Impact Of Beekeeping Practices On Biodiversity And Public Health In The Batna Region, Algeria

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Summary

This study assesses the impact of beekeeping practices on wild pollinators and biodiversity in the Batna region (eastern Algeria) based on surveys conducted among beekeepers and data provided by the Directorate of Agricultural Services (DSA). The results reveal an overwhelming predominance of the Tellian bee (Apis mellifera intermissa), representing 95% of the colonies, compared to only 5% for the Saharan bee (Apis mellifera sahariensis), as well as a strong preference for modified Langstroth hives (90% of cases). These intensive practices are correlated with a worrying reduction in wild pollinator diversity, with an estimated 40% decline in areas with high hive density, such as Ichemoul, where 70% of beekeepers report a significant decline. In addition, 60% of beekeepers report a decrease in local melliferous plants (thyme, rosemary), particularly in transhumance areas (70% of farmers). The use of chemical miticides by 80% of beekeepers and the emergence of resistance in Varroa mites (observed by 40% of respondents) aggravate these ecological pressures. These results highlight the urgency of adopting sustainable beekeeping practices, including regulating hive density, restoring floral habitats, and developing alternatives to chemical treatments to safeguard the sanitary quality of honey for human consumption, protect local ecosystems and pollination services, and promote public health.

Introduction

Beekeeping is a booming agricultural activity and a growing economic pillar in the rural economy. It supports ecosystems through crop pollination and promotes interactions between honeybees (Apis mellifera) and wild pollinators (Goulson, 2015). Beyond its economic role, this practice contributes significantly to agricultural development while protecting the environment by cross-pollinating cultivated plants (Klein et al., 2006; Dainese et al., 2019).

However, the increase in hives harms native pollinators, particularly through competition for floral resources (Mallinger et al., 2017). Algeria's climatic and geographical diversity offers favorable conditions for beekeeping, positioning the country among potential world leaders. Data from the Ministry of Agriculture (MADRP, 2017) reveal 32,000 beekeepers, with significant concentrations in Bouira (150,000 colonies), Tizi Ouzou (104,000 colonies), and Batna (97,700 colonies).

Beekeeping is a significant economic activity in the semi-arid region of Batna but faces significant challenges. Chronic drought and parasitic diseases compromise colony productivity and disrupt bee population dynamics (Benarfa et al., 2025). Intensive practices, including modern beehives and syrup feeding, directly threaten wild

pollinators—bees, butterflies, and beetles—by reducing their food resources (Goulson et al., 2015). This situation requires a thorough assessment of the impacts on pollinators and local biodiversity.

Faced with these challenges, sustainable beekeeping is a relevant solution for reconciling beekeeping productivity and ecosystem preservation. In this context, our study aims to analyze standard beekeeping practices in the Batna region, assess their impact on wild pollinators and local biodiversity, and propose recommendations for sustainable beekeeping. Specifically, we will examine how the intensification of beekeeping practices has affected local ecosystems in recent years while identifying solutions to balance beekeeping development and biodiversity conservation.

Materials and Methods

Study area

The wilaya of Batna, located in the Eastern Highlands of Algeria (Aurès region), is characterized by a semi-arid climate and notable floral diversity. It is located 410 km southeast of Algiers and rises to an altitude of more than 900 m **(DSP, 2021).** Geographically, it extends between 4° and 7° east longitude and 35° to 36° north latitude. Its relief, mainly mountainous and hilly, is dominated by several djebels (mountain ranges typical of the region), which structure the entire landscape. Extreme contrasts mark the climate: summer temperatures can reach 45 °C in the shade, while winter temperatures frequently drop below 0 °C at night **(DSP, 2021).**
The vegetation, adapted to drought, is dominated by melliferous species such as rosemary (Rosmarinus officinalis) and thyme (Thymus vulgaris**) (Bensouici et al., 2020).** This floral richness explains the importance of beekeeping activity in the region.
The study was conducted in three localities representative of intensive beekeeping: Hidoussa, Ichemoul, and Tkout.

