Research 3.3 Varroa

A.Varroa Discussion history

ZEST hives (August 2014) were seen to be functionally free of varroa, being not present in the hive debris. The following text was written prior to this being known, but is repeated here unchanged as a record of previous speculation, but Section D has been added which attempts to explain why the unintended consequence of the ZEST hive is its freedom from varroa.

Bees have a natural inclination to clean a hive of any extraneous matter, undesirable pests and parasites. Varroa mites are recovered from hive debris that appears to have suffered damage such as a dented carapace that could only have been caused by the bees.

If any animal's environment is difficult in some way (such as cold and/or damp habitat) it is unlikely that it attends to its cleaning duties as well as it might. Humans living in a house with walls running with water, draughts and is cold are less likely to be bothered than with a house with central heating that is in sound condition. Rats may even be accepted by humans as a comparatively minor problem as varroa may be, by bees, in their environmentally unfriendly hives.

It is a certainty that a healthy hive environment will allow the bees to spend more time and effort in destroying varroa. The only question is to what degree this takes place.

The Varroa mite originated in the Asian honeybee Apis Cerana. It was only located on the eastern side of the Himalayan Mountains, which had formed a barrier to its expansion. Man's activities moved it into the much more productive western honeybee (Apis Mellifera) where there was no natural resistance to Varroa's exponential expansion in numbers. This was alleged to be caused by the longer pupation period of the western honeybee, which allowed the Varroa mite an extended maturation period in the pupating cell. It was assumed that the Asian honey bee had evolved a 2 day shorter pupation period to achieve stasis in varroa numbers.

Drones have a longer pupation period than workers or queens in both species so the varroa mite naturally prefers (by 10 or 12 times) to lay eggs in the drone cells of both species. Despite this preference it was not just the drones in Apis Cerana that had apparently evolved a shorter pupation period, but the whole genus, which points away from the evolution of an evolved reduced pupation period. The honeybee grub/pupa gestation period appears to vary upon ambient and brood nest temperatures rather than to have evolved to be shorter.

We have also been forcing honey bees to draw out their honeycomb from wax foundation which has cells embossed on it at 5.4mm. This is an unnatural worker sized cell which would normally be an average of 4.9mm. When the bees are determined to make drone cells they override the 5.4mm, increasing it yet further to contain drones. It seems that the egg to hatch period is extended by both ambient temperature and cell size. The smaller the cell the quicker it is to hatch. In high temperature conditions, queen cells can hatch in 14 rather than 16 or 17 days and

so it must be with workers and drones, reducing the Varroa's time to mature in the cells.
If hotter conditions and smaller cells encourage shorter egg to hatch periods in honeybees then it is logical that colder conditions and larger cells will do the opposite. This would give the Varroa an advantage that it was formally unaccustomed to and may explain why the spring is particularly prone to seeing Varroa in large numbers after a winter of perhaps longer pupation periods in worker cells.
The way forward in suppressing varroa would appear not to be breeding a hygienic bee, but warmer hives and natural (smaller cell size) comb. No parasite host has ever managed to rid itself of its parasites by evolving.

In discussion with Tony Wright and Roy Pink working on the ZEST hive concept in North Devon it was agreed that they would independently test the concept of the ZEST insulated hive and compare it with a ZEST insulated and heated version. This took place during the 2010 season.

As a result of this experiment we began discussing some circumstantial evidence that points to a possible new understanding of the varroa/bee life cycle and which may lead to a technical method of both disrupting the varroa life cycle while giving the more obvious advantages to bees of a heated (and dry) environment.

If an alien species is moved into an environment it is unlikely to live in stasis with it. It will either expand or contract (and die out, but we do not hear of these). Examples of expanding species are the rabbit, cane toad and indeed British humanity in Australia. The absence of natural negative influences on those creatures in the new environment allowed them to survive, thrive and even to play better cricket.

And so it may be with the varroa mite.

The conventional wisdom regarding the varroa's success in colonising Apis Mellifera is that the egg/hatch period of the Mellifera drone was 2 days longer than in Asian bee, upon which the mite originated. Asian bee drones had apparently evolved to live in stasis with the varroa mite by reducing its egg/hatch period by 2 days. The theory went on to say that the 2 extra days of Apis Mellifera gave the mite the edge so that a rising population of mites became the norm on Apis Mellifera. So far so good, but now consider these facts as well:

1. The short period of very hot weather of 2010 disrupted 2 queen breeders in North Dorset where bred queen cells had all hatched at 13 days. One of these breeders was the author.

