Egypt. J. Agric. Sci. (2024)75 (Special Issue): 48-59.
Doi: 10.21608/ejarc.2024.345965

Egyptian Journal of Agricultural Sciences
Journal homepage: www.ejarc.journals.ekb.eg
Published by: Faculty of Agriculture, Cairo University, Egypt
Print ISSN 2812-4847 Online ISSN 2812-4855

14th International Conference of Arab Beekeepers Union, 13-15 November, 2023, Cairo - Egypt

Analysis of Tunisian Beekeepers' Perceptions in Honey Bee Diseases and Pests Management

By

Souha Jmal*[1], Hanen Ben Ismail[1, 2], Manel Hamzaoui[1], Hassene Ben Salem[3] and Hajer Debbabi[1]

[1] *National Institute of Agronomy of Tunisia (INAT), University of Carthage, UR17AGR01, 1082 Tunis, Tunisia*
[2] *Faculty of Mathematical, Physical and Natural Sciences of Tunis, University of Tunis El Manar, LR11ES09, 2092 Tunis, Tunisia*
[3] *Office of Livestock and Pasture (OEP), 1002 Tunis, Tunisia*

ABSTRACT

Honey bee diseases and pests caused dramatic losses of Tunisian honey bee colonies during the past years. This research aimed to evaluate of beekeepers' perceptions on bee diseases and pests, and current management practices via interview method of 80 beekeepers in the North of Tunisia. The data were analyzed using descriptive analysis. Most of the beekeepers reported that Varroosis was the most dangerous pest (97.5%), followed by Foulbrood (19%). Moreover, "moth" butterfly (heteroecious) was the most cited pest (15.2%). Diseases and pest reports were significantly correlated with the educational level of the beekeepers, their training, route to beekeeping (heritage) and number of bee hives. The treatment of diseases was carried out twice a year by most beekeepers (70.7%), once (25.3%) or three times (4%) per year, mainly in winter (62.1%) and autumn (37.9%). The used sanitary products by the respondents were Apivar® (63.9%), Apistan® (35.1%), Apiguard® (35.1%), a mixture of garlic and petrolatum (6.5%), or a mixture of garlic and thyme essential oil (1.3%), accordingly to the disease nature ($p<0.05$). The treatment type was significantly related to beekeepers' age and education, number of bee hives and the disease nature ($p<0.05$), whereas significant correlations of numbers and season of treatment applications were found with beekeepers' age, honey laboratory analysis and disease nature ($p<0.05$). Finally, 98% of beekeepers have implemented preventive prophylactic measures before honey harvesting based on apiary hygiene control, which confirms that the beekeepers are aware of the importance of sanitation.

Keywords: *Beekeeping; bee pests, bee diseases, varroosis, foulbrood perceptions, sanitation*

1. INTRODUCTION

Beekeeping in Tunisia is of great importance for its economic growth and local development, food security and nutrition as well as for nature conservation. In Tunisia, the beekeeping sector contributes 0.1% of national gross domestic product (GDP) and 1% of agricultural GDP. Average annual honey production has been estimated at 2,360 tons in 2021, which increased by 57% between 2011 and 2021. Tunisian production is mainly intended for domestic consumption (99% of production in 2021), with very low annual honey consumption at around 0.2 kg/inhabitant (MAWRMF, 2022) compared with European countries. It is limited in particular by household purchasing power. In addition to production of honey and other products from the hive, beekeeping contributes also

*Corresponding author E. mail: jmal.souha.91@gmail.com

Received: 01.10.2023 **Accepted: 14.03.2024** **Available online: 16:03.2024**

to up to 30% of global food production, through pollinating many crops, including pome fruits, berries, vegetables, nuts and oilseeds. Pollination enables plants to produce fruit and vegetables of better quality, in greater quantity and more uniformly. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2016) estimated that the annual market value of 5-8 % of global agricultural production was directly linked to pollination services, at between $235 billion and $577 billion dollars (in 2015). According to the Tunisian Ministry of Agriculture, Water Resources and Maritime Fisheries (MAWRMF, 2022), there are around 13,200 beekeepers, 65% of whom have fewer than 50 hives. Only 21.1% of beekeepers (>100 hives) are professionals. Nevertheless, worldwide, including Tunisia, irregularities in honey bee colonies and thus in honey production, were recently observed, leading to economic losses (OEP, 2022). Climate change, exposure to pesticides (Chmiel *et al*., 2020; Siviter *et al.*, 2021), and habitat loss (Rong and Sadhukhan, 2021) as well as diseases and pathogens, particularly parasites were the main factors contributing disproportionately to the decline in honey bee populations.

