Environmental Effects On VARROA POPULATIONS

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Introduction

Almost all beekeepers rely on acaricides such as Apistan® (fluvalinate) or CheckMite™ (coumaphos) to control *Varroa* mites in colonies of honey bees. Most apply chemicals in the early Spring before the main honey flow or in the Autumn after harvesting the honey crop to avoid contamination of honey. Although acaricides initially provide adequate control of *Varroa* mites, beekeepers should refrain from regimented and indiscriminate use of chemicals in their colonies because chronic use of an acaricide over time leads to the development of acaricide-resistant mites. Some populations of *Varroa* mites in the U.S. are now resistant to fluvalinate, coumaphos or amitraz (Elzen et al. 1998, Elzen et al. 1999, Elzen and Westervelt 2002). Acaricides may also contaminate wax and honey (Wallner 1999).

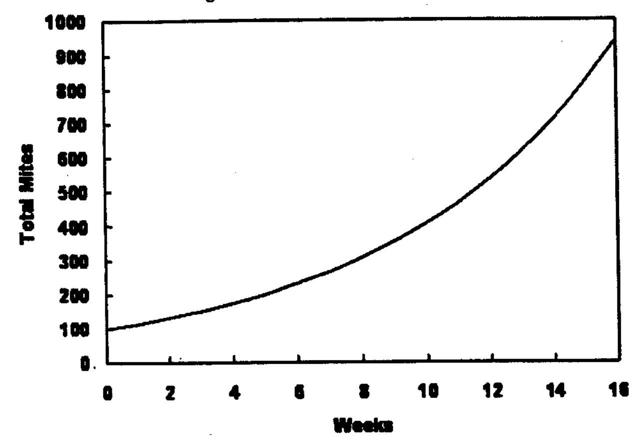
Use of non-chemical controls for *Varroa* mites circumvents or delays the problems of acaricide-resistant mites and chemical residues in wax and honey. Non-chemical controls for *Varroa* mites include use of *Varroa* -resistant honey bees, mite trapping by removal of capped drone brood, screened floors, and sticky traps. These techniques are important components of integrated pest management (IPM). IPM for a beekeeper begins with an understanding that absolute control of *Varroa* mite populations is probably unattainable. Honey bees tolerate low-level infestations without significant economic loss to the beekeeper. Beekeepers practicing IPM manage *Varroa* mite populations with non-chemical methods that slow mite population growth and increase the time to reach a critical or economic threshold when acaricides are needed. The economic threshold is the maximum population of *Varroa* mites below which does not significantly harm a colony, and growth of the mite population beyond the threshold likely results in significant injury to the bees and economic loss to the beekeeper (Delaplane and Hood 1999).

Two important features of IPM are (1) sampling colonies of honey bees to estimate the size of the *Varroa* mite populations, and (2) projecting how large the population of *Varroa* mites will likely grow from the point of sampling to the end of the brood-rearing season. This article summarizes information about growth of *Varroa* mite populations over a 10-year period in Louisiana that we recently published in a scientific journal (Harris et al., 2003). We showed that growth of mite populations varied significantly among years during 1993-2002. The lowest growth rates occurred during periods of hot and dry weather. Beekeepers may have saved treatment costs by monitoring mite populations and not treating colonies during these years.

Growth of Varroa Mite Populations

Populations of *Varroa* mites grow exponentially, at least in the early stages of infestation. A population grows exponentially when its increase is proportional to what is already there. For example, the mite population in a colony of bees can grow from 10 mites to 23 mites during six weeks in Louisiana. If the same colony had begun with 100 mites, the resulting mite population would be 232 mites after six weeks. Similarly, if the colony had begun with 500 mites, the total mite population would be 1,158 mites after six weeks. Although the final mite populations differ in these three scenarios, the growth rate of the mite populations is the same in all three cases.

Figure *1 – A typical growth curve for* Varroa *mite populations during Spring-Summer in Baton Rouge, LA (initial mite population = 100 mites). The curve represents the same exponential growth rate (r=0.140 week^{-1}) that was calculated for the three case scenarios given in the text.*



The growth rate is the net difference between the average birth and death rates for a population. The birth and death rates for *Varroa* mites are probably relatively constant if the host colony of bees is strong and healthy and brood-rearing continues without breaks during the beekeeping season. The birth rate is determined by (a) the average number of mature daughters per mother mite per unit time, and (b) the average percentage of female mites that successfully reproduce per unit time. The death rate includes separate mortality rates per unit time for adult female mites when they live in brood cells and when they live on adult bees.