2. African bees are able to live with varroa. (See "Just a Mite" on Page 86 of the Beekeepers Quarterly issue June 2010).

3. Bees in Asia can apparently live with varroa due to an evolved reduced pupation period of the drone in which its eggs are laid, but the reduced period occurs in the queen and workers as well. Why should this be?

4. There is a bee keeper who lives in Toulouse that claims to have honeybees immune to varroa and sells them out as such.

5. There remain feral colonies in (often, but not always centrally heated) house roofs that show no signs of succumbing to varroa.

6. The three Mediterranean countries of Spain, Italy and Greece now have a rising honey bee population while the countries north of there have a declining one.

The common feature of these six locations is hot, hot, hot, hot, hot and hot.

Small overwintered nukes were found to be entirely free of the varroa marker of deformed wing virus, perhaps because they could not sustain any brood throughout the winter. The varroa may have died of old age before they could reproduce.

It may be that very cold and very hot are not good for varroa but for different reasons. The first may be, because there is no brood and the latter because the bee's pupation period is reduced in very hot conditions.

We may have a perfect climate for varroa in Northern Europe. Perhaps heating even in the summer is the way forward for varroa control in summer. Heating in summer would move the colony south into an African climate where varroa does not overwhelm the colonies.

Both the cold and heated ZEST hives have not, so far, exhibited any presence of Nosema and after 8 years of testing remains so. The test has only been in small numbers so far. Time and numbers will prove it or not.

If the egg lay to hatch period is indeed reduced from the accepted norm in very hot ambient conditions in all bee species then it is likely that a cold winter ambient temperature will increase that period. An extended pupation period of say 2 days longer for pupation than the norm during cold ambient temperatures would give the varroa mite an opportunity for exponential growth in its numbers throughout the winter. They are certainly seen in larger numbers in the spring than in the autumn. This can be put down to being fewer bees to see the mites on in the spring, but this may not be the whole story.

Perhaps the Asian bee's 2 day shorter pupation period for the queen, drone and worker may be due not to evolution, but the higher temperature in Asian countries which speeds the bee breeding cycle, enabling it to live in stasis with the varroa mite.

It was discovered during 2011 that while the winter heated hive did better than the unheated ones the varroa mite count was also raised. This does not negate the theory that varroa are ambient temperature sensitive for the reasons stated. The raised temperature of the heated hive may have been not high enough or consistent enough.

B.The Search for a Varroa Attractant

This is notable in the U.K. for its absence. The American Agricultural Ministry has done some work which appears to support the possibility of a trap method for varroa. They claim to have found 2 chemicals that the mite is attracted to and have made a trap they claim that works. If true this is good news. They are not at present keen to tell anyone what these chemicals are until patents are in place, but if it does work as intended we will have a treatment that is entirely acceptable to all of us. A varroa attractor in a trap rather than a poison has a lot of style.

With money becoming available in the UK for bee disease research little thought appears to have been given to the prospect of making a varroa trap upon similar lines to a cockroach trap, which uses an attractant. The advantage of an attractant to trap the varroa mite (rather than a varroaicide) is that it is a harmless to bees and their products. The mite cannot develop immunity to an attractant without modifying its behaviour to become harmless..........i.e. by not being attracted.

Ross Conrad in his book "Natural Beekeeping" published in 2007 by the "Chelsea Green Publishing" in Vermont tells us that Methyl Palmitate is the Varroa pheromone and it Googles as such. He did not have a viable trap and gave up on the idea after he suggested in humour that he should patent it. Methyl Palmitate may yet have its day with a viable trap. Assuming that a trap can be found that works the task becomes finding and proving an attractant. There are substances other than Methyl Palmitate that have possibilities.

Peanut butter may work, but a successful attractant (if not varroa pheromone) is more likely to be based upon the chemical difference between a worker and drone grub immediately prior to sealing. It is known that the varroa mite has a 10-12 times greater propensity to lay its eggs in a drone cell than a worker. All creatures have a sense of taste/smell and the varroa mite is likely to use this to find the drone grubs to lay eggs in its cell. It has evolved to do so, because the drone is sealed for 2 days longer than the worker and this increased drone pupation period allows the varroa to gain a reproductive advantage, increasing its numbers more up to the point (and beyond) of collapsing the colony. The Asian bee, from where the varroa mite originated, has allegedly evolved to reduce its drone pupation period by two days and can therefore live in stasis with it.

So what is the chemical difference of a drone grub from a worker grub that the varroa mother finds so attractive and can the difference be determined with the use of Gas Chromatography chemical analysis with a view to making the chemical difference for use as an attractant. Has it already been done?