Honey bees are often infected by diseases and parasites that can be transmitted between bee colonies (Schmeller *et al.*, 2020). These include bacterial diseases, American foulbrood, *Paenibacillus larvae*, and European foulbrood, *Melissococcus plutonius*, fungal diseases (*Nosema apis* and *Nosema carinae)*, viral diseases, deformed wing virus, chronic paralysis virus, acute paralysis virus, black cell virus and protozoa. Also, insect pests, greater wax moth, *Galleria mellonella* and the lesser wax moth, *Achroia grisella*, parasitic mites, *Varroa destructor* and vertebrate pests. Among all these pests, the *Varroa* mite represents a major threat to commercial beekeeping worldwide. It is a notifiable infestation to the Office International of Epizooties (OIE)/ World Organization for Animal Health (Pirk *et al.*, 2016). It spreads very rapidly and causes severe damage to its host colonies, where it breeds inside capped brood cells to protect them from most acaricides (Chauhan *et al*., 2021). It is responsible for the loss of more than 50 % of *Apis mellifera* honey bee colonies worldwide (Chauhan *et al.*, 2021). Bacterial diseases such as the European Foulbroods (EFB) and the American Foulbroods (AFB) and the severe bee rot, *Pestis apium* may cause serious losses of brood and colony collapse, and are notifiable to OIE. These diseases represent the most prevalent and highly dangerous of the honey bee brood diseases, leading to high morbidity (Matović *et al.*, 2023). These agents have been detected in countries on all continents (Boncristiani *et al.*, 2020), thus have economic significance for beekeeping industry worldwide (Matović *et al.*, 2023). In addition to its harmful effects on biodiversity and natural resources, climate change impairs bee health and can exacerbate indirectly the severity and distribution of pests and diseases. Indeed, climatic habitat shift leads to mixing between bee communities, disseminating diseases and pests amongst populations (Schmeller *et al.*, 2020). Therefore, climate change is perceived as the major threat for beekeeping (Chmiel *et al.*, 2020 and Siviter *et al.*, 2021).

Implementation of suitable pathogen management and prevention control strategies in bee hives, particularly against *V. destructor* mites, is crucial for preserving bee colonies' health and productivity. Bee health and disease prevention strategies are based on Good Farming Practices (GFPs) and Good Veterinary Practices (GVPs) in apicultural production (Hendrikx *et al.*, 2009). Nekoei *et al.* (2023) have reviewed management and treatment options used to reduce pathogen loads or infestation levels. Synthetic miticides are actually used by fumigation against *Varroa* mites, but residues in all hive products and resistance have been observed these past years. Therefore, sustainable organic biocontrol medications against *Varroa* mites have come into widespread use. They are based on trickling, fumigation or spraying organic acids (oxalic and formic acids) and thymol essential oils from medicinal plants, but their actions depend on climatic and in-hive conditions, and application methods, leading to partial or temporary efficacy (Giese and Giese, 2013 and Nekoei *et al.,* 2023). Recently, the honey bee recombinant DNA vaccine for oral application has been developed for the treatment of *V. destructor* (Giese and Giese, 2013).

In addition, in terms of hygiene, the European Food and Safety Agency (EFSA) recommendations are based not only on the treatment of bee colonies, but also on the disinfection of equipment. The EFSA also recommends the destruction of affected or suspected colonies and contaminated material in order to ensure the rapid eradication of any outbreak of a contagious disease (Hendrikx *et al.,* 2009). Most of the management and treatment strategies to be implemented depend on beekeepers' initiatives as well as local governmental rules, which may vary considerably from country to country. The actions and measures undertaken by beekeepers in their apiaries depend on their perception of the threats. Jacques *et al.* (2017) have established a strong relation between colony losses and European beekeepers' education and training. Professional beekeepers are able to detect quickly the symptoms, especially those due to *V. destructor* and FB, and to implement suitable control countermeasures, leading to the survival of their bee colonies. Therefore, this study aimed to evaluating the Tunisian beekeepers' perceptions on bee diseases and pests, and their current management and treatment options, in order to develop successful integrated management practices, with the aim of the development and promotion of Tunisian honey value chain.

2. MATERIALS AND METHODS

The research methodology was based on a survey conducted through face-to-face interviewing and semi-structured questionnaire. It was developed through Google website, and directly administered in Tunisian dialect from long time. Respondents were recruited on a voluntary basis. The questionnaire consisted of a series of questions that were expected to be answered by beekeepers. The first part of the questionnaire included the questions related to: (1) the characteristics of beekeeping production and operations, (2) diseases and pests' inquiry, (3) treatment management, and (4) hygiene cleaning and disinfection procedures. The last part was about beekeeper respondents' socio-demographic characteristics (gender, age, education, training and experience in beekeeping, route into beekeeping.

Statistical analysis

Data were analyzed by descriptive statistics, as percentages, and Chi-Square Test, using IBM SPSS® statistics version 22 software.

