POPULATION DYNAMIC OF VARROA DESTRUCTOR IN THE LOCAL HONEY BEE APIS MELLIFERA INTERMISSA IN ALGERIA.

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ABSTRACT

Population dynamics of Varroa destructor were studied for two years (septembre 2012–2014) in 20 Apis mellifera intermissa colonies located in Blida (center of Algeria). The number of bees, the amount of open brood and capped, daily natural mortality, level of infestation of adult bees and level of infestation of the brood, was monitored.

The brood cycle and behavior of reproduction in Apis mellifera intermissa is set by exceptional and seasonal contrasts in climate: dry summer (June to September), with an almost complete stop brood. Autumn, relatively wet causes a second peak of activity and brood development. The values of the infestation rate of brood and bees show peaks in August, this period when there is the minimum amount of both bees and brood in the colony. In all colonies, the population of Varroa presented during the spring curve of exponential growth, which is explained by the continued presence of brood. In the growth phase, followed by a collapse of populations of mites, which in our experimental conditions, occurred from early summer, along with a weakening of colonies phase. Successive brood cycles allow the population growth of Varroa, while the absence of brood during the summer months has the opposite effect of reducing populations of Varroa. It appears that the level of Varroa infestation in colonies varies according to climatic conditions (seasonal) and internal conditions of each colony. In Mediterranean climates of Algeria, the milder winter climatic conditions and the possibility to collect food resources during a considerable part of the winter count for the permanent brood-rearing activity of honey bee colonies, which is relevant for the intrinsic growth rate of Varroa in these regions.
INTRODUCTION

The mite Varroa destructor (Anderson and Trueman, 2000) is one of the most serious threats to the beekeeping worldwide and in Algeria (Adjlane et al., 2012). The pathogenic action induced by the parasite related to honey bee colony population dynamics. Africanized bees have a degree of tolerance to the mite (De Jong et al., 1984; Camazine, 1986; Moritz and Mautz, 1990; Message and Goncalves, 1995, Vandame 1996; Medina and Martin, 1999; Anderson, 2000). in Africanized bee parasite population dynamics differ from those of European races; therefore, the colonies can survive without treatment (Guzman-Novoa et al., 1999). Different growth of the mite population were also observed between European races, sub-races, ecotypes intra-racial and colonies and between different geographical areas (Ruttner and Hanel, 1992; . Branco et al, 1999).

It is also known that the dynamics of mite populations respond to the climatic conditions and the dynamics of bee populations (Presnce the brood and the number of male brood cells (Garcia Fernandez et al, 1995;).)

The dynamics of mite populations have been studied and modeled for European races of Apis mellifera (Calis et al., 1999). Fries et al (1994) propose a mathematical simulation to construct a model for the dynamics of the mite. This model is structured on the basis of three compartments: the phoretic mite, Varroa of worker brood and males. Calis et al (1999) integrated data to build models and characteristic curves of the evolution of varroa. These data are related to the influence of climatic conditions, the behavioral characteristics of bees against the mite and various control strategies that can perform the beekeeper.

Research work in Algeria on varroa is worn mainly on the hygienic behavior (Adjlane and Haddad, 2013), effectiveness of the products (Loucif-Ayad et al., 2010; Adjlane et al., 2013, Adjlane et al., 2015) and the relationship between the varroa and viruses (Adjlane et al., 2015; Haddad et al., 2015). To our knowledge no studies have been done on the dynamics of populations of mites on race local bee Apis mellifera intermissa. This gap justified this study. To study the population dynamics of Varroa destructor in A. m. intermissa colonies, the development of the infestation levels of adult bees and brood of workers sealed, and the number mites on the bottom board of the hive, were studied in relation to population dynamics bee for a one year period. In addition, calculations of the size of the mite population were made. The research was carried out in a fixed apiary under typical conditions of the Algerian beekeeping
MATERIALS AND METHODS

Place of study
The study was conducted between September 2012 and September 2014 in an apiary located in the Bougara region (Blida). The apiary is made up of 20 colonies characterized by a number frames occupied by bees from September to October.

