 12% [79]. Therefore, bee venom has a chemically highly efficient structure. It contains substances that are very important and actively used in the field of pharmacology. For this reason, various methods of collecting bee venom have been developed [80]. One of them is a glass plate apparatus placed in parallel with wires spaced 5-10 mm apart. This device is placed on the hive flight board or the bottom board of the hive. 12-volt current is applied to the porous plate, which creates a slight shock effect on the bees passing through contact. With the shock effect, the bees release their venom on the glass plate and do not die because they cannot pass through the glass plate by trying to prick their stingers. When the bees drop the liquid poison on the glass plate, it turns into crystalline, and the crystallized poison is collected with the help of a razor blade. Bee venom is used in the protection and defense of the colony against enemies and in the treatment of various

diseases. The use of bee venom is more limited compared to other bee products, but it is sold as tablets in pharmacies in developed countries such as the USA and attracts great interest. Bee venom is a product that can be used in joint disorders such as rheumatism. This product is often used as an anti-inflammatory in flu infections, in the treatment of allergic diseases, and the treatment of diseases such as gout and asthma [81]. The American Apitherapy Association has reported that it is also used in eczema, tissue hardening, skin cancer, and scar removal. Bee venom is a highly preferred product in the treatment of epilepsy, some types of cancer, throat infections, migraines, cholesterol, sinusitis, and ulcers [82].

## 9. What to do with a bee sting and bee sting?

The stinger on the back of worker bees is the most effective weapon for self-defense. Although the bees' stinger is behind them, they can easily stab their enemy with their stinger in all kinds of defense. The bee stinger consists of two parts. The first part is the oval-shaped venom sac, which is connected to the intestines from the abdominal cavity. The second part is the stinger. On the stinger, 9 hook-shaped structures look like arrowheads. It is these hooks that prevent the bee from coming back out after sticking the stinger [83]. After stinging, the bees inject the venom stored in the venom sac into the enemy's body and the enemy feels great pain. In addition to the stinger, which it cannot remove because of the hooks, sometimes a part of its intestines also breaks off and remains where the stinger is stuck together with the venom sac. The life of the bee whose stinger remains stuck in the enemy's body ends within 1-2 days. For this reason, bees with the stinger stuck in the enemy become more aggressive and attack the enemy more. However, the bee with a stinger has no chance to sting again and after the bee stings, panic, and hand, arm, etc. movements should not be made. Such movements attract the attention of other bees and cause them to attack [84].

Bee venom has a distinctive odor, and the spread of this odor causes other bees to become irritable. Therefore, in case of a bee sting, the sting should be washed. When removing the bee stinger from the sting site, it should be removed by holding the venom sac. Because if the poison enters the body through the stinger, it causes increased pain. The danger of a bee sting depends on the person's constitution, allergies, or the number of stinging bees [85]. In the case of a bee sting where a person is allergic to bee stings; redness, itching, and swelling are seen throughout the body. In addition, there are symptoms such as breathing difficulties, abdominal pain, vomiting, and heart palpitations. In addition, as the throat muscles contract and the pharynx swells, breathing becomes increasingly difficult and the patient may suffocate [86]. The most effective alternative and fast medicine method against bee stings is cleaning with ammonia. It can be applied to the place where the bee stings, as well as 5-10 drops in a glass of water. It is not correct to rub or suck where the bee stings. Putting ice on the sting, applying yogurt, or drinking buttermilk contributes to the reduction of pain [87].

## 10. Conclusion

Beekeeping is a branch of agriculture where products such as honey, beeswax, pollen, propolis, and bee venom are produced with traditional and modern methods from the past to the present. It has become a very popular profession in our country and developed countries. Bees contribute not only to crop production but also to pollination and fertilization factors of plants in the ecosystem. For this reason, bees are one of the living groups that play an active role in natural selection and have a high risk of contamination. To prevent this risk of contamination and to approach the hive with the right techniques and methods, it is necessary to acquire basic information. It is not correct to learn basic information about beekeeping from hearsay and wrong sources, it is better to learn from people who have done this job and have experience or from current sources that have a command of the literature. Bee diseases in the hive, parasites, queen use, nutritional status, and colony management are the main causes of bee losses. Therefore, unconscious use of pesticides; hive sizes and spacing; location of the hive and care of the bees; water, air, and environmental pollution should be taken into consideration.