Data collection

This study is based on an exhaustive survey conducted over 12 months among 50 beekeepers representative of the main beekeeping areas of Batna (Hidoussa, Ichemoul, Tkout), supplemented by interviews with the regional beekeeping cooperative, local environmental associations, and the technical services of the DSA. A detailed questionnaire of 32 questions (a combination of closed, open, and numerical questions) collected quantitative and qualitative data on beekeeping practices (types of hives, feeding, health management) and their perceived impacts on biodiversity (evolution of wild pollinator populations, floral diversity). These data were statistically analyzed via flat sorting and correlation analyses to assess the relationships between beekeeping practices and the status of wild pollinators.

Data analysis

Responses were analyzed using descriptive statistics (percentages, means, standard deviations) and statistical tests (Pearson correlation, ANOVA) with R software (version 4.3.0) to assess the relationships between beekeeping practices and beekeepers' observations. The significance threshold was set at $p < 0.05$.

Results

1. Analysis of Beekeeping Practices

1.1 Distribution of bee breeds reared

The Tellian bee (Apis mellifera intermissa) is the dominant breed in the Batna region, accounting for 95% of the colonies, while the Saharan bee (Apis mellifera sahariensis) is endangered, with only 5% of colonies confirming its status as a declining species. A Chi-square (χ^2) statistical analysis revealed a highly significant difference in the distribution of bee breeds ($\chi^2 = 162.5$, $df = 1$, $p < 0.001$) (Table 1).

1.2 Number and type of hives

According to the survey data, the number of hives per beekeeper varies between 10 and 100, with an average of 68.46 ± 18.32 hives. The most frequently encountered number is 15 hives. In addition, 30% of apiaries have

15 or fewer hives, while 70% have 70 hives or fewer. The study reveals that 90% of beekeepers in the region use modern Langstroth-type hives, modified to better adapt to the local warm climate. These hives, compact and easy to handle, allow for more abundant honey harvests. The remaining 10% still use traditional hives (such as Dadant or Layens), which are less popular because of their size and relatively lower yield.

A statistical analysis by the chi-square test ($\chi^2 = 128.9$; df = 1; $p < 0.001$) (Table 1) confirms the significant preference for Langstroth hives. This dominance is explained by their better adaptation to local climatic conditions and their increased productivity. These results highlight the widespread adoption of modern beekeeping practices in the region.

Table 1: Main beekeeping practices and their associated impacts

Variable	Category	Percentage	Test used	Value	p-value
Dominant Breed	Tellian Bee	95 %	Chi²	162.5	< 0.001
Type of hive	Langstroth modified	90 %	Chi²	128.9	< 0.001
Use of miticides	Chemical	80 %	Chi²	72.0	< 0.001
Decrease in pollinators	High-density areas	70 %	Test binomial	-	< 0.001

1.3 Feeding

Almost all beekeepers (98%) practice winter and spring feeding using a light syrup composed mainly of water, sugar, and lemon at a ratio of 1 kg of sugar to 1 L of water. Candy and honey are usually reserved for sale. On the other hand, 2% of beekeepers say they do not use this practice. This relative homogeneity of practices testifies to an adaptation to local economic constraints.

1.4 Treatment of diseases

1.4.1 Use of chemicals

Varroa mites appear to be the primary health threat. There is a clear predominance of chemical treatments (80% of beekeepers) compared to natural methods (20%) ($\chi^2 = 72.0$, df = 1, $p < 0.001$) (Table 1). These chemical treatments, applied mainly in autumn and spring, show a negative correlation with wild pollinator populations (wild bees, butterflies) ($r = -0.52$, $p = 0.003$) (Table 2), with 60% of beekeepers reporting their decline in areas with high use of acaricides.

1.4.2 Resistance of dust mites

Among chemical users, 40% report a decrease in effectiveness (proportion test, $z = 3.45$, $p = 0.001$), indicating the emergence of resistance in dust mites.

