Trop J Nat Prod Res, November 2025; 9(11): 5629 - 5638

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Tropical Journal of Natural Product Research

Available online at https://www.tjnpr.org

Original Research Article

New Data on the Production of Natural Honey in Morocco: Practices of Beekeepers, Melliferous Plants, and Production Features

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ARTICLE INFO

Article history:
Received 17 August 2025
Revised 08 November 2025
Accepted 14 November 2025
Published online 01 December 2025

ABSTRACT

Despite the importance of honey production in food, medicine, and the economy of Morocco, the data on practices, productivity, and melliferous plants are rare and fragmentary. Therefore, this study evaluated the age, gender, and practices of beekeepers from Fez-Meknes, Daraa-Tafilalet, Rabat-Sale-Kenitra, and Tangier-Tetouan-Al Hoceima. Honey production addressed the used plants, quality, quantity, and limiting factors. Data was collected via questionnaire and analyzed with descriptive and multivariate statistics. In total, 100 beekeepers were included, with a dominance of men (90%) aged between 25 and 50 years. 60% of beekeepers used modern hives. *Apis mellifera intermissa* was the most common (65%). Most participants (74%) practice transhumance, and 45% of beekeepers are transhumant. In total, 10 melliferous plants were recorded, and the most popular were jujube (14%), carob (13%), and eucalyptus (12%). These plants flower in spring, summer, and autumn. Varroa presented the largest menace to bee health (44%), followed by hornets (16%), nosema (15%), moths (14%), and loque (12%). To protect their beehives, participants use different treatments, including fumigation with local medicinal plants (37%), followed by thymol (21%). This study revealed new data on the beekeepers, production, and practices in different areas of Morocco and is suggested to serve as a reference for future studies and for conservation efforts, mainly for bee and plant species.

Keywords: Beekeepers, Practices, Honey Production, Quality, Limiting Factors, Treatments, Morocco.

Introduction

Beekeeping, an ancient agricultural practice, involves breeding honeybees to gather honey and other hive products.[1] This practice, originally from Africa, is crucial for socio-economic development and environmental conservation.[2,3] Income generation, forest preservation, and the abundance of pollinators are all impacted by it.[4] The growth of the bioeconomy and the forest-based bioeconomy could become more widely accepted if beekeeping systems are integrated into the traditional economy, as well as the agricultural and environmental sectors.[5] The bioeconomic approach, which has emerged over the last 20 years, particularly in industrialized nations, can promote an economic shift toward the use of forest resources, including bees.[6,7] Morocco's beekeeping potential is great and unique due to the diversity of its flora, fauna, and landscapes, making it one of the most fascinating regions in terms of biology and biogeography.[8]

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Citation: Chentoufi S, Zahri A, Nekhla H, Squalli W, Mansouri I, Azzouzi A, El Ghadraoui L. New Data on the Production of Natural Honey in Morocco: Practices of Beekeepers, Melliferous Plants, and Production Features. Trop J Nat Prod Res. 2025; 9(11): 5629 – 5637 https://doi.org/10.26538/tjnpr/v9i11.50

Official Journal of Natural Product Research Group, Faculty of Pharmacy, University of Benin, Benin City, Nigeria

Further, the Green Morocco Plan (GMP), launched in 2008, has encouraged the development of high-performance agriculture, including the beekeeping sector. In addition, its second pillar promotes small-scale agriculture by encouraging the collective organization of small farms.[9] This approach has increased agricultural production, but the dynamics of collectivization still need to be better supported.[10] As for beekeeping, it is still evolving in Morocco, where the modern beehive has gradually penetrated all regions, giving rise to several coexisting socio-technical models.[11] However, existing studies have not yet evaluated the effects of the mentioned projects on beekeeping production.

A wealth of knowledge and resources exists surrounding Moroccan beekeeping and its renowned honey.[12] Moroccan honey has a long and rich history, is known for its flavor and health benefits, and is distinguished by its traditional methods and superior products. It has received praise from all over the world.[8]

Moroccan honey is celebrated not only for its exceptional flavor and medicinal properties but also for its authentic, artisanal production methods that have been passed down through generations.[13,14] Varieties such as thyme, orange blossom, and euphorbia honey are particularly prized for their purity and nutritional value.[15] The country's unique climatic and botanical diversity contributes to the distinct characteristics of its honey, making it a product of both ecological and cultural significance.[16] As a result, Moroccan honey has gained international recognition for its superior quality and traditional craftsmanship.

This ancestral practice is deeply anchored in traditions and makes a significant contribution to rural development and environmental conservation.[17–19] Beyond its cultural significance, apiculture serves as a crucial driver of rural development. To promote beekeeping is to promote agriculture and thus help people reduce their exposure to poverty.[20] And over 36,000 beekeepers depend on this activity for their

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

livelihoods, either wholly or partially. Additionally, beekeeping plays a crucial role in pollinating natural and cultivated plants, enhancing the quantity and quality of crop yields, particularly in fruit orchards, vegetable gardens, and industrial crops.[21–23] However, the impacts of beekeeping on the farmers and local communities need further investigation, mainly large-scale inventories.