This study focuses on the importance of beekeeping in our lives, how to start beekeeping, and how to care for bees and bee products. While dealing with beekeeping, it is discussed how the correct bee breeding should be based

on the literature. In this way, certain problems have been overcome. We believe that it will guide the way for future bee studies.

## Acknowledgment

The authors report there are no competing interests to declare.

## References

[1]L. I. de Guzman, G. R. Williams, K. Khongphinitbunjong, and P. Chantawannakul, 'Ecology, Life History, and Management of Tropilaelaps Mites', *J. Econ. Entomol.*, vol. 110, no. 2, pp. 319–332, Apr. 2017, doi: 10.1093/jee/tow304.
[2]A. Chirsanova, T. Capcanari, A. Boistean, and I. Khanchel, 'Bee Honey: History, Characteristics, Proerties, Benefits and Adulteration in the Beekeeping Sector', *J. Soc. Sci.*, vol. 4, no. 3, pp. 98–114, Sep. 2021, doi: 10.52326/jss.utm.2021.4(3).11.
[3]Eroğlu Özgür, 'Historical Development And Current Status Of Beekeepıng In Turkey And The World', *Atlas J.*, vol. 6, no. 27, pp. 345–354, Jan. 2020, doi: 10.31568/atlas.433.
[4]B. YÜCEL and M. KÖSOĞLU, 'Comparisons of Mugla Ecotype and Italian Cross Honey Bees for Some Performances in Aegean Region (Turkey)', *Kafkas Univ. Vet. Fak. Derg.*, 2009, doi: 10.9775/kvfd.2011.5092.
[5]D. Sammataro, U. Gerson, and G. Needham, 'Parasitic Mites of Honey Bees: Life History, Implications, and Impact', *Annu. Rev. Entomol.*, vol. 45, no. 1, pp. 519–548, Jan. 2000, doi: 10.1146/annurev.ento.45.1.519.
[6]'Adnexal Glands of the Sting Apparatus of Bees: Anatomy and Histology, I (Hymenoptera: Colletidae and Andrenidae) on JSTOR'.
[7]G. D. Birloiu, S. Diaconescu, and C. G. Nicolae, 'Study on the Maintenance of Bee Families Into Vertical Hives on Dadant and Layens Frames', *Sci. Pap. D-Animal Sci.*, vol. 58, no. October, pp. 239–246, 2015.
[8]G. Papa *et al.*, 'The Honey Bee Apis mellifera: An Insect at the Interface between Human and Ecosystem Health', *Biology (Basel).*, vol. 11, no. 2, p. 233, Feb. 2022, doi: 10.3390/biology11020233.
[9]G. Kritsky, 'Beekeeping from Antiquity Through the Middle Ages', *Annu. Rev. Entomol.*, vol. 62, no. 1, pp. 249–264, Jan. 2017, doi: 10.1146/annurev-ento-031616-035115.
[10]P. V. Rao, K. T. Krishnan, N. Salleh, and S. H. Gan, 'Biological and therapeutic effects of honey produced by honey bees and stingless bees: a comparative review', *Rev. Bras. Farmacogn.*, vol. 26, no. 5, pp. 657–664, Sep. 2016, doi: 10.1016/j.bjp.2016.01.012.
[11]M. V. Srinivasan, 'Honey Bees as a Model for Vision, Perception, and Cognition', vol. 55, pp. 267–284, Dec. 2009, doi: 10.1146/ANNUREV.ENTO.010908.164537.
[12]D. Zhao, D. Chen, X. Su, X. Zhang, and Y. Liu, 'Transcriptome explores changes in gene expression profile contributed by Camellia sinensis (L.) in Apis cerana cerana and Apis mellifera ligustica', *J. Asia. Pac. Entomol.*, vol. 25, no. 3, p. 101973, Sep. 2022, doi: 10.1016/J.ASPEN.2022.101973.