3. RESULTS AND DISCUSSIONS

The most import results about demographics and main characteristics for respondents are summarized in Table (1). The Respondents were men (76.3 %), aged between 26-59 years old, (73.7 %), university educated (57.5 %) with at least 6 years of experience (81.3%) in the sector, and specifically trained (47.9 %). Schouten and Lloyd (2019) reported a positive impact of beekeeping extension, education and training on honey productivity and beekeeping income. Beekeeping was a subsidiary activity for most of the respondents (71.3%), and thus was considered as a source of extra-income. Only 35.1 % were heritage beekeepers, and thus, have knowledge and skills concerning bees, honey, and related products. About the features of agricultural exploitations, most of respondents (77.5 %) are private, only 6.3 % are cooperatives.

Table (1): Distribution of respondents' characteristics (n=80).

Type of characteristics	Characteristics	% respondents
Gender	Women Men	23.7 76.3
Age (years old)	18-25 26-40 41-59 60 and more	21.1 33.5 40.2 5.2
Education	Primary High School Baccalaureate University Professional Training	15.0 15.0 6.5 57.5 5.0
Occupational Status	Main activity Subsidiary activity	28.7 71.3
Beekeeping training	Yes No	47.9 52.1
Total years of experience in beekeeping	<1 1-5 6-10 11-20 21-30 >30 Does not answer	0 13.7 25.0 18.8 17.5 20.0 5.0
Routes into beekeeping	Heritage Non heritage	35.1 64.9
Farm legal status	Private agricultural exploitation Private company Agricultural cooperative Plot rented by the state for agricultural technicians	77.5 15 6.3 1.2
Number of bee hives	1-20 21-50 51-100 101-1000 >1000	10.0 18.8 37.5 32.5 1.2
Honey laboratory analysis	Yes No	57% 43%

The data was obtained through face-to-face interview and semi-structured questionnaire.

Most of the respondents (71.2%) declared having more than 50 bee hives, indicating medium to large scale sizes in the Tunisian context. In fact, 80% of Tunisian beekeepers have less than 50 hives (MARHP, 2020). All of the beekeepers interviewed owned modern hives (Langstroth type), 12.5 % have both traditional and modern hives. Only 43 % beekeepers declared to analyze their honey production in laboratories, in order to ascertain the quality of honey.

As shown in Table (2), respondents have reported Varroosis (97.5 %), as the main and harmful disease, followed by Foulbrood Bacterial (FB) diseases (18.8 %). The data in this table support that *V. destructor* is actually a pan-global pest, observed worldwide (Boncristiani *et al.*, 2020 and Chauhan *et al.*, 2021) including the Mediterranean region: Egypt (Kugonza, 2020), Turkey (Kösoğlu *et al.*, 2019), Spain, and Greece. *Varroa* mites have also been detected in Tunisia (Pirk *et al.*, 2016; Abdelkader, 2020 and Kugonza, 2020). Beekeepers can easily identify *Varroa* mites at the naked eye: they notice small reddish or brownish spots, about the size of a pinhead, on the thorax of a honeybee or on the larva (Kugonza, 2020).

AFB and EFB are present in numerous countries on all continents where honey bee breeding is developed (Boncristiani *et al.*, 2020). They include all the countries of the Mediterranean region, except Egypt where EFB has not been detected so far. However, AFB did not spread to eastern, central and western Africa (Kugonza, 2020). Since both FB are bacterial diseases affecting bee broods/ larvae, beekeepers can do visual inspection of brood combs. For AFB diagnosis, they can observe changes in the color, layout, and integrity of the cell caps, detectable twenty days after the larvae infection (Matović *et al.*, 2023). For EFB diagnosis, they will notice irregular capping of the brood; capped and uncapped cells are found irregularly scattered over the brood frame (called pepper pot brood) (Forsgren *et al.*, 2013). The difference between both is based on the high mortality (90%) of EFB infected larvae before capping whereas for

Table (2): Survey on reported diseases and pests' inquiry, according beekeepers' socio demographics (n=80).

Type of Characteristics	Characteristics	Reported diseases and pests (% respondents)			Statistics	
		Varroa	Wax moths	Foulbroods	Chi-square, df	P value
Age (years old)		97.5	15	18.8		
	25-40	100	14.3	25.7	6.792. 4	0.1473
	41-60	100	16.1	16.1		
	> 60	85.7	14.3	7.1		
Gender	Women	100	21.1	21.1	2.612. 2	0.2709
	Men	96.7	13.1	18		
Beekeeping activity	Main	100	21.7	26.1	3.381.2	0.1844
	Secondary	96.5	12.3	15.8		
Education	Primary	100	8.3	8.3	87.99.10	<0.0001
	Professional training	100	25	25		
	Baccalaureate	100	0	20		
	High School	83.3	8.3	0		
	University	100	19.6	26.1		
	Not specified	100	0	0		
Training in beekeeping	Yes	94.3	20	22.9	20.40. 4	0.0004
	No	100	15.8	15.8		
	Not specified	100	0	14.3		
Route to beekeeping: Heritage	Yes	100	14	18	30.98. 4	<0.0001
	No	92.6	18.5	18.5		
	Not specified	100	0	33.3		
Bee farm size (hives)	<20	100	0	14.3	0107.3.8	<0.0001
	20-49	100	0	7.1		
	50-99	93.3	13.3	13.3		
	100-1000	100	29.6	33.3		
	>1000	100	0	0		
Experience in beekeeping (years)	<6	100	0	9.1	72.69. 10	<0.0001
	6 - 10	100	30	30		
	11 - 20	100	12.5	13.3		
	21-30	100	21.4	28.6		
	>30	87.5	12.5	6.3		

The data was obtained through face-to-face interview and semi-structured questionnaire.

in the cells, whereas AFB infected brood commonly have very patchy brood patterns, with perforated capping (Cook, 2023).