Beekeeping in Morocco is immense, fueled by its rich and diverse melliferous resources. Eucalyptus forests, industrial crops like sunflower and colza, mountain herbs like thyme, rosemary, lavender, and wormwood, spontaneous flora, and woodlands all contribute to this abundance.[21] Bee's forage for honey plants, from which they ingest substances such as nectar, pollen, honeydew, and other products. Nectar is the basis of honey, the energy-rich food (carbohydrates) that bees need to maintain the colony. Pollen has proteins, vitamins, and other nutrients that larvae need to grow.[24] Flowers, in their diversity and abundance, provide the lifeblood of bee colonies.[25] Their availability, however, is determined by the interplay of complex environmental factors, including soil type, climate, and vegetation cover.[26]

The beekeeping segment boasts an impressive array of seven labeled honey varieties: Euphorbia honey (Tadla Azilal), strawberry tree honey (Jbel Moulay Abdeslam), Euphorbia honey (Sahara, Guelmim region, and Souss-Massa), Zendaz honey (Fez-Boulemane), and thyme honey (Souss-Massa).[21] However, a detailed analysis of this sector is hindered by a severe lack of comprehensive and timely data and statistics. Certain regions of the country grapple with scattered, inadequate, and sometimes unavailable information. Research reports on Moroccan beekeeping are rare and often inaccessible or limited to specific regions. This study aimed to provide a comprehensive examination of the various dimensions of beekeeping in Morocco, focusing on its practices, challenges, and prospects for sustainable development. To achieve this objective, a structured questionnaire was carefully designed and distributed to a diverse sample of beekeepers representing different regions of the country. This approach ensured the inclusion of a wide range of perspectives reflecting Morocco's geographical, climatic, and socio-economic diversity. The survey sought to capture detailed information on production methods, management practices, environmental constraints, and the socio-economic conditions influencing the beekeeping sector.

The findings of this research are expected to offer valuable empirical data on the current state of Moroccan apiculture, highlighting both the common challenges faced by beekeepers and the innovative solutions they adopt to overcome them. Furthermore, the study aspires to serve as a benchmark and reference point for future academic and professional investigations, given that it represents the first large-scale survey of beekeeping practices conducted across multiple Moroccan regions. Ultimately, this work contributes to enhancing understanding of the sector's dynamics and supports the development of policies aimed at strengthening Morocco's apicultural economy and environmental sustainability.

Materials and Methods

Study areas

An ethnobotanical survey was conducted between June 2021 and 2022 in four regions of Morocco: Fez-Meknes, Daraa-Tafilalet, Rabat-Sale-Kenitra, and Tangier-Tetouan-Al Hoceima (Figure 1). These regions were selected to ensure that seasonal changes in practices are considered and to ensure that they are representative of the most important areas in Morocco, in terms of flora and geographical location, in different sites of the kingdom.

The key geographical and meteorological data for each of the regions are presented in Table 1 as a summary of the climate data collected in the regions considered in this study. The utilization of these data enables the creation of a precise climatic profile for each zone and the comparison of their respective climate conditions.

Data collection

To facilitate data collection, a survey was carried out among 100 beekeepers in the regions studied. A structured questionnaire was used to collect detailed information in the five areas (Table 2). The data analysis will reveal the primary challenges confronting Moroccan beekeepers, including bee diseases, climate change, market competition, and restricted access to resources. In addition, the study will highlight development opportunities for the beekeeping sector in Morocco, particularly in the production of high-quality honey and crop pollination.

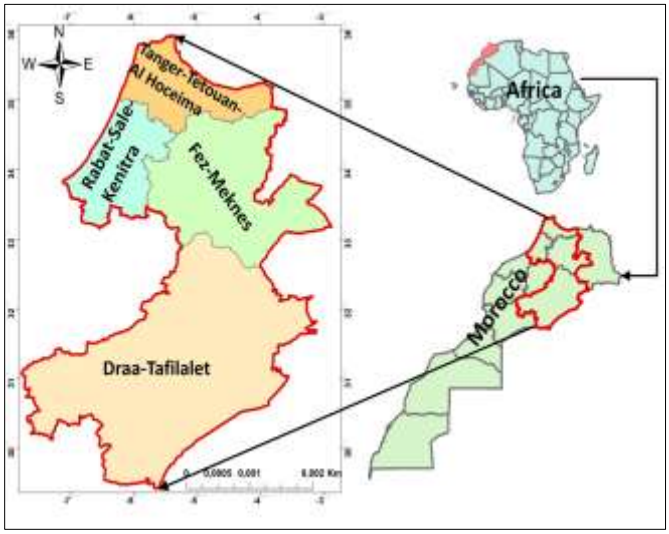

Figure 1: Geographical distribution of sampled regions in Morocco.