[13]G. Tantillo, M. Bottaro, A. Di Pinto, V. Martella, P. Di Pinto, and V. Terio, 'Virus infections of honeybees Apis Mellifera', *Ital. J. Food Saf.*, vol. 4, no. 3, Sep. 2015, doi: 10.4081/ijfs.2015.5364.
[14]A. Decourtye, E. Mader, and N. Desneux, 'Landscape enhancement of floral resources for honey bees in agro-ecosystems', *Apidologie*, vol. 41, no. 3, pp. 264–277, May 2010, doi: 10.1051/apido/2010024.
[15]S. A. Alger, P. A. Burnham, Z. S. Lamas, A. K. Brody, and L. L. Richardson, 'Home sick: impacts of migratory beekeeping on honey bee ( Apis mellifera ) pests, pathogens, and colony size', *PeerJ*, vol. 6, p. e5812, Nov. 2018, doi: 10.7717/peerj.5812.
[16]A. L. Gallant, N. H. Euliss, and Z. Browning, 'Mapping Large-Area Landscape Suitability for Honey Bees to Assess the Influence of Land-Use Change on Sustainability of National Pollination Services', *PLoS One*, vol. 9, no. 6, p. e99268, Jun. 2014, doi: 10.1371/journal.pone.0099268.
[17]R. M. Underwood, B. E. Traver, and M. M. López-Uribe, 'Beekeeping Management Practices Are Associated with Operation Size and Beekeepers' Philosophy towards in-Hive Chemicals', *Insects*, vol. 10, no. 1, p. 10, Jan. 2019, doi: 10.3390/insects10010010.
[18]N. L. Carreck *et al.*, 'Standard methods for Apis mellifera anatomy and dissection', *J. Apic. Res.*, vol. 52, no. 4, pp. 1–40, Jan. 2013, doi: 10.3896/IBRA.1.52.4.03.
[19]E. F. Phillips, 'The Size of Hives and Frames', *Bee World*, vol. 14, no. 2, pp. 13–15, Feb. 1933, doi: 10.1080/0005772X.1933.11093197.
[20]W. I. W. Ismail, 'A review on beekeeping in Malaysia: History, importance and future directions', *J. Sustain. Sci. Manag.*, vol. 11, no. 2, pp. 70–80, 2016.
[21]C. Alaux, C. Dantec, H. Parrinello, and Y. Le Conte, 'Nutrigenomics in honey bees: digital gene expression analysis of pollen's nutritive effects on healthy and varroa-parasitized bees', *BMC Genomics*, vol. 12, no. 1, p. 496, Dec. 2011, doi: 10.1186/1471-2164-12-496.
[22]T. Erez *et al.*, 'Multiple benefits of breeding honey bees for hygienic behavior', *J. Invertebr. Pathol.*, vol. 193, p. 107788, Sep. 2022, doi: 10.1016/j.jip.2022.107788.
[23]S. W. Cobey, D. R. Tarpy, and J. Woyke, 'Standard methods for instrumental insemination of Apis mellifera queens', *J. Apic. Res.*, vol. 52, no. 4, pp. 1–18, Jan. 2013, doi: 10.3896/IBRA.1.52.4.09.
[24]R. B. Gonçalves, O. M. De Meira, and B. B. Rosa, 'Total-evidence dating and morphological partitioning: a novel approach to understand the phylogeny and biogeography of augochlorine bees (Hymenoptera: Apoidea)', *Zool. J. Linn. Soc.*, vol. 195, no. 4, pp. 1390–1406, Jul. 2022, doi: 10.1093/zoolinnean/zlab098.
[25]A. Rafael Braga, D. G. Gomes, R. Rogers, E. E. Hassler, B. M. Freitas, and J. A. Cazier, 'A method for mining combined data from in-hive