All colonies were treated before experimenting with Apivar for 6 weeks in order to eliminate varroa and start the test with the same number of varroa in all the colonies. The study area is characterized by:
- An average relative humidity high enough.
- Rather frequent periods of frost.
- A hot summer with temperatures ranging between 18 °C and 41 °C with an average of 29 °C; the spring, there is a variation in temperature between 9 and 31 °C (average of 19 °C); these thermal data is collected by a metrological station in the placed in the site.

DYNAMIC OF POPULATIONS OF VARROA

Estimation of natural mortality of Varroa
To follow the natural mortality of Varroa, hives are equipped with a diaper placed at the bottom of the hive, these diapers are coated with fatty material. Each mixture is protected by a metal grid preventing bees to access these diapers for cleaning. This method is essentially based on the fact that at any time of year, the Varroa die and their bodies necessarily fall to the bottom of the hive where it is possible to find them. The schedule of Varroa mortality surveys was conducted once a week.

Estimation of Varroa infestation rate in the brood
Every 3 weeks, and the entire colony, a sample of 200 cells emerging brood is open, in order to determine the rate of infestation of the brood. It is a method that requires a good knowledge of Varroa and its immature. The brood infestation rate is the parameter that best reflects the degree of infestation of the colony (Garcia - Fernandez et al., 1995; branco et al., 2006; Lee et al., 2010).

The rate of infestation of the brood (A) is determined by the following equation:

$$A \% = \frac{\text{Number of cells infested with Varroa}}{\text{Number of open cells}} \times 100$$

Estimation of populations of Varroa phoretic
Shake the bees in various solutions is an effective way to detect the presence of Varroa in the freshly killed bee samples (De Jong et al., 1982; Mautz et al., 1982; Eischen et al., 1999; Fakhimzadeh 2000). The method involves taking several frames of brood about 100 adult bees and pour into a container that contains alcohol 70 °. After a few seconds when all the bees have died, it is necessary to shake a few minutes all (alcohol +
bees) so that all the Varroa can detach from their host. When all the bees are removed, the Varroa remain at the bottom of the container. Also the account.

From the bee samples, a simple rule of three allows you to see the rate of infestation of bees (B)

\[
B \, (\%) = \frac{\text{Number of Varroa phoretic found}}{\text{Number of bees collected}} \times 100
\]

**Statistical analysis**

All our results presented in all of our studies have been a statistical analysis that includes:
- Descriptive statistics (mean, standard deviation, coefficient of correlation, histogram, graph).
- A statistical analysis by the variance analysis method

**RESULTS**

**Dynamic evolution of populations of bees**

The number of bees and brood cells is estimated periodically and reflects the state of the colony on the day of the estimate. We obtain a graph representing all the colonies throughout the test period (Figure 1 and Figure 2). Analysis of variance showed that the sampling period significantly influences the evolution of open and capped brood, as well as the total population of bees, for cons are not found colonies effect (P statistical test).

![Figure 1](image.png)

**Figure 1. Evolution of the number of bees in the colonies**
We find that the number of bees and brood cells significantly vary from one period to another.

The flowering period from March to May is quite noticeable; it is characterized by a maximum of bee populations and brood frames. In March, there is a maximum of bee populations of 35,000 and 14,000 brood cell. We note also is the brood is present throughout the year in this mediterranean climate with minimal during the month of August (high temperature). This decrease in the summer season can be explained partly by the reduction of nectar resources and thus reduced egg in parallel with the beginning of the summer, and secondly by the probable influence of the varroa this impairment.