In this research, beekeepers have provided a general answer, not distinguishing between AFB and EFB. As shown in Table 2, wax moths were the most cited pests (15%). Wax moths, *Galleria* and *Achroia* can destroy beeswax combs, making pollen, honey and lay eggs unavailable for the next generation of bees. They are not considered as serious as other stress agents are, but they are opportunists and indicators of poor management practices, leading to bee absconding and economic losses (Kugonza, 2020). Wax moths are present in almost all parts of the world. In the Mediterranean Region, they were found in Turkey, Egypt, Morocco, Algeria and Tunisia (Boncristiani *et al.*, 2020 and Kugonza, 2020). They are usually located in areas of the hives (top bars and inner covers) that are not accessible for bees. Wax moth detection can be based on visual inspection by beekeepers showing: (1) tunnels of silk throughout combs, (2) patterns of bald brood caused by bees uncapping cells where wax moth larvae have tunneled, and (3) cocoons stuck to frames and parts of the hive (Ellis *et al.*, 2013).

As indicated in Table (2), diseases and pest reports were significantly related with beekeepers' education, training and experience in beekeeping, its route to beekeeping (heritage) as well as number of bee hives ($p<0.05$). In fact, since diagnosis can be based on regular visual inspection of hives, Tunisian beekeepers have the knowledge to detect bee diseases and pests, and to treat them consequently, thus reducing harmful effects. Similarly, other studies have reported beekeepers know colonies from pest ledge and experience as the most significant factors in the protection of bee colonies from pests and diseases (Lawal and Banjo, 2010 and Jacques *et al.*, 2017; Mezher *et al.*, 2021). Beekeepers are aware that pests and diseases can affect beehive losses (Lawal and Banjo, 2010 and Dias de Freitas *et al.*, 2022) and alter both the quantity and quality of honey (Lawal and Banjo, 2010; Schmeller *et al.*, 2020), and therefore their farm profitability. *Varroa* infestation control can occur using synthetic or natural chemicals as shown in Table (3).

According to the results in Table (3),

Table (3): Distribution of respondents on chemical treatments against *Varroa destructor* used in surveyed apiaries (n=80)

Item	Treatment	Respondents (%)
Type of treatment	Apivar®	63.9
	Apistan®	35.1
	Apiguard®	35.1
	Garlic_+ petrolatum	5.6
	Garlic + thyme essential oil	1.3
Frequency of Treatment	1	25.3
	2	70.7
	>2	4
Season of Treatment	Autumn	70.5
	Winter	82.1
	Spring	3.8
	Summer	6.4

The data was obtained through face-to-face interview

Apivar® (500 mg of Amitraz/strip, Veto Pharma) was the most used chemical miticide to control *V. destructor* (63.9% of respondents), followed by Apistan® (824 mg of Tau-fluvalinate/strip, Vita Europe) (35.1%). They are long-term treatments (longer than 6-10 weeks) and require less handling and renewal, compared to organic molecules, but they leave traces of residue in the waxes. After 20-30 years of use, *V. destructor* is beginning to show signs of resistance to Apivar® and Apistan® (Bahreini *et al.*, 2020), with only a limited number of other options being developed. According to Leza *et al.* (2015), thymol-based Apiguard® represents an interesting alternative product for integrated control due to not only the low risk of *V. destructor* resistance, but also to low residues in bee products. Apiguard® (35.1% of respondents) is widely used in organic beekeeping. Thymol (Apiguard®, Thyme essential oil) has acaricidal activity and repellent effects (Gracia *et al.,* 2017). Loucif-Ayad *et al.* (2010) in Algeria and Leza *et al.* (2015) in Spain have shown better effectiveness of treatments based on Apiguard® when compared with Apivar®. However, Apiguard appeared to be less effective in warm climates (Leza *et al.,* 2015). According to the results, some beekeepers used a combination of these medicines. Other natural miticides based on garlic, were also used by 6.9 % respondents' beekeepers. Al-Kenawy *et al.* (2021) have shown the efficiency of garlic paste in reducing by 76-78%, V. destructor mites infesting honeybee colonies. Plates can be impregnated with petrolatum in order to attach mites to the plates when they fell from the bees.

