



Prevalence and risk factors of wax moth in bee colonies in the Central and Central-West regions of Burkina Faso: pilot study

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ABSTRACT

Beekeeping is a very old practice in Burkina Faso and has many advantages, including the availability of honey resources, of endogenous knowledge and support from public policies. However, it faces challenges, including health problems, which are poorly documented. This cross-sectional study was conducted between March and May 2019 in the Central and Central-west regions of Burkina Faso to determine the prevalence and risk factors of wax moth in bee colonies. A total of 200 modern hives were visited of which 106 were colonized or previously colonized. Methods of observation and inspection of the hives were used to search for witnesses of the wax moth infestation: eggs, larvae, pupae cocoons, woven silk cloth, gallery in wax or adult butterflies. A pre-tested questionnaire was used to collect information on beekeepers and apiaries characteristics. An inspection sheet was used to record observations made during the inspection of the hives. The results revealed that the average size was 18 hives by apiary. Hives used were Kenyan, Dadant, and rectangular frame hives with a colonization rate of 53%. The overall prevalence of wax moth was 23.6% [15.5-31.7%]. Other predators/pests were observed in 43.4% of the hives, the main ones being beetles (25.5%) and ants (17%). The analysis of the radio adjusted odds ratio showed the absence of risk factors among the modalities of the studied variables. In view of the results of this pilot study, more extensive studies could be carried out to have a better understanding of the epidemiology of the infestation and its possible impact that it can have on honey production.

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Keywords: Bee, Beekeeping, Wax moth, Prevalence, Burkina Faso.

INTRODUCTION

In Burkina Faso, as in other regions of the world, beekeeping is a very old activity. Once little considered among the animal sectors, beekeeping has become an activity of interest in recent years, providing jobs and foreign currency (MRAH, 2019). Indeed, beekeeping is an important source of income for rural populations (Yédomonhan and Akoègninou, 2009; Birhan et al., 2015) and a means of income diversification (Ahouandjinou et al., 2016). Also, honeybees play an important role in nature through the pollination of various plants (Jonwangwe et al., 2011). The average annual honey production has been estimated at more than 1000 tons of honey in 2018 (MRAH, 2019). In addition, bees participate in maintaining biological diversity and improving agricultural production and productivity through pollination (Bradbear, 2010). The honey sector has many advantages including the availability of wild bee colonies, the availability of honey plants, the existence of beekeeping practices and a growing market (Nombré et al., 2009).

Nevertheless, it faces technical, financial, and sanitary constraints (Nombré, 2003; Kaboré, 2017). In terms of health, infestations of the small beetle (*Aethina tumida*), the varroa mite (*Varroa sp.*), and the wax moth have been detected in bee colonies in Burkina Faso (Sankara et al., 2015; Aebi et al., 2016).

However, specific investigations on these pathologies have not yet been carried out. The wax moth, which corresponds to part of the development cycle of a butterfly in hives, could be responsible for damage and economic losses such as the destruction of beekeeping equipment (Lalita et al., 2018) and production losses. In case of severe infestation, strong colonies weaken rapidly and weak colonies are sometimes completely destroyed (Ritter and Kencharddi, 2005). In Burkina Faso, wax moth was identified but has not been sufficiently documented to date. Thus, no specific study on the prevalence and the risk factors associated with the infestation has been carried out, which makes it difficult

to implement control measures. It is in this context that this prospective study was conducted with the main objective of determining the prevalence of wax moth in bee colonies in the study area.

MATERIALS AND METHODS

Study area

For this pilot study on prevalence of wax moth in Burkina Faso, the Central and Central-west regions were randomly selected among the thirteen (13) regions of the country. They are in the Sudano-Sahelian agro-climatic zone characterized by two (02) seasons including a dry season and a wet season (Thiombiano and Kampmann, 2010). Rainfall in the Central-West varies from 700 mm to 1200 mm from the north to the south of the region, while that of the Centre rarely exceeds 700 mm of water per year. Average temperatures in this Sudano-Sahelian zone are between 20 °C and 36 °C. Two provinces, three communes and five villages were concerned, considering the availability of beekeepers during the study period and the proximity of the apiaries (Figure 1).

Methodology

This study was conducted between March and June 2019. Data collection was based on the hive inspection method employed by Kebede et al. (2015). The identification of wax moth eggs, larvae, pupae and adult, as evidence of wax moth infestation was based on the standard wax moth research methods developed by Ellis et al. (2013). An inspection sheet and a questionnaire were used to record inspection results and collect data on apiaries and beekeepers.