sensors, weather and apiary inspections to forecast the health status of honey bee colonies', *Comput. Electron. Agric.*, vol. 169, p. 105161, Feb. 2020, doi: 10.1016/j.compag.2019.105161.
[26]R. Seltzer *et al.*, 'Breeding for hygienic behavior in honey bees ( Apis mellifera ): a strong paternal effect', *J. Apic. Res.*, vol. 62, no. 3, pp. 419–428, May 2023, doi: 10.1080/00218839.2022.2140927.
[27]A. L. Toth, S. Kantarovich, A. F. Meisel, and G. E. Robinson, 'Nutritional status influences socially regulated foraging ontogeny in honey bees', *J. Exp. Biol.*, vol. 208, no. 24, pp. 4641–4649, Dec. 2005, doi: 10.1242/jeb.01956.
[28]D. S. Khoury, A. B. Barron, and M. R. Myerscough, 'Modelling Food and Population Dynamics in Honey Bee Colonies', *PLoS One*, vol. 8, no. 5, p. e59084, May 2013, doi: 10.1371/journal.pone.0059084.
[29]S. E. Jandricic and G. W. Otis, 'The potential for using male selection in breeding honey bees resistant to Varroa destructor', *Bee World*, vol. 84, no. 4, pp. 155–164, Jan. 2003, doi: 10.1080/0005772X.2003.11099597.
[30]I. Tlak Gajger, J. Vlainić, P. Šoštarić, J. Prešern, J. Bubnič, and M. I. Smodiš Škerl, 'Effects on Some Therapeutical, Biochemical, and Immunological Parameters of Honey Bee (Apis mellifera) Exposed to Probiotic Treatments, in Field and Laboratory Conditions', *Insects*, vol. 11, no. 9, p. 638, Sep. 2020, doi: 10.3390/insects11090638.
[31]A. Gray *et al.*, 'Loss rates of honey bee colonies during winter 2017/18 in 36 countries participating in the COLOSS survey, including effects of forage sources', *J. Apic. Res.*, vol. 58, no. 4, pp. 479–485, Aug. 2019, doi: 10.1080/00218839.2019.1615661.
[32]S. A. M. Khalifa *et al.*, 'Overview of Bee Pollination and Its Economic Value for Crop Production', *Insects*, vol. 12, no. 8, p. 688, Jul. 2021, doi: 10.3390/insects12080688.
[33]A. Q. Chisom, *Share' Agrıcultural Technology For School' S And Colleges*, no. November. 2022.
[34]H. Human *et al.*, 'Miscellaneous standard methods for Apis mellifera research', *J. Apic. Res.*, vol. 52, no. 4, pp. 1–53, Jan. 2013, doi: 10.3896/IBRA.1.52.4.10.
[35]F. Azzouz-Olden, A. Hunt, and G. DeGrandi-Hoffman, 'Transcriptional response of honey bee (Apis mellifera) to differential nutritional status and Nosema infection', *BMC Genomics*, vol. 19, no. 1, p. 628, Dec. 2018, doi: 10.1186/s12864-018-5007-0.
[36]M. A. Abd Jalil, A. R. Kasmuri, and H. Hadi, 'Stingless Bee Honey, the Natural Wound Healer: A Review', *Skin Pharmacol. Physiol.*, vol. 30, no. 2, pp. 66–75, 2017, doi: 10.1159/000458416.
[37]M. P. Nolan and K. S. Delaplane, 'Distance between honey bee Apis mellifera colonies regulates populations of Varroa destructor at a landscape scale', *Apidologie*, vol. 48, no. 1, pp. 8–16, Feb. 2017, doi: 10.1007/s13592-016-0443-9.
[38]P. Rosenkranz, I. Fries, O. Boecking, and M. Stürmer, 'Damaged Varroa mites in the debris of honey bee (Apis mellifera L) colonies with and without hatching brood', *Apidologie*, vol. 28, no. 6, pp. 427–437, 1997, doi: 10.1051/apido:19970609.
[39]A. J. McMenamin and M. L. Flenniken, 'Recently identified bee viruses and their impact on bee pollinators', *Curr. Opin. Insect Sci.*, vol. 26, pp. 120–129, Apr. 2018, doi: 10.1016/j.cois.2018.02.009.