If you Google the following key words........ larval food / Varroa Destructor / cell invasion / semiochemical the second item on the Google page is worth a read. It does seem as though larval food is an attractant to varroa,

If varroa destructor is attracted to larval food and has a 10-12 times propensity to lay eggs in a drone cell it is reasonable to postulate that larval food (Royal Jelly) is greater in a drone grub than a worker.

If true this goes against the received wisdom that the drones are fed larval food for the same period as the workers before moving to a mixture of pollen and honey. There is a persuasive symmetry where both the queen and drone are fed only on royal jelly. It may be that the worker is the odd one out by being fed pollen and honey when still a larva.

If true, this would also explain why the varroa mite overwhelmingly prefers to travel on nurse bees which produce the royal jelly. They are meals on wheels.

The chemical difference of drone and worker larval food is likely to be seminal to making an effective chemical attractant for varroa. The best I could find on the matter was in a book by Mark L. Winston called The Biology of the Honey Bee on Pages 61 and 62 which gives a list of the chemicals in drone food, any of which may be the attractant to the varroa mite. Conversely any chemicals in the worker larva that are not in the drone may be a repellent to them. I quote from Mr. Winstons book (page 62) as follows:

The older drone larva receives more diverse proteins than the worker larvae. *Food of older drone larvae contains more carbohydrates, riboflavin and folic acid and less thianin, biotin, pantothenic acid, choline, pyridoxine, protein, fat, ash and niacin. These may form the basis for an essence of drone varroa attractant.*

C.The Varroa life cycle.

The received wisdom is that the varroa mite lives for about 27 days, but can live much longer (up to 5 months or even a year) in the winter for (presumably) the purpose of carrying it through the winter. This longer period is suspicious and is hard to prove. Were all varroa marked in some way and then found 5 months later? Furthermore the varroa mite evolved in a hotter Asian climate where brood is always present. How did the mite suddenly gain the ability to live for many months (5 times longer) when it came here where brood may not be present all year?


Roy Pink in smug mode with 4kgs.honey.

Roy found the following by Jeanne Pierre Chapleau dated March 2002 (revised March 2003) and which supports our own theories on the matter regarding ambient temperature and its effect on varroa breeding success.

The important difference in the global results obtained in 2000 (29.2% more varroa mites) and 2001 (37% less varroa mites) for sub group AV suggest a confirmation of the negative thermal influence assumed in the 2000 trials. In 2000, all of the anti-varroa bottom boards were operated with the bottom opened while in 2001, with the exception of the YBO group, the bottom boards were operated with the bottom *closed. To our knowledge, this is the only operational factor that was systematically different between the 2000 and 2001 trials. The results strongly suggest a connection between this factor and the negative results obtained with the use of anti-varroa bottom boards during the 2000 trials. We can legitimately assume that the brood cluster temperature was lowered with the use of the opened anti-varroa bottom board. Numerous references can be found in scientific literature confirming that lower temperature conditions enhance the development of varroa populations. Ingemar Fries (12) states: "(…) mite population seems to grow faster in cooler climates than in warmer areas (…) it has been suggested that climatic factors are decisive in determining the mite population growth although the mechanism remains unclear." We can believe that a longer period of time in the capped brood stage resulting from a lower temperature favours an increase in the reproductive rate of the varroa mite's population. An increase of time in the capped brood stage enables the young female varroa mites to reach maturity before the bee emerges from its cell. Kraus and Velthuis (14) found that artificially reducing the brood temperature of colonies had the effect of doubling the mite population in comparison with control groups. Their laboratory tests allowed them to determine that 33 C was the optimal temperature for varroa mite reproduction. Kraus and Velthuis (14) suggest that beekeepers adopt practices that aid colonies in maintaining brood temperature at 35 C. The results obtained by Kraus and Velthuis were not available when planning for the 2000 trials as they were published in October of the same year. Reference to the influence of temperature on the rhythm of natural varroa drop can also be found in recent scientific literature. Thomas C. Webster (4) found that this drop is correlated to the average outdoor daytime temperature. J.T. Ambrose (13) also found (2001) that when infested adult bees were exposed to variable temperatures in laboratory conditions, the percentage of varroa mites falling from the bees increased with the elevation of the ambient temperature. Here again we can deduce that the brood chamber temperature should not be lowered.*

It is already well known that Varroa are seen in greater numbers in strong colonies. This is counter intuitive, but may have its cause in the wintering of large colonies which have the ability to maintain brood through-out the year and for which the mites are profoundly grateful.