A simple random sampling method was used. The possession of barbed or framed hives was considered as a criterion for inclusion in the study. Considering the formula $n = z^2 pq / e^2$ (Cochran, 1963), with an expected prevalence (p) of 90% (Kientega, 2011), a precision (e) of 5% ($z = 1.96$), the minimum sample size was estimated at 138 colonies. But, a total of 106 populated or previously populated hives were inspected according to the availability.

Statistical analysis

The data collected at the inspection and from the beekeepers were entered into the Excel spreadsheet and transferred to R software version 3.2.3 where descriptive and analytical statistical analyses were performed using the Rcmdr package. The χ^2 and/or Fischer's exact test was used to study the relationship between the infestation and some variables. For the identification of risk factors,

a two-by-two logistic regression was used to calculate the raw Odds ratio. Then, the variables with a p-value of less than 0.2 were integrated into a generalized linear model for the calculation of the adjusted odds ratios. The difference was considered significant if the p-value was less than 0.05. The QGIS version 2.4 software was used to produce the map of the study area.

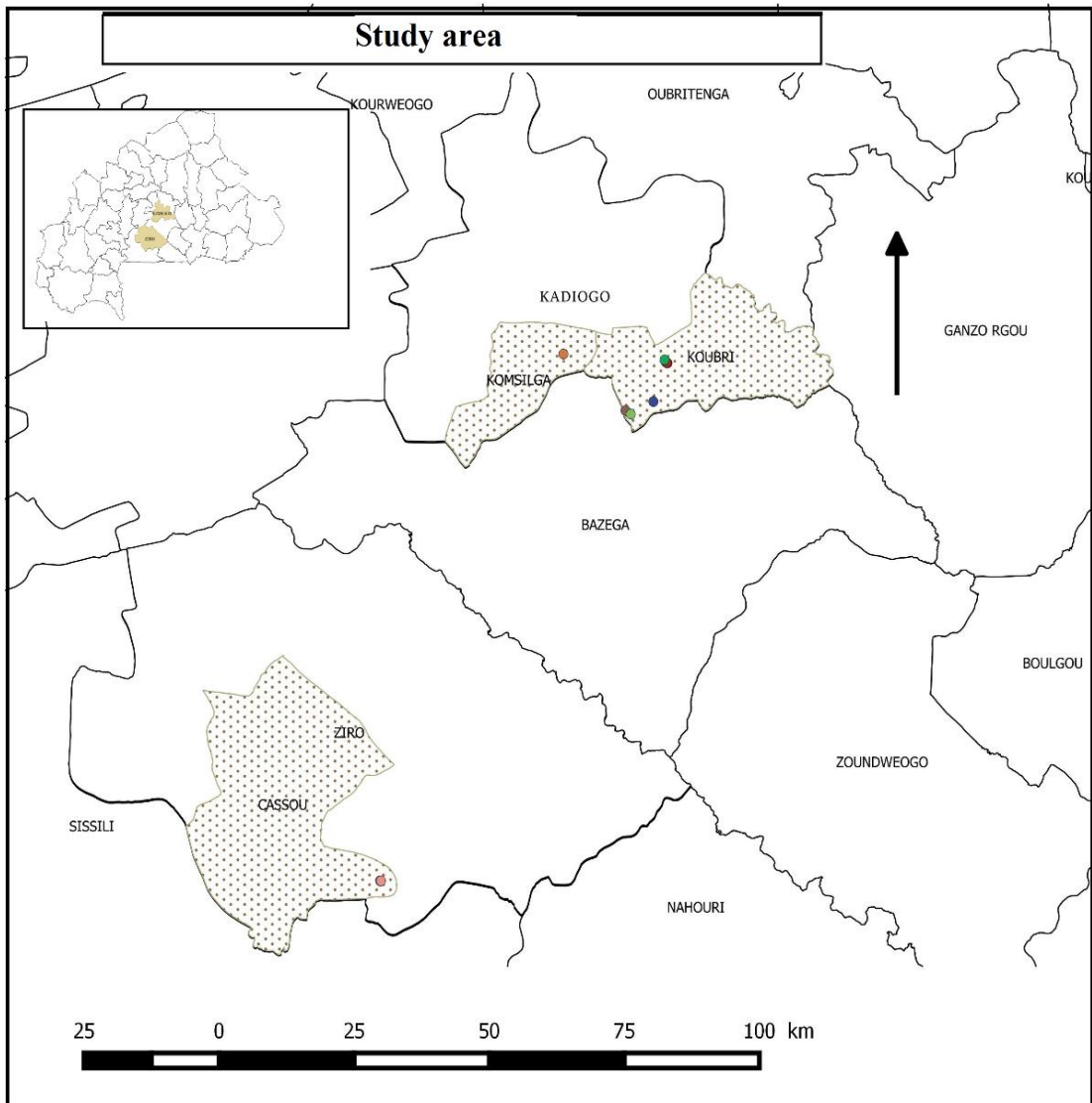


Figure 1: Study area and apiary sites.

RESULTS

Characteristics of beekeepers and apiaries

In the 11 apiaries visited, 200 hives were found with an average size of 18 hives per apiary. The inspection concerned 106 hives among which 93 populated hives and 13 deserted hives. Thus, the colonization rate was estimated at 53%. As for the types of hives used, the Kenyan hive (70.8%) was the most dominant, followed by the Dadant hive and the rectangular frame hive (Figure 2).

The hives were mainly prepared by embossing the bars or frames (84.9%), but some beekeepers practiced in addition to embossing, smoking (15.1%) with certain plant parts. The hives were placed in 66%, 18.9% and 15.1% respectively on high relief, swampy and flat land. The averages of parameters such as age of the hives, frequency of visits and harvesting were 7.8 years, and 2 visits per year and 2 harvests/year respectively. Prevalence of wax moth in the study area