According to the literature, high loads of *V. destructor* in bee colonies are observed before summer collapse or overwintering and are risk factors for colony loss throughout the season (Bartlett, 2022). This situation has been exacerbated by climate change: the autumn infestation by *V. destructor* in Central Europe can be reinforced by the increase in spring and autumn temperatures (Smoliński *et al*., 2021). In this context, Tunisian beekeepers have implemented prophylactic measures in apiaries through treatments twice a year (70.7 % of respondents), mainly in winter (82.1 %) and autumn (70.5 %). The treatment type was significantly related to beekeepers age and education, number of bee hives and the disease nature ($p<0.05$), whereas as significant correlations of numbers and season of treatment applications were found with beekeepers' age, honey laboratory analysis and disease nature ($p<0.05$) (Data not shown). According to Jacques *et al.* (2017) in Europe, beekeepers' knowledge on disease detection and management (specifically for varroosis and AFB) is essential to applying earlier prophylactic measures and good beekeeping practices. The use of antibiotics such as oxytetracycline, sulfathiazole and Terramycin to treat FB bacterial infections was not mentioned by surveyed beekeepers. Antibiotics are considered as a last resort and they are not used for prophylactic purposes to avoid drug resistance and the presence of residues in bee products (Patel and Rahul, 2020). There are also antimicrobial and antioxidant molecules in the honey produced by the hives (Nolan *et al.,* 2019). In case of infection, EFSA recommends destroying the entire infected or suspected colonies. Therefore, most of Tunisian professional beekeepers implement preventative prophylactic measures to help avoid diseases and pests, and keep apiaries safe and healthy, as recommended by EFSA. In regulatory terms in Tunisia, beekeeping structures are subject to health approval as defined in the Order of the Minister of Agriculture and Hydraulic Resources of May 26, 2006, setting out the terms of veterinary health control, the conditions and procedures for granting of health approval for establishments producing, processing and packaging animal products. Among good beekeeping practices, apiary hygiene constitutes a prevention and control measure against honey bee diseases and pests.

Our survey revealed a compliance regarding the hygiene of premises, hives and equipment: 98.7% of respondents claimed cleaning and disinfecting them before and after the harvest. Interestingly, according to our surveys, professional beekeepers are more concerned about the diseases affecting their stock, as well as the problems of predators and parasites, than amateur beekeepers. This is probably due to the different profitability objectives between amateur and professional beekeepers. Deaths caused by disease and parasites are very detrimental to professional beekeepers, who have to make a living from their operations. Moreover. as professionals (>100 hives) have less time to devote to each hive, they pay more attention to the health and sanitary aspects.

The respondents used more of products for cleaning and disinfecting premises, hives and equipment (Table, 4).

Table (4): Respondents by ways of cleaning and disinfection methods used in surveyed apiaries.

Way of cleaning	Disinfection methods	Respondents (%)
Premises disinfecting products	Hot water	43.4
	Warm sodium hypochloride solution	34.2
	Detergents	17.1
	Detergents and disinfectants	15.8
Hive and equipment disinfecting products	Hot water	34.6
	Warm sodium hypochlorite solution	24.4
	Detergents	10.3
	Detergents and disinfectants	23.1
	Blowtorch for hive bodies	46.2

The data was obtained through face-to-face interview and semi-structured questionnaire.

Disinfecting with boiling water is a common physical method used in beekeeping (Bojanić-Rašović, 2021). This is the most used method by the respondents, for cleaning and disinfecting premises (43%) and equipment (34%). However, this method requires preliminary mechanical cleaning. Temperature and contact time are very important for the efficacy of the operation (Bojanić Rašović, 2021). 46.2 % of respondents declared disinfecting hives bodies with a blowtorch, which is a very efficient physical method to destroy the pathogens that are on them. According to results, beekeepers mostly used chemical methods, then physical ones (Table 4). Sodium hypochlorite (NaClO) is the most used agent in our survey for cleaning and disinfecting premises (34%) and equipment (24%). It is a well-established antimicrobial agent, and it is very affordable. A concentration of warm 5 % sodium hypochlorite for approximately 30 minutes is needed to achieve a disinfectant effect (Bojanić-Rašović, 2021). Patel and Rahul (2020) have documented that dipping the hive parts in 3% sodium hypochlorite NaClO solution was effective to destroy FB bacterial agents. However, this chemical can leave some traces on equipment. Therefore, beekeepers use detergents alone, or combined with disinfectants that usually affect the metabolism of microorganisms (Bojanić-Rašović, 2021). Detergents are bactericid and fungistatic, but they have no effect on spores and viruses (Bojanić-Rašović, 2021). They are used for washing and cleaning of metal and wooden surfaces. The main constraints for beekeepers at this level, a lack of information and training as well as a limited access to veterinary treatments for bees. According to respondents, the medicines available on the Tunisian market to treat bee diseases are few in number and do not meet the growing need for effective veterinary medicines. For them, scientific research and development efforts remain inadequate in terms of treatments against microbial and parasitic species in a climate change context. Schmeller *et al.* (2020) have reported that *V. destructor* spreads more rapidly in hot and humid environments. Medicines and treatments are very free for professional organizations and small beekeepers, but this is still limited because of the very low budget. Beekeepers' associations receive indirect financial assistance from the Tunisian government through Livestock and Pasture Office (70% of equipment and tools), while beekeepers belonging to professional organizations pay only 30%. This aid does not apply to independent beekeepers. In order to ensure the protection of bee health, our study has highlighted that beekeepers must be trained, in particular on the knowledge and diagnosis (clinical signs) of bee diseases and pests, the control, prevention and control of infectious diseases of bees. They also need support through technical assistance for implementing good beekeeping practices and good hygiene practices in their apiaries. The application of the principles of these good practices not only ensures the health safety of hive products including honey, but also better preserves the health of bee colonies. In reality, good beekeeping practices constitute the basis for the implementation of an internal management and control system based on the principles of Hazard Analysis Critical Control Point (HACCP), considering that the HACCP system itself is not legally compulsory for beekeepers as primary producers.