[40]R. Brodschneider and K. Crailsheim, 'Nutrition and health in honey bees', *Apidologie*, vol. 41, no. 3, pp. 278–294, May 2010, doi: 10.1051/APIDO/2010012.
[41]R. Landaverde, M. T. Rodriguez, and J. A. Parrella, 'Honey Production and Climate Change: Beekeepers' Perceptions, Farm Adaptation Strategies, and Information Needs', *Insects*, vol. 14, no. 6, p. 493, May 2023, doi: 10.3390/insects14060493.
[42]P. Hristov, R. Shumkova, N. Palova, and B. Neov, 'Factors Associated with Honey Bee Colony Losses: A Mini-Review', *Vet. Sci.*, vol. 7, no. 4, p. 166, Oct. 2020, doi: 10.3390/vetsci7040166.
[43]J. Horn *et al.*, 'Honey Bee Colony Performance Affected By Crop Diversity and Farmland Structure: A Modeling Framework', *Ecol. Appl.*, vol. 31, no. 1, Jan. 2021, doi: 10.1002/eap.2216.
[44]T. O. Bykova *et al.*, 'Morphometric variability of wild honey bees of the mountain forest zone of Crimea as a material for breeding', *E3S Web Conf.*, vol. 224, p. 04014, Dec. 2020, doi: 10.1051/e3sconf/202022404014.
[45]J. M. Peters, O. Peleg, and L. Mahadevan, 'Thermoregulatory morphodynamics of honeybee swarm clusters', *J. Exp. Biol.*, vol. 225, no. 5, Mar. 2022, doi: 10.1242/jeb.242234.
[46]C. Campell, R. M. Parry, and R. Tashakkori, 'Non-Invasive Spectral-Based Swarm Detection', in *SoutheastCon 2023*, Apr. 2023, pp. 253–260. doi: 10.1109/SoutheastCon51012.2023.10115171.
[47]H. Akkaya and S. Alkan, 'Beekeeping in anatolia from the hittites to the present day', *J. Apic. Res.*, vol. 46, no. 2, pp. 120–124, 2007, doi: 10.1080/00218839.2007.11101378.
[48]E. A. Neşe Özmen, 'Bal Antimikrobiyel Özellikleri Ve İnsan Sağlığı Üzerine Etkileri', *A. Bilimi / Bee Sci.*, no. November, pp. 155–160, 2006.
[49]C. Mutlu *et al.*, 'Bal ve Diğer Arı Ürünlerinin Bazı Özellikleri ve İnsan Sağlığı Üzerine Etkileri Some Properties of Honey and Other Bee Products and Their Effects on Human Health', *Akad. Gıda*, vol. 15, no. 1, pp. 75–83, 2017.
[50]E. Zhou *et al.*, 'Effects of Bee Pollen Derived From Acer Mono Maxim. or Phellodendron amurense Rupr. on the Lipid Composition of Royal Jelly Secreted by Honeybees', *Foods*, vol. 12, no. 3, p. 625, Feb. 2023, doi: 10.3390/foods12030625.
[51]S. Ahmad, M. G. Campos, F. Fratini, S. Z. Altaye, and J. Li, 'New Insights into the Biological and Pharmaceutical Properties of Royal Jelly', *Int. J. Mol. Sci.*, vol. 21, no. 2, p. 382, Jan. 2020, doi: 10.3390/ijms21020382.
[52]I. Journal, O. F. Researches, and I. N. Biosciences, 'Review on Physico-Chemical Nutritional and', no. May, pp. 163–179, 2022.
[53]E. Tsavea *et al.*, 'Physicochemical Characterization and Biological Properties of Pine Honey Produced across Greece', *Foods*, vol. 11, no. 7, p. 943, Mar. 2022, doi: 10.3390/foods11070943.
[54]V. Honey, 'Chemical and Organoleptic Characterization of', no. May, 2023.
[55]C. Li, M. Tang, X. Li, and X. Zhou, 'Community Dynamics in Structure and Function of Honey Bee Gut Bacteria in Response to Winter Dietary Shift', *MBio*, vol. 13, no. 5, Oct. 2022, doi: 10.1128/mbio.01131-22.
[56]L. L. Botina, R. C. Bernardes, W. F. Barbosa, M. A. P. Lima, R. N. C. Guedes, and G. F. Martins, 'Toxicological assessments of agrochemical effects on stingless bees (Apidae, Meliponini)', *MethodsX*, vol. 7, p. 100906, 2020, doi: 10.1016/j.mex.2020.100906.