1.4.3 Public Health and Honey Quality

In addition to their environmental impact , intensive beekeeping practices in the Batna region raise concerns about the quality of the honey produced**.** Eighty percent (80%) of beekeepers report frequent use of chemical acaricides, which may leave residues in honey and wax and pose a risk to consumer health**.** Although most beekeepers respect the recommended safety intervals before harvest**,** 25% admit they do not always follow technical guidelines**,** particularly during periods of high infestation. When treatments are applied during nectar flow**,** this lack of compliance can increase the risk of hive product contamination.

1.5 Transhumance

This practice concerns 70% of beekeepers, who move their hives to the mountainous areas of the Saharan Atlas in summer. However, 50% of them see an impact on local pollinators, probably due to competition for floral resources.

Table 2: Significant correlations between beekeeping practices and environmental factors

Relationship analyzed	Test	Coefficient	p-value
Acaricides ↔ Drop pollinators	Pearson (r)	-0.52	0.003
Drought ↔ Decline in honey flora	Pearson (r)	-0.61	0.008

2. Impact of Beekeeping Practices on Wild Pollinators

2.1 Decline in Wild Pollinator Populations

The study reveals that 70% of beekeepers observe a significant decrease in the populations of wild pollinators (solitary bees, butterflies, hoverflies) over the last decade. This trend is particularly pronounced in areas with high beekeeping density, such as the Ichemoul region, where wild bee diversity has dropped to 40% (Figure 1). Linear regression analysis confirms this inverse relationship between hive density and pollinator diversity ($R^2 = 0.65$, $p < 0.01$), with an average reduction of 40% in wild bee diversity in the most exploited areas.

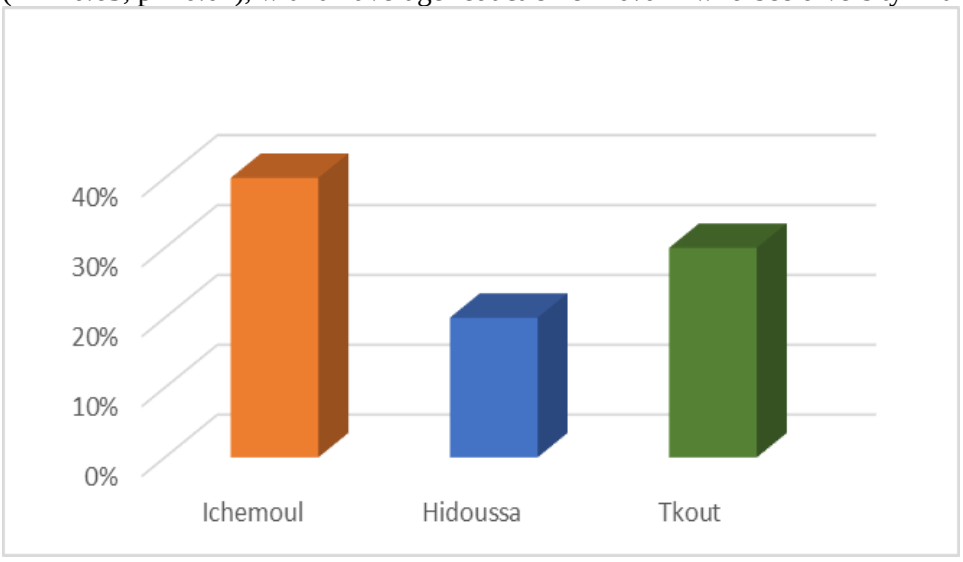

Figure 1: Reduction of wild pollinators in the study area.

2.2 Impact mechanisms

2.2.1 Competition for floral resources

The analyses show that areas of intensive transhumance (practiced by 70% of beekeepers) have significantly lower floral diversity (ANOVA: $F = 18.3$, $p < 0.001$) than non-transhumant areas. This reduction in nectariferous resources leads to increased interspecific competition, as evidenced by 50% of beekeepers ($\chi^2 = 24.1$, $df = 1$, $p < 0.001$). Field observations corroborate these statistical results, showing a correlation between beekeeping intensification and the decline of native pollinators.