Conclusion and recommendations

The obtained result has established that among pests and diseases affecting apiaries, V. destructor is a major issue for Tunisian beekeeping sector. Interestingly beekeeper respondents have developed mitigation strategies based on preventive prophylactic measures including apiary hygiene, and on the use of chemical synthetic and/or natural miticides. Our findings indicated that beekeepers' experience, education and knowledge on disease detection and management are crucial for preserving bee colonies' health and productivity, and therefore bee farm profitability. Limitations of this study would be related to the data collection method, through face-to-face interviews. This would introduce bias, due to respondents' subjective opinions and to interviewer effects. However, according to Jacques *et al.* (2017), these data represent valuable contributions for policy makers, as well as for corroborating scientific findings.

Our findings may be of special interest for policy makers, stakeholders and other actors for designing and implementing successful integrated bee diseases and pest management strategies, in order to support Tunisian beekeeping sector. Given that this is a multifactorial issue, recommended solutions would be:

- Strengthen the national program for the prevention and control of bee diseases;
- Implement an integrated fight program against *Varroa.*
- Organize health prophylaxis campaigns and strengthen colony control on beekeeping farms.
- Strengthen the technical capacities of beekeepers, by developing training courses relating to breeding techniques, the detection and the treatments of diseases and pests, as well as traceability, good beekeeping practices and good hygiene practices;
- Support beekeepers in their fight to protect the health of colonies through extension services.
- Promote the availability of treatments on the market at preferential prices.
- Better, regulate transhumance in order to fight against diseases spread during transhumance, and to avoid a concentration of apiaries in a limited geographical area.
- Arise awareness of amateur beekeepers to sanitary bee issues.
- Provide support for the digitalization of production systems and promote the use of innovative technologies for livestock monitoring: Innovative technologies, such as drones, sensors, and forecasting models, can help beekeepers monitor and manage their production more efficiently. In general, our findings may be of special interest for policy makers, stakeholders and other actors for designing and implementing successful integrated bee diseases and pest management strategies, in order to support Tunisian beekeeping.

Authors' contributions

All authors contributed in conceptualization, methodology, software, validation, formal analysis investigation, resources, data curtain, writing the original draft preparation, writing, review, editing, supervision and funding acquisition. All authors have read and agreed to the published version of the manuscript.

Competing interests

All authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

5. REFERENCES

Abdelkader, F. B. (2020). Situation of beekeeping in North Africa. J. Apitherapy Nature. 3 (1):1-9.

Al-Kenawy, Y., Yousif-Khalil S.I., Omarh S.M. and Mansour H.M. (2021). Efficiency of some botanical materials as control agents against *Varroa* destructor mite (Anderson and Truman) infesting honeybee' colonies. Zagazig J. Agric. Res. 48 (1): 79-84.

Bahreini, R., Nasr M., Docherty C., de Herdt O., Muirhead S. and Feinde D. (2020). Evaluation of potential miticide toxicity to *Varroa destructor* and honey bees, *Apis mellifera*, under laboratory conditions. Sci. Rep. 10: 21529.

Bartlett, L. J. (2020). Frontiers in effective control of problem parasites in beekeeping'. Int. J. Parasitol: Parasites and Wildlife, 17: 263-272.

Bojanić-Rašović, M. (2021). The Most Important Methods of Disinfection: In Beekeeping. Agric. For. 67(3): 167-176.

Boncristiani, H., Ellis J. D., Bustamante T., Graham J., Jack C., Kimmel C.B., and Schmehl D.R. (2020). World honey bee health: the global distribution of western honey bee (*Apis mellifera* L.) pests and pathogens. Bee World. 98 (1): 2-6.