Table 1: Geographical and climatological characteristics of the sampled regions

	Geographic data	T °C (max/day)	T °C (max/night)	Sunshine hours	Rainfall (mm)	Humidity
Fez-Meknes	34°08'59.7"N 5°02'20.7"W	25.9	11.3	3.103	325	67.0 %
Daraa-Tafilalet	30°28'33.4"N 5°49'56.2"W	25.1	11.5	3.139	416	69.0 %
Rabat-Sale-Kenitra	34°1'15.17"N 6°50' 29.9"W	22.9	12.5	2.920	504	80.0 %
Tangier-Tetouan-Al Hoceima	35°46′ 00"N 5°48′00"W	23.1	15.4	2.847	343	67.0 %

N: North; O: West

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

Data analysis

The collected data were organized in Excel sheets depending on the study parameters. We computed percentages and frequencies for the variables under study. The data for all parameters were qualitative. Therefore, the Chi-square test was used to compare The study examines sociodemographic features, beekeeping practices, melliferous plants, causes of mortality among bees, treatments for bee health, and honey production. This test was selected since the data are qualitative and the objective is to compare the parameters studied depending on the age, gender, type of practices, and geographical area. Further, correspondence analysis was used to analyze the distribution of recorded plants depending on the sampled sites. This analysis was selected since the data are multivariate and qualitative, and then the plant species were considered as dependent variables, while the sampled areas were considered as independent variables. Tests were conducted in IBM SPSS 25, and significant values were considered at $P<0.05$. Graphs and figures were built in GraphPad Prism 8.3.0 (538).

Results and Discussion

Social information for beekeepers

We evaluated the socio-demographic characteristics of the participants in this study, and Figure 2 illustrates the results**.** The analysis of the collected data revealed that the examined parameters varied significantly across the sampled regions. Sidi Slimane recorded the highest number of participating beekeepers, representing 24% of the total sample, followed by Taza-Meghraoua (20%), Bouyablane-Taza (16%), and Kenitra-Oulmes (15%). The average age of Moroccan beekeepers was estimated at 48 years, with the majority belonging to the 25–50-year age group. Most respondents reported having between 10 and 20 years of experience in beekeeping, indicating a relatively mature and skilled workforce. Regarding gender distribution, the sector remains predominantly male, with 90% of beekeepers identified as men and only 10% as women, reflecting a persistent gender imbalance within Moroccan apiculture.

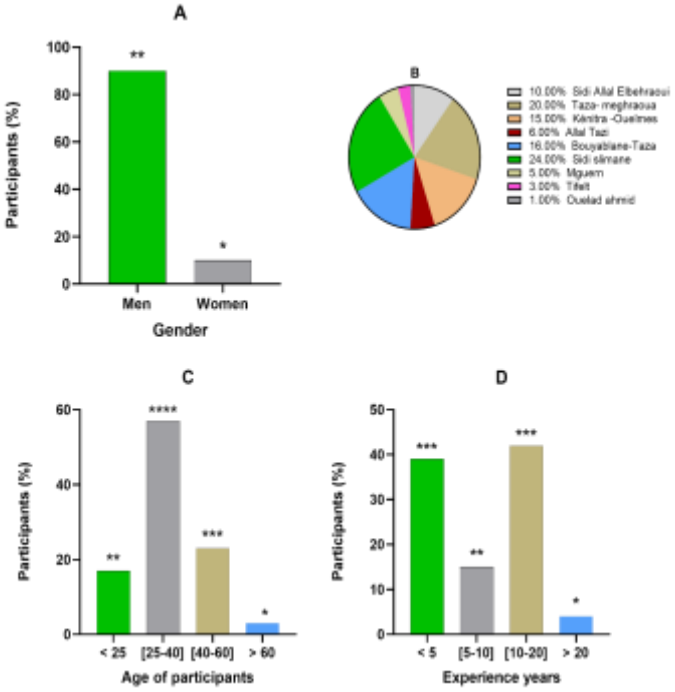

Figure 2: Sociodemographic and experience of beekeepers in the study areas (* denotes statistical difference: *<**<***<****)

Types of hives and breeding bees

Figure 3 presents the types of hives used in the study sites. Based on the recorded data, 60% of beekeepers use modern hives. In contrast, only 40% use traditional hives. This underlines the evolution of beekeeping practices towards more efficient and productive methods. Beehives are spread across the study areas, particularly in the major provinces of Boulemane and Taza, Sidi Slimane, and Sidi Allal El Bahraoui, often through cooperatives. Figure 3 presents the results of bee breed diversity. The analysis of graphs indicates that the results are significantly variable. The first category consists of *Apis mellifera intermissa*, which accounts for 65% of colonies, while the second is made up of colonies with a mixture of *Apis mellifera intermissa* and *Apis mellifera sahariensis*, accounting for the remaining 35%. On the other hand, 63% of *Apis mellifera intermissa* achieved the required level of honey production and confirmed their ability to cope with the most widespread bee diseases, whereas only 37% of *Apis mellifera sahariensis* achieved the same level.