[57]R. Végh, M. Csóka, Z. Mednyánszky, and L. Sipos, 'Pesticide residues in bee bread, propolis, beeswax and royal jelly – A review of the literature and dietary risk assessment', *Food Chem. Toxicol.*, vol. 176, p. 113806, Jun. 2023, doi: 10.1016/j.fct.2023.113806.
[58]E. D. Mazur, M. Czopowicz, and A. M. Gajda, 'Two Faces of the Screened Bottom Boards—An Ambiguous Influence on the Honey Bee Winter Colony Loss Rate', *Insects*, vol. 13, no. 12, p. 1128, Dec. 2022, doi: 10.3390/insects13121128.
[59]R. Subramanian, H. Umesh Hebbar, and N. K. Rastogi, 'Processing of Honey: A Review', *Int. J. Food Prop.*, vol. 10, no. 1, pp. 127–143, Jan. 2007, doi: 10.1080/10942910600981708.
[60]D. S. Brar *et al.*, 'A comprehensive review on unethical honey: Validation by emerging techniques', *Food Control*, vol. 145, p. 109482, Mar. 2023, doi: 10.1016/j.foodcont.2022.109482.
[61]S. Bogdanov *et al.*, 'Honey quality and international regulatory standards: review by the International Honey Commission', *Bee World*, vol. 80, no. 2, pp. 61–69, Jan. 1999, doi: 10.1080/0005772X.1999.11099428.
[62]A. Leska, A. Nowak, I. Nowak, and A. Górczyńska, 'Effects of Insecticides and Microbiological Contaminants on Apis mellifera Health', *Molecules*, vol. 26, no. 16, p. 5080, Aug. 2021, doi: 10.3390/molecules26165080.
[63]L. Bicudo de Almeida-Muradian *et al.*, 'Standard methods for Apis mellifera honey research', *J. Apic. Res.*, vol. 59, no. 3, pp. 1–62, May 2020, doi: 10.1080/00218839.2020.1738135.
[64]G. Başdoğan, O. Sağdıç, T. Daştan, S. Acar, and G. Düz, 'Farklı Bölgelerden Toplanan Arı Polenlerinin Fizikokimyasal Özellikleri ve Şeker Profillerinin Belirlenmesi', *Eur. J. Sci. Technol.*, no. 15, pp. 627–631, 2019, doi: 10.31590/ejosat.535054.
[65]M. Arıgül Apan, M. Zorba, and Ü. Kayaboynu, 'Bal Arısı ve Bal Arısı Ürünleri', *Sinop Üniversitesi Fen Bilim. Derg.*, vol. 6, no. 2, pp. 202–223, Dec. 2021, doi: 10.33484/sinopfbd.992345.
[66]J. S. Algethami *et al.*, 'Bee Pollen: Clinical Trials and Patent Applications', *Nutrients*, vol. 14, no. 14, p. 2858, Jul. 2022, doi: 10.3390/nu14142858.
[67]R. Bleha, T. Shevtsova, V. Kružík, J. Brindza, and A. Sinica, 'Morphology, physicochemical properties and antioxidant capacity of bee pollens', *Czech J. Food Sci.*, vol. 37, no. 1, pp. 1–8, Feb. 2019, doi: 10.17221/139/2018-CJFS.
[68]M. Thakur and V. Nanda, 'Composition and functionality of bee pollen: A review', *Trends Food Sci. Technol.*, vol. 98, pp. 82–106, Apr. 2020, doi: 10.1016/j.tifs.2020.02.001.
[69]A. M. Ares, S. Valverde, J. L. Bernal, M. J. Nozal, and J. Bernal, 'Extraction and determination of bioactive compounds from bee pollen', *J. Pharm. Biomed. Anal.*, vol. 147, pp. 110–124, Jan. 2018, doi: 10.1016/j.jpba.2017.08.009.
[70]A. Kurek-Górecka, M. Górecki, A. Rzepecka-Stojko, R. Balwierz, and J. Stojko, 'Bee Products in Dermatology and Skin Care', *Molecules*, vol. 25, no. 3, p. 556, Jan. 2020, doi: 10.3390/molecules25030556.
[71]P. R. S. Rajamanoharan and S. Vivekanandarajah Sathasivampillai, 'The role of honey in pediatric treatments in Sri Lankan Siddha medicine', *Uludag Aricilik Derg.*, vol. 20, no. 2, pp. 83–90, 2021, doi: 10.31467/uluaricilik.781259.