Overall prevalence

During this study, the infestation controls carried on were larvae, pupae, galleries dug in the wax combs, the presence of woven silk cloth or adult butterflies in the hive. On 106 colonized and previously colonized hives, infestation controls were identified in 25 hives, for an overall prevalence of 23.6% [23.5-23.7%].

Variation factors associated with wax moth infestation

The infestation was significantly higher in the Central region (32.3% [32.2-32.4%]) than in the Central-West region (9.8% [9.7-9.9%]) with a value of $p = 0.007$. The variation was also significantly different according to the

village (Table 1).

In terms of hive types, the prevalence was significantly higher ($p = 0.03$) in rectangular frame hives (100%) than in Dadant (27.6%) and Kenyan (20%) types. Finally, according to the controls encountered during hive inspection, larvae and pupae were the most observed (Figure 3).

Other observations made during the inspection of the hives

Beyond the wax moth, other bee colony enemies were observed in 43.4% of the hives inspected. Beetles (25.5%) and ants (17%) were the most observed enemies (Figure 4).

The prevalence of wax moth varied significantly according to the presence or absence of other enemies ($p = 0.0045$). In fact, 68% of the hives infested with wax moth were inhabited by other enemies.

Risk factors for wax moth

For the study of the risk factors for wax moth infestation of hives, the explanatory variables were region, hive type, apiary site, hive preparation technique, age of the hive, and presence of other pests. The univariate logistic regression results seem to indicate that the region and the presence of other pest influence wax moth infestation with a p-value respectively of 0.012 and 0.006 (Table 2). But the multivariate logistic regression by determining the adjusted odds ratio, used in epidemiology to study the relationship between a disease and several factors shown that there is no risk factor among the studied variables (Table 3).

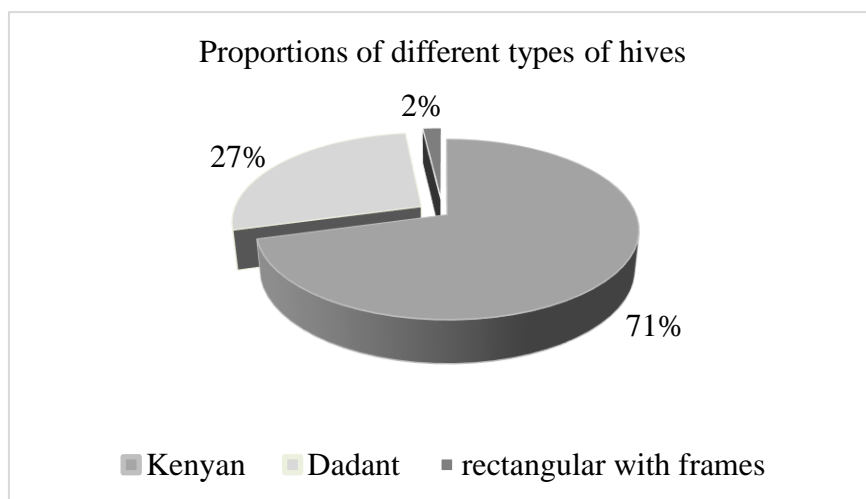


Figure 2: Types of hives used in the study apiaries.