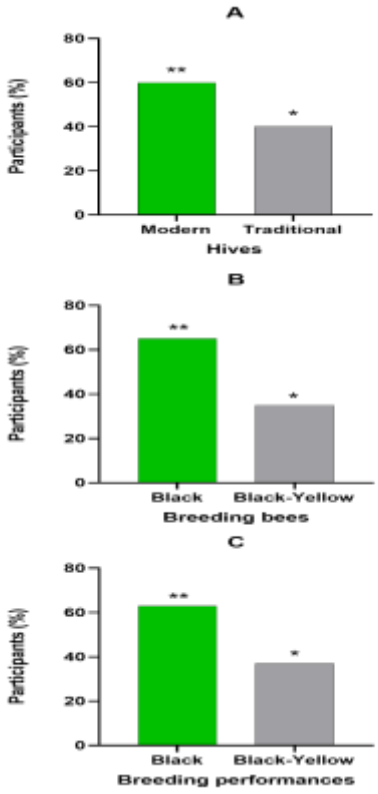

Figure 3: Repartition of modern and traditional hives (A), breeding bees (B) and performances (C)(* denotes statistical difference: *<**).
Black: *Apis melliferra intermissa* ; Black-yellow: *Apis melliferra intermissa -Apis melliferra sahariensis,*

Transhumance practice

In this step, we evaluated the participants' transhumance practices, and Figure 4 presents the results. Recorded data showed that transhumance is widespread among beekeepers in the studied areas. Most participants (74%) practice transhumance at least once a year. In contrast, 26% of interviewed beekeepers do not practice transhumance.

The frequency of transhumance practice varies significantly among participants. Furthermore, 45% of the beekeepers practice transhumance, moving their hives between 1 and 3 times per year. Moreover, 29% of the transhumant herders travel between 4 and 5 times per year. A minority of participants (26%) move transhumanly more than five times per year.

Melliferous plants

We evaluated the melliferous plants used in this step, and Figure 5 presents the results. The results obtained showed that beekeepers use a significant number of melliferous plants, including 10 different species.

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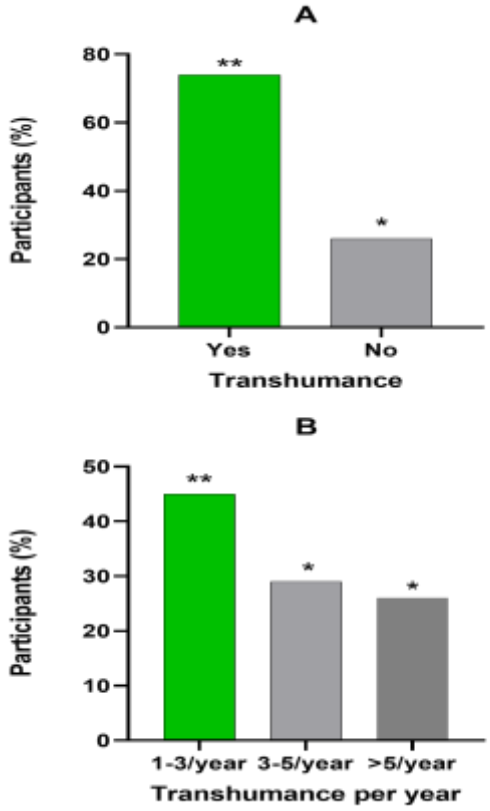

Figure 4: Transhumance practice in the study areas (A: practice; B: Number of practices per year) (* denotes statistical difference: *<**)

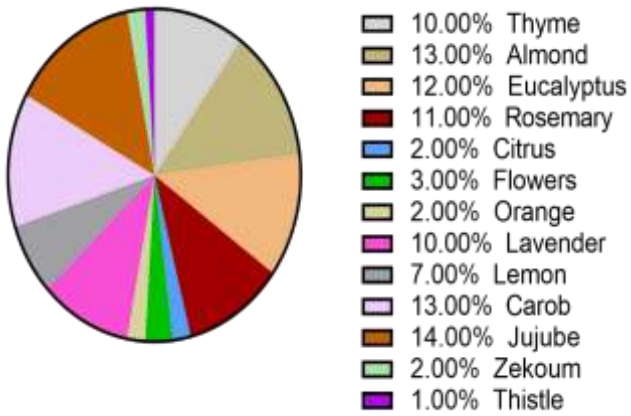

Figure 5: Melliferous plants used by beekeepers in the areas studied.

This reflects the richness of the melliferous flora in the study areas (Figure 5). The most popular plants for bees in the studied areas were jujube (14%), carob (13%), eucalyptus (12%), and 10% for rosemary, oregano, thyme, and lavender. Figure 6 presents the variation of plants among the sampled areas.

In addition to diversity, we monitored the flowering period of melliferous plants, and the results are presented in Table 3. The analysis of the field observations indicated that the flowering period was slightly variable among melliferous plants. However, flowering was focused in spring (between February and May) for most plants, including almonds, eucalyptus, rosemary, orange, lemon, and lavender. Other plants, including thyme, oregano, lavender, and jujube flowers, bloom in the summer between June and July. In contrast, the carob tree flowers at the end of the season, from August to October.

The flowering period can vary slightly according to climatic conditions and geographical location (Table 3), but the presence of melliferous plants in the regions under study provides bees with a varied food source throughout the year. This period is critical for the development of bee colonies. Thyme, oregano, lavender, and jujube are melliferous plants that flower in the summer (June to July) and help maintain honey production. The carob trees bloom from August to October, enabling the bees to accumulate their winter reserves.