![Figure 2. Evolution of the number of cells of capped brood](image)

**Dynamic evolution of populations of Varroa**

Different research on the biology of the mite and diagnostic methods have refined parallel methods for the development of varroa in the colonies, the most interesting is that of systematically and regularly count the Varroa present both in the capped brood on adult bees died naturally and those which are recovered on nappies. The rate of infestation of the brood varies depending on the time of year. The analysis of variance shows a significant influence of the sampling period on The rate of infestation of the brood, for we do not find against the effects of colonies. The average infection rate of brood during the 12-month study was 9.68%. It was 12.65% in September.
Figure 3: Evolution of the infestation of adult bees and brood rates

Figure 4: Evolution of the number of varroa mites phoretic and brood
Figure 5: Evolution of natural mortality of varroa and the total population of varroa

DISCUSSION

The causes of the decline of a colony are often multiple and cannot be reduced to a single pathogen (Fluri et al., 1998). They can be linked (Faucon, 1992) to unfavorable climatic conditions and diseases that can affect bees. In some cases, managers poisoning of a greater or lesser bee mortality and low honey (lower provisions).

In each bee colony, hatch and die every day hundreds see a thousand bees. Changes in the bee population represent a very dynamic phenomenon (Imdorf et al., 1996). The evolution of the settlements is characterized by opposing changes in populations. Increases that have their origin in the number of emerging bees (increase) on the one hand and on the other decreases are based on the number of bees cease to exist.

The number of individuals inhabiting the colony is a direct function of flora conditions, they even dependent on climatic conditions (Sousa et al., 2000; Delaplane et al., 2013). Indeed, in the case of our study, the period of high temperatures that occurred from June limits the pollen resources, which hindered the development of colonies by a non - renewal of young bees. According Peyvel (1994), the brood cycle and reproductive behavior in Apis mellifera intermissa race is set by exceptional and seasonal contrasts in
climate: dry summer (June to September), with a complete shutdown of the brood. Autumn, relatively wet causes a second peak of activity and brood development. It is known that the egg laying is not regular in time, and undergoes changes over time (Imdorf et al., 1996). Therefore, the number of available brood cells is variable, so the ICT varies over time. Regression analysis noted a highly significant negative correlation between ICT and the number of cells of capped brood: the higher the number of brood cells fall off, plus the relative brood infestation increases (P <0.05). Knowing the the rate of infestation of the brood and the number of closed brood cells for each colony throughout the trial period, we were able to trace the evolution of the number of Varroa in the brood. Statistical analysis revealed a non-significant difference between the colonies to the evolution of populations of Varroa in the brood, while highly significant differences are recorded from one period to another. The number of Varroa brood in colonies varies over time from one month to another. We recorded a maximum population of Varroa in June. It corresponds to 2800 varroa per colony. Throughout the flowering period, the population of Varroa stabilized at an average of 2500 varroa per colony. From June, we noted a significant drop in the number of Varroa in the brood, the average population increased from 2800 Varroa in early June 1200 in the month of August Varroa.

One cause of this fall would be the drastic reduction of capped brood during the summer period. Robaux and Nolet (1985) point out that, in heavily infested colonies, capped brood decreased comparatively much faster than the open brood. They explain this drop that bees abandon the old and heavily infested brood firstly, and secondly the brood perished due to cooling caused by a reduction in the strength of the colony.

According to two independent studies, the production of the brood and the bee population were compared between colonies infested with Varroa or not (Downey and Winston, 2001; Maurilhas, 2002). The results state that the colonies infested with Varroa were less brood and bees.

The beginning of summer is the end of honey and especially with the arrival of hot weather which exert an inhibitory action on the laying of the queen, which resulted in a significant decrease in populations of Varroa during this period of year. Changes in Varroa populations depend primarily on the importance of the brood. Many authors report that climate effects on production brood significant influence on the growth of populations of Varroa brood (De Jong et al, 1984; Garcia and Wilson, 1994b; Kraus and Re page 1995).