3. Floral diversity

Reduction of floral diversity

Surveys of beekeepers in Batna reveal that 60% have observed a marked reduction in floral diversity over the past five years, mainly attributed to increasing drought and overexploitation of honey resources. This trend is particularly accentuated in areas with a high beekeeping density, such as Ichemoul, where statistical analysis (ANOVA: $F = 22.7$, $p < 0.001$) shows an average floral loss of 40%, compared to only 15% in areas with little exploitation (Table 3).

Table 3: Floral Loss as a Function of Density

Type of area	Floral Loss (Medium)
High density (e.g., Ichemoul)	**40 %**
Low density	**15 %**
(ANOVA: $F = 22.7$, $p < 0.001$)	

Beekeepers report the scarcity of once-abundant honey species (thyme, rosemary), leading to a parallel decline of 40% in the diversity of wild bees. Scientific data from the Directorate of Agricultural Services (DSA, 2024) (Figure 2) corroborate these observations. This is due to increased competition for nectar resources and the gradual disappearance of host plants, creating a vicious ecological impoverishment that threatens both local flora and dependent wild pollinators.

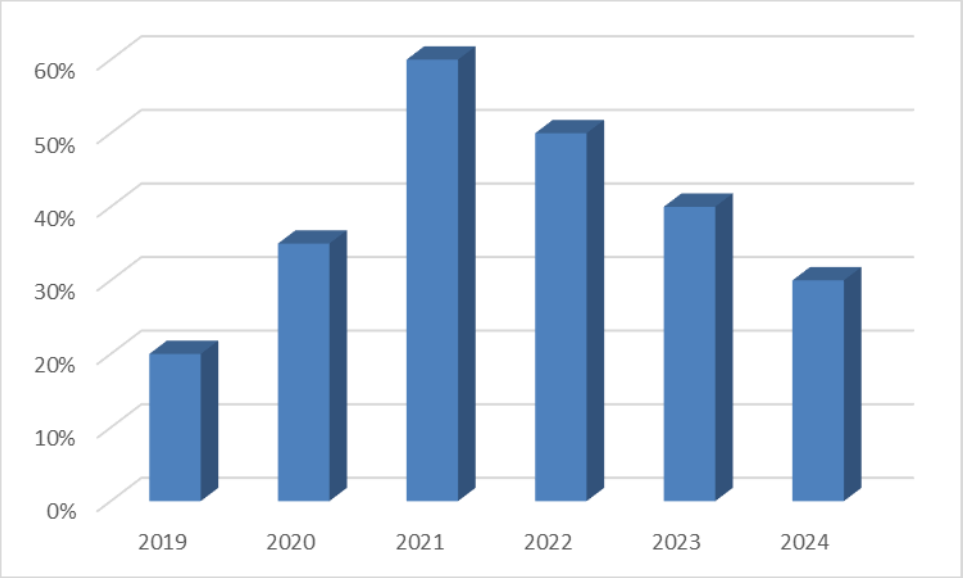

Figure 2: Percentage of floral reduction in areas with high concentration.

4. Spread of Diseases

The study reveals that 30% of beekeepers observed symptoms of varroa mites and other pathologies in wild bees in transhumance areas, showing a worrying phenomenon of inter-species transmission. This contamination is explained by the increased interactions between honeybees and wild bees around the same floral resources, combined with the increased vulnerability of native populations.

A positive correlation was found between the frequency of transhumance and disease prevalence among wild pollinators ($r = 0.45$, $p < 0.05$). Areas with high mobile beekeeping activity show a 35% increase in reported cases compared to control areas.

Although necessary for beekeeping production, transhumance practices contribute to the spread of pathogens to natural ecosystems, aggravating the already observed decline of wild pollinators. These results underline the urgency of developing appropriate health protocols to limit this cross-contamination while maintaining a viable beekeeping activity. Better spatial and temporal management of transhumance could be a way to reconcile honey production and biodiversity preservation.