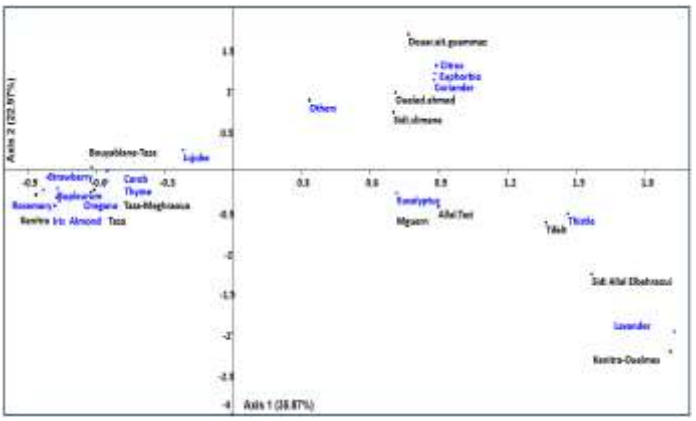

Figure 6: Correspondence Analysis of plants' distribution depending on sampled sites

Impact on hives and effective disease prevention

Figure 7 presents the results of this study, which evaluated the factors impacting beehives and their prevention. Recorded results demonstrated that parasites and disease are the two main causes of hive mortality. In terms of parasites, Varroa represented the most significant menace to bee health in the sampled regions with a percentage of 44%, followed by hornets (16%), nosema (15%), moths (14%), and loque (12%). Beekeepers also cited drought, poor feeding, and ineffective treatments as other causes that affect bee health and hive product diversity and productivity.

To protect their beehives, participants use different treatments as mentioned in Figure 7.

According to the results, treatment against varroa (88%) was the most used, reflecting the importance of this parasite as a factor in hive mortality. Further, treatments for nosema and wax moth were used by 6% of participants (Figure 7).

Treatments used to control hive diseases

Figure 8 presents the different treatments used by beekeepers to control hive diseases and their results. Based on the data, the most common method was fumigation with local medicinal plants (37%) among the beekeepers in the study areas. 21% of the beekeepers use Thymol, which is a more natural treatment. Moreover, 18% of participants used the chemical treatment Ectoz. In contrast, 10% of beekeepers use Apistan, Byvarol, rodenticide, amitraz, and mitake. Only 5% of beekeepers practice transhumance, a strategy that could prove useful in preventing diseases by moving hives to healthier areas.

Honey production and quality

We also investigated the quality and production of honey among beekeepers in the study areas, and Figure 9 presents the obtained results. Beekeepers harvest honey multiple times a year. Further, 93% of beekeepers harvest their honey 1–5 times per year, whereas 7% do it more than 5 times per year. During the annual honey yield per hive, we noticed that most beekeepers (78%) have an annual honey yield lower than 5 kg per hive. In contrast, 22% of beekeepers have an annual honey yield higher than 5 kg per hive.

ISSN 2616-0684 (Print)
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Table 2: Questionnaire designed for beekeepers covering the key aspects of beekeeping in Morocco's study regions

Beekeepers' profile	Apiary characteristics	Honey plants in the regions studied	Diseases and beekeeping protection	Production and honey quality
Last name	Number of modern hives	Honey plants in the regions studied	Beekeeping product development problems	Quantity harvested kg/year
First name	Number of traditional hives	Beekeeping: Importance of the plants identified	Types of disease	Yield kg/hive/year
Date of creation	Breed and yield of bees exploited	Practice and periods of transhumance	Causes of disease	Sales price Dh/hive
Conformity to regulations	Queen renewal		Period of disease onset	Most harvested honey
Sex			% losses/year	Best honey
Age range			treatments applied	More expensive honey
Address			Beekeeping product development problems	
Years of experience in beekeeping				

Table 3: Plants used for honey production and their flowering periods in the study areas

Melliferous plants	Vernacular name	Flowering period
Thyme	Ziîtra	June to July
Almond	Louz	February to March
Eucalyptus	Kalibtus	January to march
Rosemary	Azir	January/February to April/May
Oregano	Zaâtar	May to July
Orange	Ranj	March to April
Lavender	Khzama	May to June
Lemon	Hamd	March to May
Carob	Elkharoub	August to October
Jujube	Sadra	May to July

In terms of quality, the most appreciated honeys were those produced from oregano (24%), followed by eucalyptus (22%), thyme (20%), and rosemary (15%). In contrast, jujube and carob honeys were less popular, with preferences of 10% and 9% respectively (Figure 10).

The development of beekeeping in Morocco has been remarkable recently, with the support of the Green Morocco plan.[8] Various interests motivate a large number of people to engage in this activity. This study investigated the beekeepers and the production of honey in different regions of Morocco. The recorded data presented new results on the beekeepers' practices, quality and quantity of honey, and limiting factors.