Table 1: Prevalence of wax moth according to villages.

Villages	Prevalence (%) and confidence interval at 95%	p-value
Poédogo	50.0 [49.6-50.4]	0.005
Nakamtenga	47.8 [47.6-48.0]	
Boulbi	20.0 [17.8-22.2]	
Gomtoaga	18.8 [17.8-19.1]	
Tare	9.8 [9.7-10.0]	

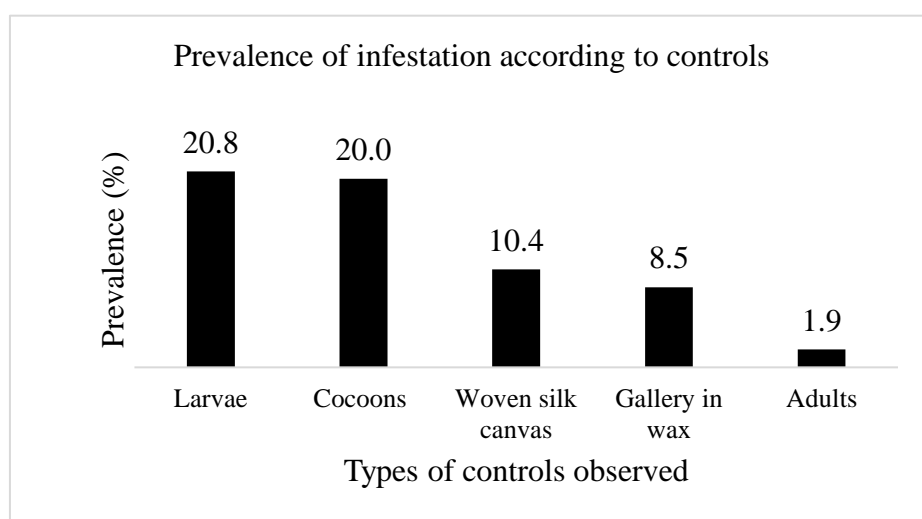


Figure 3: Prevalence of infestation according to controls observed.

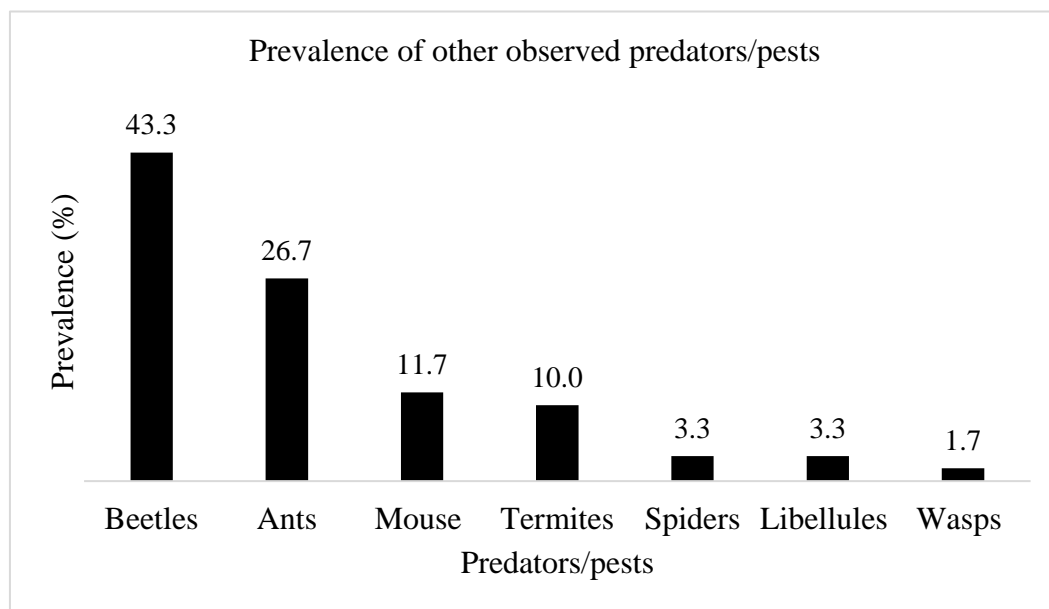


Figure 4: Prevalence of other observed predators/pests.