Discussion

Impact of beekeeping practices on wild pollinators, biodiversity and public health

Pressure from Intensive Beekeeping Practices on Wild Pollinators and Biodiversity

The results of this study show that intensive beekeeping practices, including modern beehives (such as Langstroth hives, used by 90% of beekeepers) and syrup feeding, exert significant pressure on wild pollinators. Our data reveals that 70% of beekeepers in Batna have observed a marked decrease in wild pollinator populations over the past five years, with a 40% reduction in their diversity in areas with high hive density. Henry et al. (2012) confirmed this increased competition for floral resources. As Bendifallah et al. (2020) reported, it is part of a national trend in Tizi Ouzou and Béjaïa regions.

Globally, these observations support the findings of Goulson et al. (2015), which demonstrate that honeybees can reduce the abundance of wild pollinators in fragile ecosystems by 30-50%. This situation becomes particularly worrying in the semi-arid context of the Batna region, where floral resources are naturally limited. These results underline the importance of rethinking beekeeping practices in order to preserve wild pollinators and biodiversity.

Artificial feeding with syrup, while essential for maintaining colonies during times of scarcity, has some worrying side effects. According to our observations and in line with the work of Naug (2009), this practice significantly reduces the availability of natural resources for wild pollinators. Modifying honeybees' foraging behavior disrupts natural trophic balances, exacerbating interspecific competition in local ecosystems.

Impact of disease treatment

Ecological and Health Consequences of Disease Treatments

Although crucial for apiary health, treating varroa mites has significant ecological consequences. Our data confirm that using chemical acaricides in the Batna region directly affects wild pollinators by contaminating floral resources (Goulson et al., 2015). This contamination reduces the fitness of wild populations, aggravating their already observed decline.

In addition, the increasing resistance of Varroa mites to chemical treatments, reported by 40% of beekeepers, could accentuate these effects. This calls into question the long-term viability of current methods and calls for more sustainable management practices.

In addition, excessive use of acaricides can worsen the environmental impact and compromise the effectiveness of long-term treatments (Rosenkranz et al., 2010), calling into question the sustainability of these practices. As Potts et al. (2016) have demonstrated on a global scale, these impacts contribute to the overall erosion of biodiversity.

Previous studies have shown that certain synthetic acaricides, such as amitraz or coumaphos, can leave detectable residues in honey, compromising its organoleptic qualities and food safety. The lack of structured local honey quality control exacerbates this problem. Furthermore, the beekeepers interviewed believe that existing practices, which are marked by intensification and parasitic pressure, are not necessarily compatible with the increasing demand for "pure" and "natural" honey. From a public health standpoint, raising beekeepers awareness of sanitary production practices and developing alternative treatment techniques (such as organic

acids and essential oils) are crucial strategies to guarantee a residue-free, safe product that meets consumer expectations.

Ecological impacts of transhumance

According to our data, beekeeping transhumance, practiced by 70% of beekeepers in the Batna region, represents a double challenge for local biodiversity. Although this method makes it possible to optimize honey production by following floral resources, it causes significant ecological disturbances. Our observations reveal that this mobility of hives intensifies competition for nectar-producing resources, with 50% of beekeepers reporting a notable decrease in wild pollinator populations in transhumance areas.

Beekeeping transhumance significantly promotes the transmission of diseases from honeybees to wild pollinators (Fürst et al., 2014), as evidenced by the 30% of beekeepers who observed varroa mite symptoms in wild bees in transhumance areas in Batna. This phenomenon results mainly from three mechanisms, namely the contamination of shared flowers (Graystock et al., 2015), the weakening of wild pollinators by trophic competition (Cane & Tepedino, 2017), and the amplifying effect of high hive densities (Mallinger et al., 2017). These results highlight the urgency of adopting mitigation measures, such as regulating hive densities and creating buffer zones (Geldmann & González-Varo, 2018), to reconcile beekeeping activity and biodiversity preservation in these sensitive ecosystems

Floral Diversity Loss

The reduction in floral diversity observed in the Batna region represents a determining factor in the decline of wild pollinators. This floral erosion, aggravated by the increased frequency and intensity of drought episodes linked to climate change, leads to a critical decrease in the available honey resources. Research conducted by Benachour et al. (2007) and Bendifallah et al. (2010) in Algeria has established a link between the degradation of natural habitats, the scarcity of floral species, and the concomitant decline in pollinator populations. In particular, Benachour et al. (2007) observed that competition between wild and honey bees in environments with limited floral resources contributes directly to the decline of wild bee populations. Bendifallah et al. (2010) also documented bee diversity in northern Algeria. They showed that the loss of floral species is a key factor in this region's decline in wild pollinator diversity.