Beekeeping in the Mediterranean basin is shaped by a complex interplay of factors such as hive technology, gender dynamics, and the impact of Varroa destructor on colony health and productivity.[27,28] The region's diverse ecological conditions, from arid zones to fertile coastal plains, demand adaptive hive technologies that enhance productivity while preserving bee well-being.[29] Modern hives, such as Langstroth or Dadant models, are increasingly replacing traditional clay or log hives, offering better ventilation, disease control, and honey yield.[30] However, access to advanced technologies remains uneven, often constrained by economic limitations and gender disparities. Women beekeepers are becoming more important in Mediterranean beekeeping, but they still have trouble getting training, equipment, and access to markets, which keeps them from fully participating in the industry.[31] The spread of Varroa destructor has further compounded these challenges, causing severe colony losses and threatening pollination services crucial to regional agriculture.[32] Strategies are becoming essential as they combine biotechnical methods, natural treatments, and selective breeding of resistant bee strains. Thus, the sustainability of beekeeping in the Mediterranean relies on technological innovation, gender inclusion, and effective parasite management, ensuring both ecological balance and economic resilience in this vital agroecosystem.

ISSN 2616-0684 (Print)
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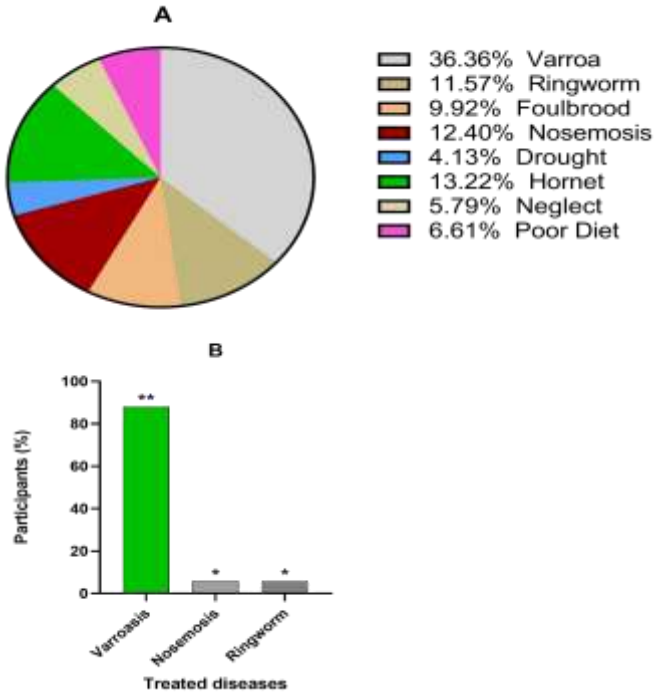

Figure 7: Causes of hives' mortalities (A) and treated diseases (B) (* denotes statistical difference: *<**)

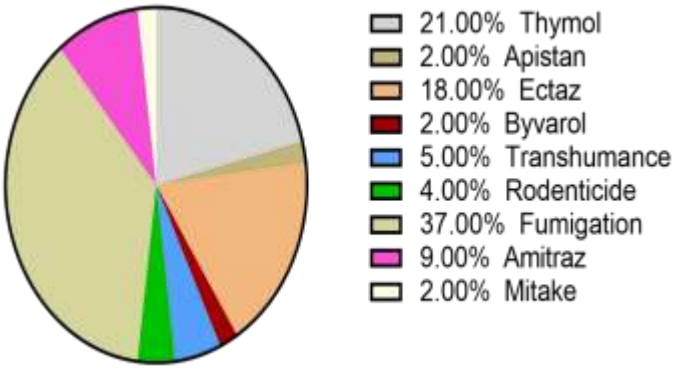

Figure 8: Treatments used by beekeepers to prevent hive diseases

In the first step of this study, we investigated the practices of beekeepers in a wide range of Moroccan regions. The recorded results indicated that all the beekeepers surveyed practice beekeeping as a profession and as their main source of income in the sampled regions. The gender of beekeepers was dominated by men compared to women, with a common age range between 25 and 50 and over 10 years of experience. These results indicate that beekeeping in Morocco is a professionally oriented activity rather than a secondary or subsistence pursuit, forming a key source of livelihood for rural households. The male dominance in the sector is a result of traditional gender roles and the fact that women don't often participate in agricultural activities that require physical mobility and technical skills. The age distribution between 25 and 50 years suggests that the sector attracts individuals in their most productive years, while the high level of experience (over 10 years) highlights the strong heritage and continuity of beekeeping practices in Moroccan rural communities. This male predominance corroborates the results of earlier studies, such as those by Bakour *et al*. in the Fez-Meknes region, where 98.48% of beekeepers were men, compared with only 1.52% women.[22] Similarly, Khabbach *et al*. [33] surveyed the Pre-Rif region of Morocco and recorded that 90.9% of beekeepers were men, compared with 9.1% women. Women beekeepers in Morocco face several barriers, including limited access to financial resources, training, and modern equipment, as well as cultural constraints that restrict their participation in rural cooperatives and decision-making structures. These challenges hinder their productivity and economic independence. To promote inclusion, policies should focus on providing targeted microcredit programs, technical training, and capacity-building initiatives, alongside encouraging the creation of women-led cooperatives. Strengthening gender-sensitive agricultural policies would empower women, enhance rural livelihoods, and contribute to the sustainable growth of Morocco's beekeeping sector.
These findings confirm that men dominate the field of honey production in Morocco. Women who enter the sector face many challenges and discrimination.[34]