According to the analysis of variance, the rate of infestation of adult bees varies only slightly from one colony to another, for against a highly significant influence is approved between sampling periods (p<0.01). For the different colonies, the average infestation rates of adult bees in early spring is 28.5%. Then there is a drop in the rate until end December with a percentage of 5%. From January, there has been a steady increase in the rate of infection where there is a percentage of 26.5%.
Given the results, the population of Varroa phoretic shows a significant change from one period to another. The average levels during the period from November to April are below 2000 varroa per colony. The maximum populations of Varroa is recorded during the summer when there is respectively 2200 and 2350 varroa during the months of July and August.

Vandame (1996) shows that the maximum of Varroa phoretic occurs at the time when the hives are most supplied brood (spring). The same author speculated that the Varroa females are subjected to a compromise between the phoresy in order to spread and infestation of the brood in the breeding goal. According to still this study Vandame (1996) recorded an average proportion of Varroa phoretic 22%. In autumn, the percentage of Varroa phoretic varies from 5 to 10%. In spring and summer, the proportion of Varroa phoretic vary from 30 to 40%.

In the Mediterranean climate of California, the population of Varroa-infested colonies increases 286 times a year (Kraus and Page Jr, 1995). According Branco et al (1999), the rapid growth of the parasite population is not due to a high rate of reproduction, but the possibility of Varroa reproduce continuously in the brood that is present most of the year. However in temperate climates, the reproduction of Varroa pauses during periods when there is no brood. Kraus and Page Jr (1995) report that in the Mediterranean climate, the rapid growth of populations of Varroa requires beekeepers to process 2 times with an effective method, while in cold or temperate autumn one treatment is enough.

Our results are completely different from the dynamics of populations of Varroa in temperate climate where harsh winter causes a decrease in winter the mite population. Maximum development Varroa and bees takes place in July and August (Robaux and Nolet, 1985).

The outbreak of a disease on the number of infectious agents and the intensity with which they occur. According to these authors, the condition of a colony results from an imbalance between firstly the vitality and resistance to infection of the colony, and secondly, the activity and the pressure of infection exerted by the pathogen. The damage caused by Varroa to bee are directly related to the level of Varroa infestation in colonies (Moretto and Mello, 2000). In fact, it's much the Varroa density than its absolute number that affects the colony. For his part, Faucon (1992) reports that the pathogenic action of the mite is related to the life cycle of the colony. Still according to the same author, the pathogenic action of Varroa is directly related to the proportion of the number of Varroa in relation to the number of bees in the colony, and the symptoms get worse when the bee population decline, while that of Varroa remain constant or continue to grow.
The average change in the mortality of the mite according to analysis of variance differs only slightly from one colony to another throughout the trial period. For cons, the same analysis shows a significant variation in the evolution of Varroa in mortality by periods.

Therefore, a correlation is sought between natural mortality on one hand, and also the total population of Varroa ($R = 0.47$). Despite this obvious correlation between the two tests, analysis of variance shows that this correlation coefficient is not significant statistically ($p > 0.05$).

Other voices were many to assert that there was no correlation between natural mortality and the total population of varroa (Rademacher, 1985; Garcia-Fernandez et al., 1995; Guzmán-Novoa et al., 2010; Frey et al., 2011).

**CONCLUSION**

The evolution of bee populations in the colonies is characterized by a maximum development of colonies in spring, just after the period and under the influence of various factors (adverse weather conditions, reduced nectar resources, increased pest pressure), there is a general weakening of the colonies. Furthermore, the review of our results of population dynamics of Varroa has shown that it is in the spring that the population is at its peak.

In all the colonies, the population of Varroa presented during the spring exponential growth curve, which reflects the continued presence of brood. In the growth phase, followed by a phase of collapse of populations of the mite, which in our experimental conditions, occurred from the beginning of summer, along with a weakening of the colonies. The successive brood cycles allow the increase of the population of Varroa, while the absence of brood during the summer months have the opposite effect of reducing populations of Varroa.

**RÉFERENCES**


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