[72]T. D. Tran, S. M. Ogbourne, P. R. Brooks, N. Sánchez-Cruz, J. L. Medina-Franco, and R. J. Quinn, 'Lessons from Exploring Chemical Space and Chemical Diversity of Propolis Components', *Int. J. Mol. Sci.*, vol. 21, no. 14, p. 4988, Jul. 2020, doi: 10.3390/ijms21144988.
[73]J. Rajput, A. Shaikh, Q. Majaz, and G. Khan, 'BEE PROPOLIS: A Comprehensive Review', *Int. J. Pharm. Res. Appl.*, vol. 7, no. May, pp. 835–845, 2022, doi: 10.35629/7781-0701835845.
[74]N. Doğan and İ. Hayoğlu, 'Propolis ve kullanım alanları', *Harran Tarım ve Gıda Bilim. Derg.*, vol. 16, no. 3, pp. 39–48, 2012.
[75]M. Martinello and F. Mutinelli, 'Antioxidant Activity in Bee Products: A Review', *Antioxidants*, vol. 10, no. 1, p. 71, Jan. 2021, doi: 10.3390/antiox10010071.
[76]N.-Y. Kwon, S.-H. Sung, H.-K. Sung, and J.-K. Park, 'Anticancer Activity of Bee Venom Components against Breast Cancer', *Toxins (Basel).*, vol. 14, no. 7, p. 460, Jul. 2022, doi: 10.3390/toxins14070460.
[77]F. Zulhendri *et al.*, 'Recent Update on the Anti-Inflammatory Activities of Propolis', *Molecules*, vol. 27, no. 23, p. 8473, Dec. 2022, doi: 10.3390/molecules27238473.
[78]D. C. de Graaf *et al.*, 'Standard methods for Apis mellifera venom research', *J. Apic. Res.*, vol. 60, no. 4, pp. 1–31, Aug. 2021, doi: 10.1080/00218839.2020.1801073.
[79]'Correction: An evaluation of the chemical content and microbiological contamination of Anatolian bee venom', *PLoS One*, vol. 17, no. 6, p. e0269579, Jun. 2022, doi: 10.1371/journal.pone.0269579.
[80]R. Bava, F. Castagna, V. Musella, C. Lupia, E. Palma, and D. Britti, 'Therapeutic Use of Bee Venom and Potential Applications in Veterinary Medicine', *Vet. Sci.*, vol. 10, no. 2, p. 119, Feb. 2023, doi: 10.3390/vetsci10020119.
[81]S. Nekoei, M. Rezvan, F. Khamesipour, C. Mayack, M. B. Molento, and P. D. Revainera, 'A systematic review of honey bee ( Apis mellifera , Linnaeus , 1758) infections and available treatment options', *Vet. Med. Sci.*, Jun. 2023, doi: 10.1002/vms3.1194.
[82]M. Carpena, B. Nuñez-Estevez, A. Soria-Lopez, and J. Simal-Gandara, 'Bee Venom: An Updating Review of Its Bioactive Molecules and Its Health Applications', *Nutrients*, vol. 12, no. 11, p. 3360, Oct. 2020, doi: 10.3390/nu12113360.
[83]J. A. Lee, E. Singletary, and N. Charlton, 'Methods of Honey Bee Stinger Removal: A Systematic Review of the Literature', *Cureus*, May 2020, doi: 10.7759/cureus.8078.
[84]S. Yang *et al.*, 'Cerebral infarction following bee stings: Case report and literature review', *Transl. Neurosci.*, vol. 13, no. 1, pp. 163–171, Jul. 2022, doi: 10.1515/tnsci-2022-0225.
[85]H.-S. Lee, Y. S. Kim, K.-S. Lee, H.-S. Seo, C.-Y. Lee, and K. K. Kim, 'Detoxification of Bee Venom Increases Its Anti-inflammatory Activity and Decreases Its Cytotoxicity and Allergenic Activity', *Appl. Biochem. Biotechnol.*, vol. 193, no. 12, pp. 4068–4082, Dec. 2021, doi: 10.1007/s12010-021-03653-2.
[86]A. Ullah *et al.*, 'Viral impacts on honey bee populations: A review', *Saudi J. Biol. Sci.*, vol. 28, no. 1, pp. 523–530, Jan. 2021, doi: 10.1016/j.sjbs.2020.10.037.
[87]M. Özüiçli *et al.*, 'Nosema Ceranae İle Doğal Enfekte Balarısı Kolonilerinde Noseba'nın Etkinliğinin Araştırılması', *J. Res. Vet. Med.*, vol.

39, no. 1, pp. 10–14, Jul. 2020, doi: 10.30782/jrvm.593762.