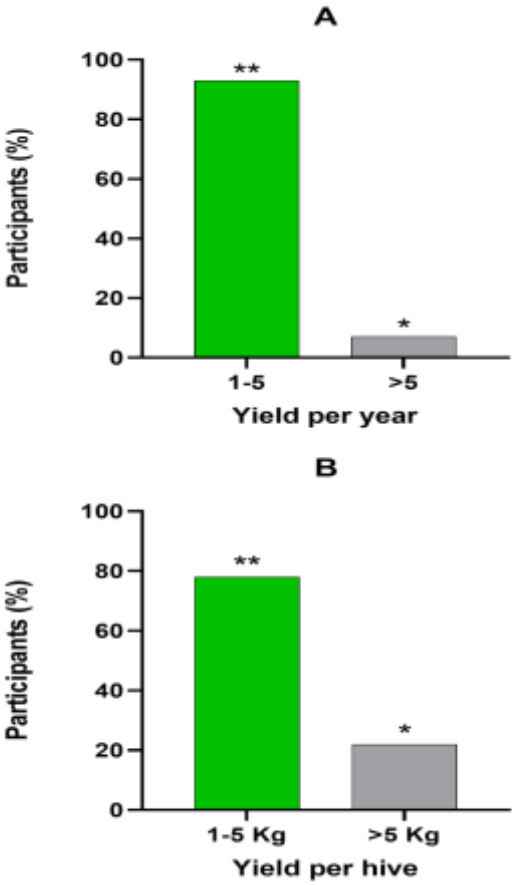

Figure 9: Honey production by beekeepers (A: yield per year; B: Yield per hive during the year of harvest) (* denotes statistical difference: *<**)

The transhumance and physical efforts during transport are suggested to be the main factors behind the abundance of men in the fields and the limited number of women.[35] Beekeeping, while promising, remains a largely male-dominated field in Morocco and other North African regions.[36–38] Therefore, we must promote inclusion and equal opportunity to enable women to fully contribute to this area's development. In terms of practices, most beekeepers in the study regions have recently switched from traditional to modern hives. The optimization of yield promoted these strategies. Beekeepers hold the belief that modern hives can enhance honey production and quality in comparison to traditional methods.
Similar results were recorded by Bakour *et al*.[22] in the North-Central region and by Chafik,[39] On the other hand, traditional hives are known for low productivity, which discourages beekeepers.[40,41]

ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

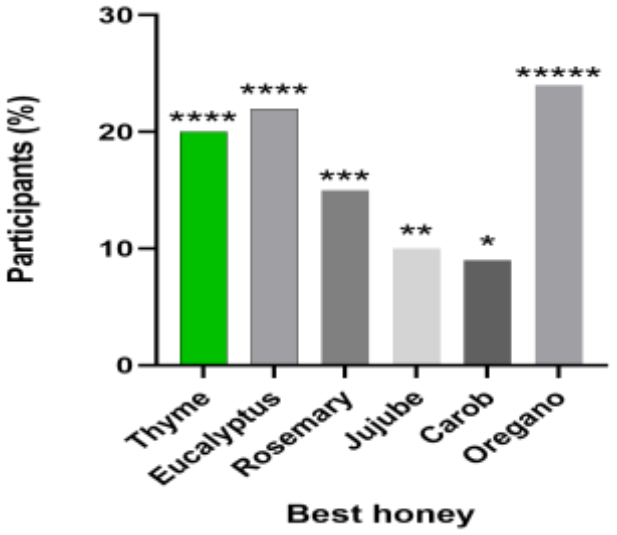

Figure 10: Best honey based on the plants (* denotes statistical difference: *<**<***<****)

Moreover, the higher productivity of modern techniques is suggested to encourage beekeepers to rethink their traditional methods and adopt more efficient technologies, combined with exposure to the latest beekeeping knowledge and practices.[42–44] In Morocco, many promoting initiatives encourage modern hives, such as the Green Morocco Plan, the National Initiative for Human Development, and the Green Generation. These initiatives offered, mainly, the financial support for beekeepers in training, logistics, and marketing.

The dominance of the two bee breeds was noted in this study, with an abundance of the *Apis mellifera intermissa* (63%), which is confirmed by the following: in Morocco, three main races of bees are found: two black "*Apis mellifera intermissa dite tellienne & Apis mellifera major."* [45–47] In this context, beekeepers must select breeds adapted to the specific conditions of each region, taking into account production objectives, disease resistance, and the behavioral characteristics of the bees.[48] The study shows a large range of transhumance practices. Most beekeepers use transhumance one to three times a year. The practice of transhumance is closely linked to the environmental dynamics of the areas chosen by beekeepers, who move their hives according to the flowering season.[49] Effective colony management and mobility planning require in-depth knowledge of the spatial and temporal dimensions of vegetation.[49,50]

The diversity of melliferous plants is crucial for beekeepers. They choose to locate their hives near these plants because of their importance in obtaining the various products from the hives. Our survey shows the abundance of jujube, carob, and others. These plants provide pollen, which is essential for bee nutrition and reproduction, and propolis, a resin that has invaluable therapeutic benefits for hive health, such as antimicrobial and anti-inflammatory properties.[51–53] These products are a source of income for local beekeepers, highlighting the importance of conserving floral biodiversity and promoting sustainable agricultural practices.