Perhaps a large colony in winter has enough bees to maintain a temperature high enough to maintain some brood, which not only sustains the varroa life cycle, but allows them to thrive with an increased pupation period, caused by the colder ambient temperature.

Experience with overwintered nukes being free of varroa is that they may have been cold enough for long enough to not be able to sustain any brood which disrupts the varroa reproduction cycle. This can only apply as long as the varroa cannot live for 5 months as an adult to carry it over a brood less period.

Very hot ambient temperatures are also disruptive to the varroa reproduction cycle, due to a shortened pupation period of bees.

A big colony that keeps brood through the winter assists the varroa reproduction cycle because there is brood, but the cold extends the pupation period. This allows more mites to mature and hatch which explains the increase in the numbers of varroa in such a colony.

The "27 days or many months" can therefore reasonably be queried. Perhaps they only live for 27 days under all conditions, but this could only be proven by taking out brood for a month in winter and seeing if varroa are still present at the end of it.

D. Varroa and the ZEST hive

The ZEST and varroa remains a moving feast. The former is functionally free of the latter, but knowing the cause of the effect needs to be explained by the deployment of comparative data loggers the results of which are shown in the Research Chapter **3.1. Traditional and ZEST Hive environments**

In traditional hives strong hives have more varroa than weak ones and are more numerous in the spring. This may be caused by prolific queens in strong colonies continuing to breed through winter when the temperature is low, but the pupation period is extended. Weaker colonies shut down breeding in winter and therefore the opportunities for varroa to breed are reduced.

The varroa breeding place of choice is alleged to be in drone cells which naturally (apparently) take longer to pupate. At least some of this extended pupation period may be not because it is a drone, but because drones are often positioned at the bottoms of and on the outside of frames where the temperature is lower.

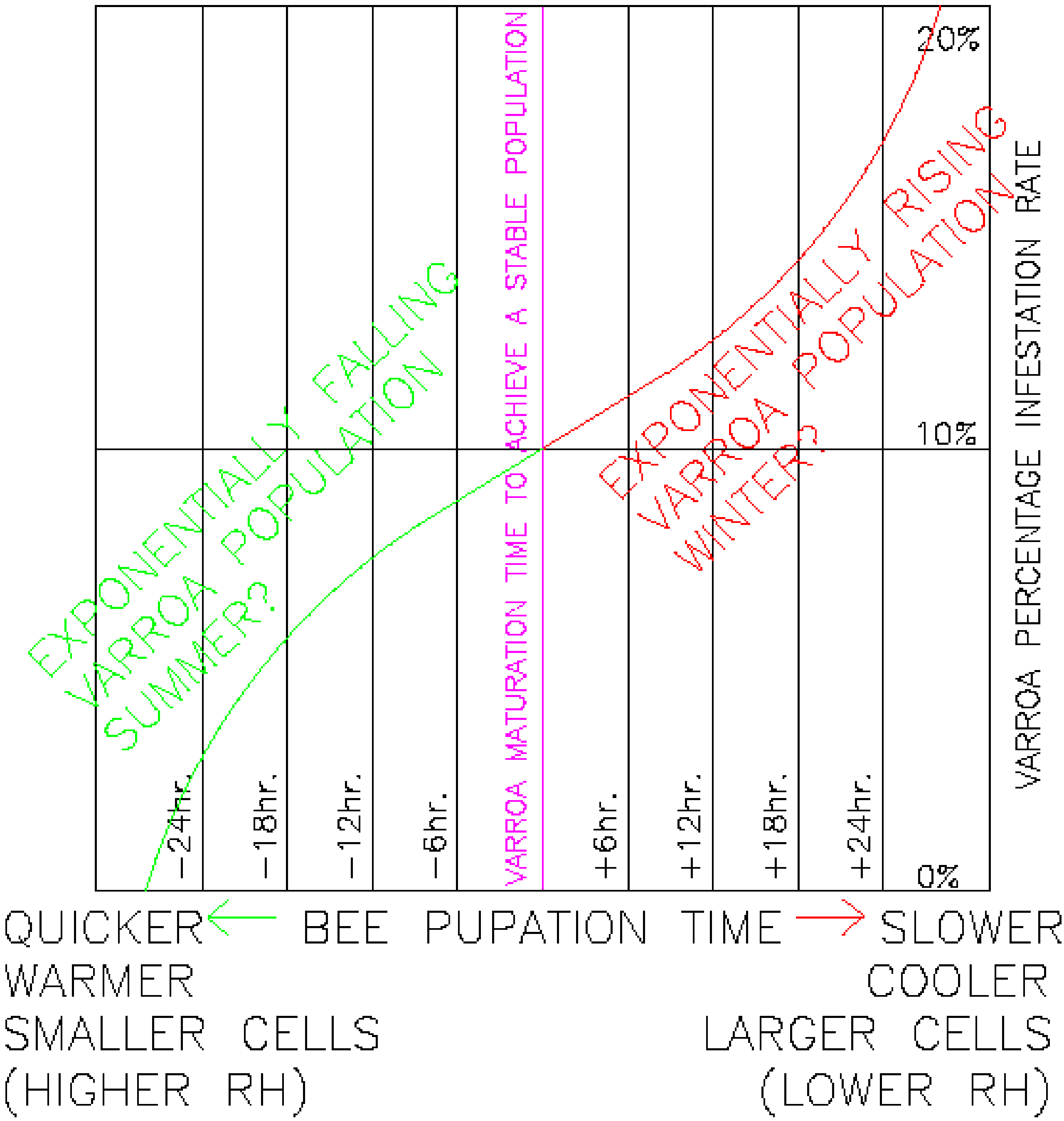
The story behind the varroa free ZEST hive debris lies at the end of a sequence of events that commenced in August 2012. Judy Challoner (a new ZEST beekeeper in Stalbridge, Dorset) preferred to not treat against bee maladies until essential and proven. When cautioned that she needed to treat against varroa she confirmed that there was no varroa in the floor debris of her ZEST. In August 2013 Judy repeated that she could still find no varroa in the floor debris. Still less than totally believing the author then had the opportunity to make an artificial swarm for Sue and Stuart Ferguson in their ZEST hive on Gold Hill in Shaftsbury. As the manipulations were carried out the hive floor debris was collected to show them some varroa, but none could be found. Their ZEST had also not been treated. Until that time the author had continued to treat his own hives against varroa with Thymol crystal filled tea bags which seemed to be working very well indeed. It would appear that varroa could not survive the ZEST natural environment anyway.