Chauhan, A., Dabhi, M., and Patnaik, R. (2021). Review on *Varroa* mite: An invasive threat to apiculture industry. J. Entomol. Zool. Stud. 9: 535-539

Chmiel, J.A., Daisley B.A., Pitek A.P., Thompson G.J. and Reid, G. (2020). Understanding the Effects of Sublethal Pesticide Exposure on Honey Bees: A Role for Probiotics as Mediators of Environmental Stress. Front. Ecol. Evol. 8: 22: 1-19.

Cook, K. (2023). American Foulbrood Versus European Foulbrood. Backyard Beekeeping. Spring 2023 issue. https://backyardbeekeeping.iamcountryside.com/health-pests/americanfoulbrood-versus-european-foulbrood/.

Dias de Freitas C., Oki Y., Resende F.M., Zamudio F., Simone de Freitas G., Moreira de Rezende K., *et al.* (2022). Impacts of pests and diseases on the decline of managed bees in Brazil: A beekeeper perspective.' J. Apic. Res. 62 (5): 969-982.

Ellis, J.D., Graham, J.R., and Mortensen, A. (2013). Standard methods for wax moth research. J. Apic. Res. 52 (1): 1-17.

Forsgren, E., Budge G.E., Charrière J.D. and Hornitzky M.A. (2013). Standard methods for European foulbrood research. J. Apic. Res. 52 (1): 1-14.

Giese, S., and Giese M. (2013). Oral vaccination of honeybees against *Varroa* Destructor'. In Molecular Vaccines: From Prophylaxis to Therapy. 1: 269-278. Vienna: Springer Vienna.

Gracia, M. J., Moreno C., Ferrer M., Sanz A., Peribáñez M. Á., and Estrada, R. (2017). Field efficacy of acaricides against *Varroa destructor*. PloS One. 12(2): e0171633.

Hendrikx, P., Chauzat M.P., Debin M., Neuman P., Fries I., Ritter W. and Gregorc A. (2009). Bee mortality and bee surveillance in Europe. EFSA Supporting Publications. 6 (9): 27e. https://www.efsa.europa.eu/en/supporting/pub/en-27.

IPBES (2016). Résumé à l'intention des décideurs du rapport d'évaluation de la Plateforme intergouvernementale scientifique et politique sur la biodiversité et les services écosystémiques concernant les pollinisateurs, la pollinisation et la production alimentaire. In S. G. Potts, V.

L. Imperatriz-Fonseca, H. T. Ngo, J. C. Biesmeijer, T. D. (Eds.).

Jacques, A., Laurent M., Consortium E., Ribière-Chabert M., Saussac M., Bougeard S., and Chauzat, M. P. (2017). A pan-European epidemiological study reveals honey bee colony survival depends on beekeeper education and disease control. PLoS One. 12 (3): e0172591.

Kösoğlu, M., Topal E., Özsoy N., Karaca Ü., Takma Ç., and Özkırım A. (2019). Perspective of Izmir province beekeepers on bee diseases and pests. Ege Üniv. Ziraat Fak. Derg. 56 (2): 187-193.

Kugonza, D. R. (2020). Africa under attack: a continent-wide mapping of pathogens, parasites and predators afflicting the hived honey bee *Apis mellifera* L. (Hymenoptera: Apidae)'. Afr. J. Rural Develop. 5 (2): 1-27.

Lawal, O. and Banjo A. (2010) 'praising the beekeeper's knowledge and perception of pests problem in beekeeping business at different ecological zones in south western Nigeria'. World J. Zool. 5 (2):137-142.

Leza, M. M., Llado G. and Miranda-Chueca M. A. (2015). Comparison of the efficacy of Apiguard (thymol) and Apivar (amitraz) in the control of *Varroa destructor* (Acari: Varroidae)'. Span. J. Agr. Res. 13(3): e05SC01.

Loucif-Ayad, W., Aribi N., Smagghe G. and Soltani N. (2010). Comparative Effectiveness of some Acaricides used to control *Varroa destructor* (Mesostigmata: Varroidae) in Algeria'. Afr. Entomol. 18 (2): 259-266.

Matović, K., Žarković A., Debeljak Z., Vidanović D., Vasković N., Tešović B., and Ćirić J. (2023). American Foulbrood old and always new challenge. Vet. Sci. 10 (3): 180.

Mezher, Z., Bubnic J., Condoleo, R., Jannoni-Sebastianini F., Leto A., Proscia F., and Formato, G. (2021). Conducting an international, exploratory survey to collect data on honey bee disease management and control. Appl. Sci. 11: 7311.

MAWRMF (2022). Fiche pratique de l'apiculture, Available at: Minister of Agriculture, Water Resources and Maritime Fisheries of Tunisia. www.avfa.agrinet.tn/supportsde-vulgarisation/, last accessed 16 September 2023.

Nekoei, S., Rezvan M., Khamesipour F., Mayack C., Molento M.B., and Revainera, P.D. (2023). A systematic review of honey bee (*Apis mellifera*, Linnaeus, 1758) infections and available treatment options. Vet. Med. Sci., 9 (4):1848-1860.