In addition, Goulson et al. (2015) showed that bee decline is aggravated by a combination of stressors, including pests, pesticide exposure, and scarcity of floral resources. Similarly, Potts et al. (2016) point out that the loss of floral biodiversity, intensified by global warming and intensive agricultural practices, is one of the leading causes of the worldwide decline of wild pollinators. This situation is all the more worrying in semi-arid ecosystems, such as Batna, which are characterized by increased vulnerability to environmental disturbances.

Beekeepers in the region report that areas with a high density of hives are home to significantly fewer wild pollinators, suggesting increased competition for floral resources. These observations are consistent with the results of several studies, including that of Goulson et al. (2015), which highlight the ability of honeybees to monopolize resources, thus reducing access to flowers for wild species.

Interspecific competition between honeybees and wild bees

The predominance of Apis mellifera intermission in the Batna region aggravates the decline of wild pollinators. Our study reveals that this domestic subspecies exert significant competitive pressure on wild species through its superior trophic efficiency when floral resources are limited. These observations are part of a well-documented global pattern, as shown by Herrara (2020) in Spain and Benachour et al. (2007) in the Constantine region (Algeria), where high densities of honeybees reduce the diversity of native pollinators by 30 to 45%.

In Algeria, a study conducted in the Constantine region showed that the Tellian bee (Apis mellifera intermissa), although adapted to local conditions, can compete with wild bees when floral resources are limited (Benachour et al., 2007). The study also revealed that the Apoidea fauna of Constantine has strong preferences for particular floral species closely linked to the native plant composition of the region, highlighting the importance of preserving the local flora to maintain a balance between wild and domestic pollinators. These

results corroborate the testimonies of beekeepers in Batna, who report a significant decrease in wild pollinators in areas with high beekeeping density.

Implications for biodiversity conservation and public health

As Potts et al. (2016) pointed out, reducing the diversity of wild pollinators in areas with high hive densities could have significant ecological consequences. Competition for nectar-producing resources is the primary mechanism explaining this decline, particularly during periods of limited flowering.

Several complementary approaches can be considered to reduce the impact of beekeeping practices on biodiversity. The regulation of hive densities in sensitive areas is a priority measure, particularly in areas with a high concentration of beekeeping, such as Hidoussa and Ichemoul. In addition, planting local honey species could restore habitats and maintain vital floral resources for wild pollinators. These approaches, whose effectiveness has been demonstrated in regions such as France (Darricau, 2023), could be adapted to the Algerian context, particularly in areas with high beekeeping density. In addition, a program to raise awareness of sustainable practices among beekeepers would promote beekeeping that is productive, respectful of local ecosystems, and conducive to biodiversity enrichment.

The results of this study, while rooted in the fields of beekeeping and ecology, have direct implications for public health. Indeed, the stability of ecosystems and food security depend on the preservation of wild pollinators and floral biodiversity, including through the pollination of food crops. Particularly in semi-arid rural areas like Batna, a disturbance of pollinators, whether domestic or wild, may result in lower agricultural yields, reduced dietary diversity, and increased susceptibility to environmental crises. Therefore, encouraging biodiversity-friendly beekeeping fully contributes to long-term public health goals.

Conclusion

This study reveals the impact of beekeeping practices on wild pollinators and biodiversity in the Batna region. The data collected underscore the urgency of adopting sustainable beekeeping practices to preserve local ecosystems, public health and maintain ecological balance. To deepen these conclusions, additional research is essential, including rigorous field monitoring and in-depth ecological analyses, to accurately assess the long-term impacts of beekeeping on ecosystem dynamics and wild pollinator populations.

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