Interrupting Nature

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Published in Bee Craft October 2024

Note: the numbers in bold refer to the supporting references at the end of the article

I recently had to introduce a queen to a colony where the original queen had perished during the removal of the colony from a ceiling. I would have liked to have seen that colony rebound in its new home with its own queen, it was showing particularly good signs of uncapping and recapping behaviour. But then, my daughter and I were able to use a queen that we had raised from a colony several years old, untreated, and never fed. Imagine that!

My daughter proudly holding a newly mated queen.

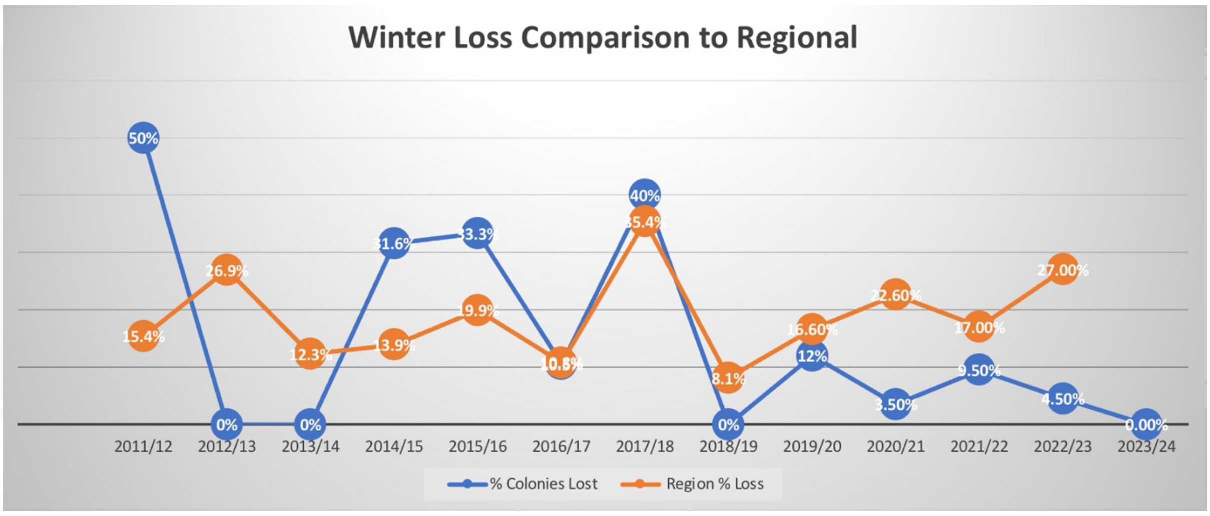
I've been keeping bees now 14 years. Initially inheriting two colonies from a beekeeper who had collected them after they'd come out of a tree on the other side of the county. He chose to stop treating after seeing their response to treatment strips, vigorously trying to remove them and I chose to continue as he had. I have never treated a colony and increased numbers by collecting swarms and using bait boxes, along the way noting several free-living colonies I could expect a swarm from. Over a decade back, this raised some eyebrows. Of course, "free living colonies were full of disease" (they aren't! **1, 2, 4, 6, 29**) but then they also "didn't exist" (they did! **4, 8, 10, 13, 15, 17)** and "Varroa resistance takes two hundred years to establish" (it doesn't! **12, 18, 20, 21, 25**), so I threw myself into reading the scientific literature. I wanted answers to give whenever my fellow beekeepers would raise the old rhetoric.


A healthy and winter ready free-living colony exposed from a tree branch following a storm.

During the initial years my colony management took a turn away from the notions of modern beekeeping practice to a more natural position, before returning to some kind of compromise. I wouldn't say this is hugely discernible at a glance. I wanted bees that survived without me and that meant removing my support. I was then not treating nor feeding. I effectively put myself in a situation where it was essential that I respect my colonies' responses to the external world and gauged how I interacted with them based upon what they were doing, and what the world around me was doing. Further to this I took to heart various research and blogs from scientific authors that described beekeeper influence on disease dynamics **5,12**. This led me to keeping colonies in a more 'apicentric' way. I use low density apiaries of 2-3 colonies, not transferring materials between them and do not combine unrelated colonies, aiming to minimise horizontal transfer of disease. I use insulated top boxes, similar to a Warrè hive and multiple small entrances to increase insulation and encourage colonies more natural ventilation strategies. Some of my hives sides are also cork insulated. I make splits instead of suppressing swarming and always maintain a healthy 'float' of honey so that they never would run dry. Keeping the first super with them always and retaining the pollen crown. As natural minded as I am, taking a crop and favouring productive more docile colonies are still on my list. For the colonies, this presents them with a less stressful situation, less impactful on and impacted by the local environment and ecology, whilst also allowing the opportunity to fail should they not have what it takes to survive and I merely shepherd the arranged scenario; keeping a watchful eye for disease, using queens and splits from my best and being prepared to intervene if things were to go pear shaped. My management laid a platform for natural selection to take place. Having watched which colonies survived best, a 'Rule of Thirds' had formed in my mind, most obvious in first year colonies. They kept their comb/stores/brood production in proportion, not too much of one over another. They had to respond to flows and seasonalities appropriately, produce healthy drones and queens' which mate successfully and they had to construct and provision a nest to survive their first winter. Doing all that in spite of *Varroa*. Unfortunately for those who had initially told me "It can't be done!", I wasn't seeing anything unusual. I believe that in giving them the opportunity to fail and without propping them up or trying to force them to live, my losses primarily occurred during the hardest part of the year, winter, leaving behind the colonies that could survive.