Many factors affect the health and demise of honeybees, including diseases, pathogens, pesticides, poor management by beekeepers, and a lack of available food. Independently of their effect on bees, all these factors interact and can have combined effects. Varroa is the primary threat to bee health in the areas surveyed, accounting for 44% of the problem. Since 2006, this parasite has caused numerous bee colony destructions,[54] as it primarily attacks the fatty mass of the bees' body,[55] which can lead to behavioral problems,[56] an immune system deficit [57]and increased longevity.[58]

Nosema is a dreaded disease for beekeepers, caused by microsporidian parasites that attack the bees' intestines, undermining their health and potentially leading to their death.[59] And hornets, which are one of the main pests of bee colonies in many countries.[60–63] Pose the greatest threat because of their predatory behavior; they actively hunt bees in flight.[60] To fight this scourge, beekeepers must implement effective control strategies. Most of the beekeepers interviewed said they preferred to use fumigation methods (**37%)** based on natural plant substances for treating the various diseases affecting their hives. Initially, acaricides were widely used to control parasites that attack bee colonies, particularly Varroa destructor, which is responsible for the death of many colonies. These results show that more and more beekeepers in Morocco are moving toward eco-friendly and sustainable methods. The preference for fumigation using natural plant substances (37%) reflects beekeepers' awareness of the harmful effects of chemical acaricides on bee health, honey quality, and the environment. This transition also indicates an effort to preserve colony resilience and align with organic production standards while still addressing major threats, such as the Varroa destructor, a pervasive and destructive parasite in Moroccan apiaries.

When applied once or twice a year, they help to keep Varroa populations below the economic nuisance threshold. However, acaricides have been shown to have several drawbacks, including mortality of *Apis mellifera*,[64] poisoning of uncapped brood,[65] contamination of hive products, and residues in honey, wax, and propolis.[66] In recent years, beekeepers have looked at plant materials as a possible alternative to synthetic acaricides for the control of Varroa, as certain parts of plants are highly effective.[67–69]

In Morocco, honey production is of considerable socio-economic importance, particularly in combating unemployment and supplying national consumption. Most beekeepers harvest their honey on average 1 to 5 times per year. The honey produced is characterized by its unique and specific biological and physicochemical properties. This makes it ideal for use not only as a natural edible sugar but also as a preventive factor and even as a health remedy. This finding indicates that climatic conditions, floral availability, and regional ecosystem diversity significantly influence honey production in Morocco. The country's seasonal flowering cycles, which vary between arid, coastal, and mountainous regions, reflect the harvesting of honey 1 to 5 times per year.

It also indicates that Moroccan beekeepers often practice traditional and sustainable methods, allowing colonies sufficient time to regenerate and maintain productivity. Moreover, this frequency aligns with the natural rhythm of nectar flows, ensuring both the quality and authenticity of Moroccan honey. Given the many qualities of oregano honey, most beekeepers in the areas surveyed prefer it. It is a natural remedy for fighting microbial infections, mainly in the digestive tract.[70] Eucalyptus, thyme, and rosemary honeys are also renowned for their antibacterial and antimycotic properties.[71]

The color, the crystallized state, the flavor, and the intense aroma are the main characteristics of the most appreciated honeys on the market. Honey is particularly renowned for its medicinal properties. In particular, it has significant antibacterial properties thanks to its essential oils, rich in monoterpenes.[72]

Conclusion

This survey was conducted across four major Moroccan regions—Fez-Meknes, Draa-Tafilalet, Rabat-Sale-Kenitra, and Tangier-Tetouan-Al Hoceima to assess their geographical distribution, contribution to national apiculture production, and identification of the main melliferous plants that serve as vital sources for high-quality Moroccan honey. The findings highlight significant regional variations in floral resources and production techniques, underlining the need for context-specific interventions. The risk and deficiency analysis of the Moroccan beekeeping sector provides a foundation for developing sustainable and realistic solutions that integrate natural, eco-friendly practices adapted to Morocco's unique socio-economic and environmental conditions. To make this sector stronger, it is suggested that (1) research and innovation in disease management and hive technologies be improved; (2) training and capacity-building programs for beekeepers, especially in rural areas, be set up; (3) women's participation and cooperative-based initiatives be encouraged; (4) policies for protecting biodiversity and preserving melliferous plants be adopted; and (5) quality certification systems be created to make Moroccan honey more

competitive in global markets. Collectively, these actions will contribute to the sustainable growth and international recognition of Morocco's apiculture sector.

Conflict of Interest

The authors declare no conflicts of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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