Various factors influence the birth and death rates for *Varroa* mites. *Varroa* mites only reproduce in capped brood cells; hence, the birth rate is zero during periods when colonies do not raise brood. Birth rates are higher for mites that reproduce in drone cells than for

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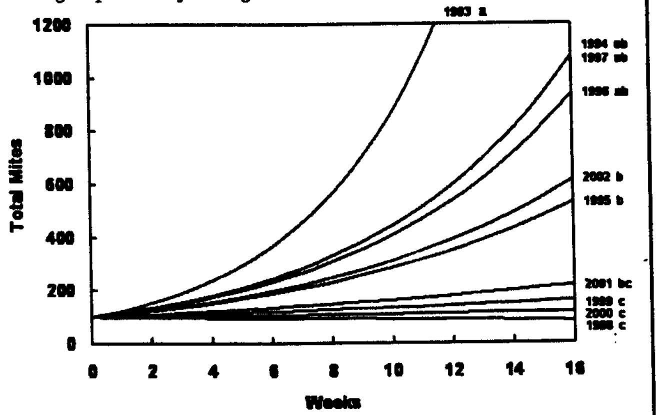
those in worker cells. The reason is that the capped period for drones (14.5 days) is two days longer than the capped period of workers (12.5 days). The longer capped period of drones permits one or two more daughter mites to mature in drone cells when compared to worker cells. Hygienic cleaning of infested brood cells interrupts mite reproduction and increases mortality of immature and perhaps mature mites, and both effects lower the birth rate (Wilkinson et al. 2001). Death rates could be increased by grooming behavior of honey bees that bite and kill *Varroa* mites, but most European races of honey bees do not show effective grooming rates (Wilkinson et al. 2001). Environmental factors also influence the birth and death rates for *Varroa* mites (see below).

In a typical year in Louisiana, mite populations increase seven to 10-fold in 16 weeks when bees are actively rearing brood (Fig 1). The slope of this growth curve is the exponential growth rate (*r*). Steep curves reflect high growth rates, while shallow curves indicate low growth rates. A growth rate is negative if the death rate exceeds the birth rate. Growth rates can be measured by estimating populations of *Varroa* mites at least two different times during the beekeeping season. The following equation, made famous by Thomas Malthus in 1798, can be used to estimate the exponential growth rate (*r*) of *Varroa* mite populations:

Figure 2 – Growth of Varroa *mite populations over a 10-year period (standardized to an initial mite population = 100 mites). Years with the same letter(s) are not statistically different (a = 0.05). The three lowest growth rates (1998-2000) occurred during a period of drought in Lousiana.*



(final mite population) = (initial mite population) ' e^rt^

where *r* is the growth rate, *t* is duration of the period (weeks), and *e* is the base of the natural logarithm (***e*** = 2.71828). The mite populations from any of the previous scenarios can be used as an example of estimating a growth rate (*r*). The growth rate in the third case would be calculated by rearranging the equation, taking the natural logarithm of both sides and solving for *r*.

r = [natural log (1,158 mites ÷ 500 mites)] ÷ 6 weeks

r = 0.140 per week

Exponential growth rates for *Varroa* mites have been reported in the range of *r* = 0.108 - 0.236 per week (Harris et al., 2003).

Estimation of the exponential growth rate (*r*) can be a useful method for predicting mite populations. However, no population of animals grows exponentially for an indefinite period. If left unchecked, most populations reach a point where increased competition for resources (e.g. food and shelter) and stresses related to overcrowding reduce the average birth rate or increase the average death rate (or both). Thus, the exponential growth equation cannot adequately predict the growth of *Varroa* mite populations for long periods (e.g. 1-2 years). However, it provides reasonable approximations for the growth of mite populations from a few hundred to a few thousand mites over a 4-6 month period during the active brood rearing seasons.

Growth Rates for *Varroa* Mites in Louisiana

We monitored populations of *Varroa* mites in 11-29 colonies of bees in short field trials during each year of the study (1993-2002). Queens used in all tests were purchased or donated from 40 different sources. None of the queens had been bred for resistance to *Varroa* mites. Starting with mite populations of < 900 mites and allowing growth for short periods kept mite populations low enough that the exponential growth equation provided reasonable approximations of the growth rate. We used combs with only worker-sized cells and did not permit colonies to raise drones. Restricting mite reproduction to worker cells simplified the estimate of growth rates because we did not need to measure separate rates for mites reproducing in worker and drone cells.