Table 2 : Univariate Logistic Regression Statistics.

Variables	Modalities	Unadjusted odds ratio	95% confidence interval	P-value
Region	Center	4.14	1.39 – 14.01	0.012
	Central West	Reference		
Type of hive	Beehives with bars	Reference		0.180
	Beehives with frames	1.90	0.74 – 4.88	
Apiary sites	Shaded	2.19	0.87 – 5.49	0.09
	Dry	Reference		
Preparation of the hive	Embossing and smoking	0.71	0.18 – 2.71	0.622
	Embossing only	Reference		
Age of the hive	Amortized	Reference		0.69
	Not amortized	0.83	0.33 – 2.07	
Presence of other pests	Present	3.81	1.46 – 9.90	0.006
	Absent	Reference		

Table 3: Multivariate logistic regression statistics.

Variables	Modalities	Adjusted odds ratio	95% confidence interval	P-value
Region	Center	3.06	0.71 – 13.08	0.13
	Central West	Reference		
Type of hive	Beehives with bars	1.73	0.60 – 4.95	0.30
	Beehives with frames	Reference		

Apiary sites	Shaded	0.94	0.31 – 2.86	0.92
	Dry	Reference		
Age of the hive	Amortized	Reference		0.65
	Not amortized	0.78	0.27 – 2.25	
Presence of other pests	Present	2.37	0.76 – 7.42	0.13
	Absent	Reference		

DISCUSSION

Characteristics of apiaries and beekeepers

Of the three types of hives encountered, the predominance of Kenyan hives (71%) observed is like the observations of Kientega (2011) and Kaboré (2017), who found 57.1% and 94.2% Kenyan hives in the apiaries of the Hauts-Bassins and Central-West regions, respectively. With the advent of modern beekeeping since the 1980, beekeeping centers were created and projects were implemented with the promotion of modern beekeeping through the popularization of modern techniques and the Kenyan hive (Freytag, 2010). However, the level of use remains variable according to the availability of beekeeping centers or beekeeping projects in the regions. As an illustration, the establishment of the NGO Wendpuié in the Central-West region contributed to the promotion of modern beekeeping through the organization of trainings in the region and surroundings, in the promotion of modern beekeeping in the region (Freytag, 2010).

Regardless of hive type, the overall hive population rate of 53% is significantly lower than the results found by Kientega (2011). The author found that in 88% of villages in classified forests in the southern Sudanian zone, the stand rate was close to 100%. It should be noted that in Burkina Faso, hive colonization is still based on the capture of wild colonies. So, the rate would be influenced by the potential for honey production, notably the availability of wild bee swarms. The classified forest zone studied by Kientega (2011) would constitute an important source of nectar and water resources, and therefore likely to host many bee colonies, in contrast to the Sudano-Sahelian zone of the Centre and Centre-West dominated by savannahs (MEF, 2009). Nevertheless,

beekeepers' practices combined with predator/pest and pesticide effects would contribute to reduce the number of colonies (Aebi *et al.*, 2016).

Prevalence and risk factors for wax moth in the study area

The identification of infested bee colonies in this study confirms the presence of the infestation in Burkina Faso. The presence of wax moth had been reported in tropical areas (Villières, 1987; Leven *et al.*, 2005) and in Burkina Faso by other authors (Nombré, 2003; Kientega, 2011; Aebi *et al.*, 2016). This presence would testify to the ubiquity of the wax moth (Ellis *et al.*, 2013).

The overall prevalence of 23.6% is much lower than those found by Kientega (2011) in the classified forests of Dindéréso, Kua, Kuinima and the riparian villages in western Burkina Faso (90%). It is also slightly lower than the prevalence found by Kebede *et al.* (2015) in modern hives in Ethiopia (27.4%). There are several reasons for these discrepancies, the most important of which are climatic factors. In fact, in the present study, average monthly temperatures sometimes exceeded 35 °C while the optimum temperature range for the complete cycle of the wax moth is between 24 and 35 °C (Charrière and Imdorf, 2004), which would reduce infestations contrary to the zone of classified forests where temperatures do not reach 35 °C (Kaboré *et al.*, 2017). The rainfall also influences the development cycle of wax moth and are indeed factors in seasonal variations in prevalence (Sohail *et al.*, 2017; Lalita *et al.*, 2018; Kumar and Khan, 2018). In addition, the study conducted by Kientega (2011), involved both modern and traditional hives.