In the spring of 2015 Dave Durrant carried out a live varroa count on his 9 hives using the shook icing sugar method. No Varroa were found in the 8 strongest hives and a few in the 9th weakest one.

After a long consistently cold winter and in the late spring of 2016 a few varroa could be found in most ZEST hives, but quickly disappeared in the late spring and summer as the ZEST hive environment appeared to assert its authority with a reduction in varroa.

Hive debris from a ZEST hive shows no fallen varroa

THE ZEST VARROA EXTINCTION/SURVIVAL DIAGRAM



Above 37 deg. the pupa die.
35 deg. 10-11 days as pupa.(summer?) 96-98% surviving
31 deg. 14-15 days as pupa.(winter?) 89-100% surviving.
Below 29 deg. the pupa die.
Therefore winter is varroa breeding heaven due to more pupation time for varroa to mature.
Google:- "Synaptic organisation in the adult bee brain is influenced by brood temperature control during pupal development" and view table 1.

The ZEST extinction/survival diagram is a best guess why the ZEST hive is functionally varroa free. It needs to be considered with the data logger information in **Chapter 3.1 Traditional and ZEST Hive Environments,** gathered over spring and winter 2017 from a traditional wood and a ZEST hive. Both had their temperature, and relative humidity data logged in the brood centre and compared with a data logger of ambient condition.

The varroa mite's exponential growth in numbers in any honeybee colony is determined by the time it has in the bee's pupating cells to itself mature. A sufficient reduction in bee pupation time in winter will reduce varroa's prospects to one of continuous exponential decline. This seems to have happened in a ZEST environment which is warm and more easily thermo-regulated by the bees. Its relative humidity is also higher.

The honeycomb in the ZEST hive is naturally drawn out as in the wild, but on a plastic, wood or bamboo lattice frame. This natural cell size averages about 4.9mm whereas the wax foundation sheets generally used in traditional hives is 5.4mm. This naturally smaller cell is likely to reduce the bee's pupation period in an animal world where smaller usually means quicker.

The ZEST hive is warm and dry due to its insulation, thermal mass and top bee entry/ventilation and is more easily thermo-regulated by the bees to an ideal 35 degrees. This is likely to speed the biological process, again reducing the pupation period of the bees.

This understanding, if correct, explains why varroa is seen in large numbers in the spring after a winter in which a longer bee pupation period has assisted them in their exponential expansion.