Uniform colonies with ca. 1 kilogram of bees were established in each apiary in late Spring (April - June) by subdividing a large package of bees (65-70 lbs) (Harbo and Harris 1999, see also http://msa.ars.usda.gov/la/btn/hbb/jwh/SMRD/SMRD.htm). All colonies in a test were located in one apiary, and one to three tests were conducted each year. Estimates of initial and final mite populations and the growth rate were made for a total of 194 colonies during the study. Each estimate of the total mite population was the sum of the numbers of mites living in capped worker brood and mites on adult bees. The growth rates were averaged over each year, and the average growth rates were statistically different among some years (Fig 2). The highest growth rate occurred in 1993, which was the first full season in which *Varroa* mites were known in Baton Rouge. The lowest growth rates occurred 1998-2001.

The growth of mite populations were not significantly correlated to growth of the bee population during the test, capped brood area measured at the end of a test, or to the duration of the test, which varied from 9 to 19 weeks. Extremely low growth rates for *Varroa* mites were related to weather conditions. A significant drought occurred in 1998-2000, which coincided with the years having the lowest growth rates. We examined various climate variables (temperature, relative humidity and rainfall) for each day during an experiment to see if any variable correlated to the growth rate. The average growth rates for *Varroa* mites were not correlated to average daily rainfall during the test periods.

Growth rates were correlated to ambient temperature and relative humidity. For example, growth rates were lowest during years with more hot days during experiments. A hot day was defined as one with the maximum ambient air temperature > 35 °C (95 °F). Each of the three years with the lowest growth rates had 30-40 % hot days during experiments. The highest growth rates occurred during 5 years in which only 0-10 % of the days in field trials were hot days. Because hotter days tend to have lower water vapor content in the air, low growth rates for *Varroa* mites were correlated to lower average relative humidities.

We suspect that the average birth or death rates for populations of *Varroa* mites were affected by temperature and relative humidity. Perhaps honey bees could not thermoregulate their nests properly during the drought, allowing the broodnest to become warmer and less humid than normal. We cannot be sure because we did not monitor environmental conditions within the broodnest. Other studies report effects of temperature and relative humidity on the birth and death rates for *Varroa* mites inside brood cells kept under controlled conditions. The percentage of *Varroa* mites that successfully reproduce is reduced at temperatures higher than the typical broodnest temperature for honey bees (Le Conte et al. 1990, Kraus et al. 1998). *Varroa* mites stop reproducing if the relative humidity is held below 40% RH or above 80% RH (Le Conte et al. 1990, Kraus and Velthuis 1997). Adult and immature *Varroa* mites begin to die if the broodnest temperature exceeds 38°C (Le Conte et al. 1990). The effects of temperature and relative humidity on reproduction and mortality of *Varroa* mites probably relate to desiccation (water loss) of *Varroa* mites under different conditions (Bruce et al. 1997).

What does variable growth of *Varroa* mite populations mean for beekeepers?

The important conclusion is that environmental factors influenced the growth of *Varroa* mite populations. Growth rates for *Varroa* mites may differ between months within the same season, years in which the weather conditions dramatically depart from the normal climate conditions, or even between colonies when some in the same apiary are placed in full sun exposure and others are in total shade. There may be many situations in which growth rates are so low that chemical treatments are not needed to control mite populations.

Find A Sampling Method Find A Threshold *Sample, Sample, Sample*

We encourage all beekeepers to sample their colonies and use non-chemical control methods against *Varroa* mites. A good starting point would be to choose one sampling method and use a threshold population that has been determined for a region with a climate similar to where the beekeeper lives. If no such benchmark is available, consider using the economic threshold determined for the southeastern U.S. by Delaplane and Hood (1999). They suggest that colonies with 25,000 - 34,000 bees need to be treated if the mite population reaches 3,172 - 4,261 mites by August in Georgia and surrounding areas. If colonies have mite populations well below this level in August, they do not need to be treated until the following Spring. For more information, Goodwin and Eaton (2001) provide an extensive guide for beekeepers that describes various methods used to sample colonies for *Varroa* mites and guidelines for making decisions of when to treat colonies with acaricides.

Conclusion

In this article, we summarized information about the growth of *Varroa* mite populations over a 10-year period in Louisiana. Growth of *Varroa* mite populations was greatly influenced by weather conditions. There were three to four years during the decade in which the growth rate for *Varroa* mites was slow enough that damaging population levels were probably never reached during the Spring-Summer months (assuming that mite populations in the Spring were low and only worker brood was available to the mites). Excessive cost and exposure of colonies to acaricides could have been avoided in those years if beekeepers had monitored the actual pest population and treated only when necessary. BC

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