Nolan, V. C., Harrison J. and Cox, J. A. (2019). Dissecting the antimicrobial composition of honey. Antibiotics. 8 (4): 251.

OEP (2022). Livestock sector data in Tunisia 2021. Available at: www.oep.nat.tn (last accessed 12 September 2023).

Patel, S., and Rahul S. N. (2020). Diseases of honeybees and their management. Popular Kheti. 8 (4): 83.

Pirk, C.W., Strauss U., Yusuf A.A., Démares F., and Human H. (2016). Honeybee health in Africa: A Review. Apidologie. 47: 276-300.

Rong, C. and Sadhukhan S. (2021). Decline of bees, a major pollinator: A Review. BKGC Scholars. 2 (2): 35-43.

Schmeller, D.S., Courchamp F., and Killeen G. (2020). Biodiversity loss, emerging pathogens and human health risks. Biodivers. Conserv. 29: 3095-3102.

Schouten, C., and Lloyd, J.D. (2019). Considerations and factors influencing the success of beekeeping programs in developing countries. Bee World. 96(3): 75-80.

Siviter, H., Bailes E.J., Martin C.D., Oliver T.R., Koricheva J., Leadbeater E. and Brown M.J. (2021). Agrochemicals interact synergistically to increase bee mortality. Nature. 596 (7872): 389-392.

Smoliński, S., Langowska A. and Glazaczow, A. (2021). Raised seasonal temperatures reinforce autumn *Varroa destructor* infestation in honey bee colonies. Sci. Rep. 11: 22256.

تحليل تصورات النحالين التونسيين في إدارة أمراض وآفات نحل العسل

سهى الجمل[1], حنان بن إسماعيل [1,2], منال حمزاوي[1], حسان بن سالم[3] وهاجر الدبابي[1]

1 المعهد الوطني للعلوم الفلاحية بتونس, جامعة قرطاج, UR17AGR01, 1082- تونس
2 كلية العلوم للرياضيات والفيزياء والطبيعيات, جامعة تونس المنار, LR11ES09 ، 2092- تونس
ديوان تربية الماشية وتوفير المرعى, 1002- تونس

ملخص

سببت أمراض وآفات النحل خسائر فادحة في عدد خلايا النحل في تونس خلال السنوات الماضية. يهدف البحث الحالي إلى تحليل تصورات النحالين التونسيين حول إدارة أمراض وآفات النحل من خلال المقابلة الشخصية وجهًا لوجه مع 80 من مربي النحل في شمال تونس. تم تحليل البيانات باستخدام التحليل الوصفي. أكد أغلب مربي النحل المبحوثين أن أكاروس الفاروا (97.5%) هو الآفة الرئيسية والخطيرة، يليها مرض تعفن الحضنة الأمريكي (19%). علاوة على ذلك، فإن الآفة الأكثر ذكرًا (15.2%) هي ما يسمى بفراشة "العثة". ارتبطت تقارير أمراض وآفات النحل بأن انتشار الأمراض مرتبط بشكل كبير بالمستوى الدراسي للنحالين, تدريبهم وخبرتهم في قطاع تربية النحل، توارث هذه المهنة من الآباء والأجداد بالإضافة إلى عدد خلايا النحل لديهم. أفاد النحالون الذين شملهم الاستطلاع أن معالجة الأمراض والآفات تتم مرتين في السنة لدى معظم النحالين (70.7%), مرة واحدة (25.3%) أو ثلاثة (4%) سنوياً, يذكر ان المعالجة تكون خاصة خلال فصل الشتاء (62.1%) وفصل الخريف (37.9%). يمارس النحال بعض التدابير العلاجية في المناحل, مثل استعمال مبيدات كيميائية مثل Apivar® (63.9%) , Apistan® (35.1%) Apiguard® (35.1%)، خليط من الثوم والفازلين (6.5%), أو خليط من زيت الثوم والزعتر العطري (1.3%) تبعاً لطبيعة المرض. أوضحت النتائج أن استعمال أحد انوع العلاج المعتمدة من النحالين مرتبطا بشكل كبير بعمر النحال، مستواه الدراسي, عدد خلايا النحل وطبيعة المرض. وقد لوحظ ارتباط كبير بين الأعداد وموسم تطبيق العلاج حسب عمر النحال، التحليل المخبري للعسل وطبيعة المرض. كما تبين أن 98.7% من المبحوثين يقومون بتنظيف وتطهير المباني وخلايا النحل والمعدات قبل جني العسل وبعده وهذا يدل على وعي النحال بأهمية نظافة وسلامة المنحل.

المؤتمر الرابع عشر لإتحاد النحالين العرب, 13-15 نوفمبر (2023), القاهرة- مصر
المجلة المصرية للعلوم الزراعية (2024)المجلد 75 (إصدار خاص): 48-59.