As for the results obtained by Kebede *et*

al. (2015), our studies have been conducted during the same periods and under similar temperature ranges, the difference could be related to the type of hives, the most common of which were Kenyan hives. The hives with supers are larger than the Kenyan ones and would cause the existence of unoccupied rays favoring the establishment of the wax moth (Alemayehu *et al.*, 2017). In addition, when harvesting frame hives, the wax combs in the form of empty cells are kept after extraction and returned to the hive, contributing to the aging of the combs that attract the wax moth (Villières, 1987). This particularity of frame hives would justify the fact that the prevalence was significantly higher in frame hives than in top bar hives during our study.

The prevalence found nevertheless remains high in relation to the size of the apiaries and the damage that can be caused by the presence of wax moth. It varied significantly by region and village. The conditions for setting up and management of apiaries with poorly shiny apiaries (Kientega, 2011) would justify this level of prevalence. The level of knowledge of beekeepers varies according to the zone, in connection with insufficient supervision and training (Kaboré, 2017) is at the origin of the variations. Thus, poorly identified sites with low nectar sources will lead to scarcity and weakening of colonies, making them vulnerable to infestation (Leven *et al.*, 2005; Alemayehu *et al.*, 2017; Jack and Ellis, 2018). Apiary management characterized by low frequency of visits or late harvests are also factors that cause butterflies to settle in the hives by the appearance of old and unoccupied combs (Charrière and Imdorf, 2004; Kebede *et al.*, 2015).

Other observations made during the inspection of the hives

During the study of the prevalence of wax moth, the methodology used allowed to note the presence of other pests in the hives such as beetles, ants, mice, termites, etc. Most of these pests had already been reported in various regions of Burkina Faso and in other countries (Sankara *et al.*, 2015; Kientega, 2011; Ahouandjinou *et al.*, 2016). The observed

presence of these predators and the level of prevalence would be due to the conditions favorable to their development, associated with the practices of beekeepers (lack of regular visits, exchange of frames or bars between hives, etc.) which would favor their spread. Also, many beekeepers have not a lot of knowledge for bee diseases (Barry *et al.*, 2018). As for the particular case of the hive beetle, the pest is native to Sub-Saharan Africa where it finds favorable conditions for its development and propagation. Also, our study revealed that the presence of the wax moth in hives creates favorable conditions for the development of certain other pests or other diseases (Boucher, 2016) in case it takes hold first, although the reverse is not excluded. These incidental results would constitute new avenues to investigate regarding to the possible impact of these bee enemies on the production and quality of beehive products.

Risk factors

The study of risk factors through multivariate logistic regression did not identify any risk factors. Our results are different from those of Sohail *et al.* (2017) who took into account meteorological factors. This could be explained by the fact that the variables studied did not constitute risk factors for wax moth infestation of colonies during this study. Indeed, the appearance and development would be the result of meteorological factors and more precisely the temperature (Sohail *et al.*, 2017). Through the calculation of unadjusted Odds ratios, univariate logistic regression showed region and the presence of other parasites as risk factors. This could be explained by the different knowledge of beekeepers and the weakening of colonies by other parasites (Vidal-Naquet, 2012), thus making them susceptible. However, as much as the wax moth may favor their establishment (Boucher, 2016), so much they may create favorable conditions for the establishment of the wax

Conclusion

The prevalence of wax moth is relatively high and associated with the presence of other predators/pests in the study

area. The results show that the conditions necessary for the development of wax moth are present. The level of prevalence suggests an impact on bee colonies and honey production. In perspective, it will be very useful to initiate further investigations over a long period of time and different agro-ecological zones and to evaluate the impact of the infestation on colony life and production. The other bee enemies identified should be study to know their specific prevalence and their impact on wax moth infestation. Already actions of sensitization on the wax moth will have to be initiated with the beekeepers in order to improve the management of their colonies.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS CONTRIBUTIONS

BAK, BC, DLD, IN, AT et AMGB designed the study; BAK and BC collected the data on the field; BAK, BC, DLD and KMD made the statistical analysis and wrote first draft of the manuscript; SP, GMSO, AT and AMGB made observations on the first draft of the manuscript. All the authors contribute to revised the reviewers' corrections.

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