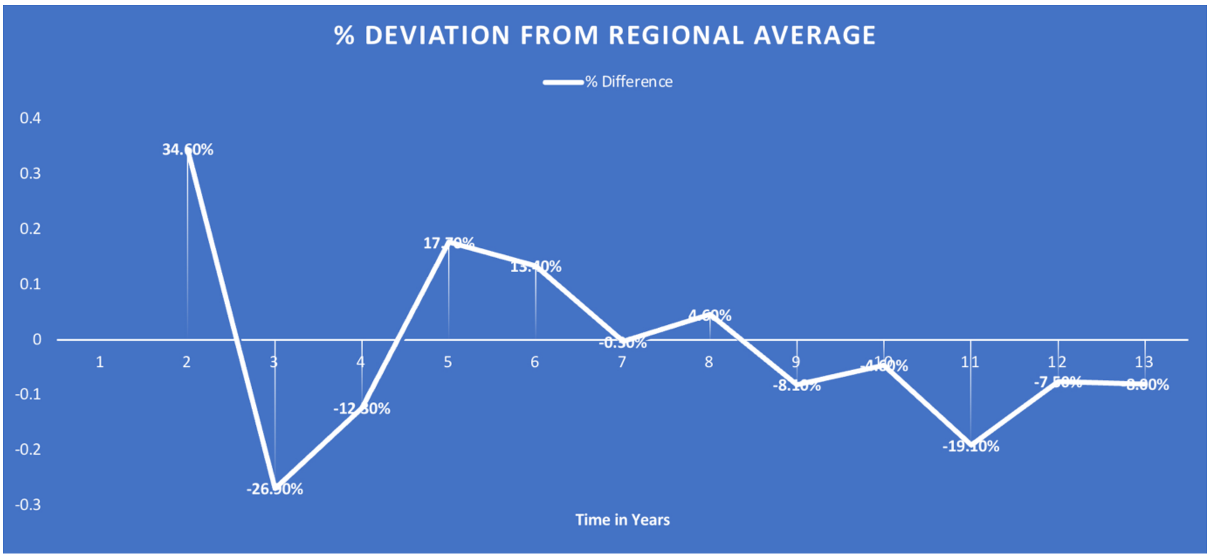
One of my long-term untreated production colonies being very productive.

To many this approach may sound like complete madness, it may not be for everyone, and I would agree, except that it worked. Along this 'journey' I had asked myself over and over, why hadn't I had to go to the lengths I'd seen others going to? Heading into this I was prepared for all kinds of efforts. I performed assays for hygienic behaviours, counted infertile mites and had scoured countless bottom boards utilising BeeBases varroa monitor constantly. Those activities soon went out the window, noting a suite of interesting activities performed by the bees themselves. You can see in my winter loss record, that after two winters of higher-than-normal losses things improved to a point of seeing better than average losses. Exploding head emoji! Those two winters between 2014-16 of 30% losses are important to note, as they diverged from local loss rates significantly.



Loss comparison between my winter losses (blue line) and the regional average (orange). Note the winters of 2014/15 and 2015/16 at approx 30%. I include all colonies irrespective of size in my data.

Loss deviation from regional average. Data points below the midline indicate losses below the average for the area.



Despite this, I was seeing the same hygienic behaviours others were seeing together with a lack of DWV. Prof Martin later explained this as a symptom of the uncapping/recapping and brood removal which lowered the mite population and therefore virus levels.

Removed pupal body parts including antennae (Hockey Sticks)

But why had this worked with around 15-40 colonies, with such minimal effort? The answer came just a few years ago in 2020, I was called out to help a local forestry team with a colony of honeybees in a tree. Not an unusual story, but I took the opportunity to ask permission to head onto their land and walk their forests. By that winter I had found 18 natural tree nests and recovered three logs containing colonies. I am now monitoring 88 nest sites, 7 recovered logs and 10 specially designed 'habitat hives' (for sampling) across 2500 acres of woodland. Not to mention the 20+ too far for me to continually monitor or the 9 colonies my local beekeeping group monitor. I have become quite adept at finding free living colonies. Having found another five during the time it's taken me to write this article, perhaps there is an article for another time. If we extrapolate the density data from the forests colonies there is potential for another 100-130 nest sites in the 3500 acres of woodland in the wider environment. That's 200 possible nest sites, not taking into account a great number of free-living colonies in the villages, the towns, hedge lines, the non intervention beekeepers, my fellow non-treaters or the beekeepers using their own bees. Intentionally but accidentally, in allowing nature to take its course in my managed colonies, my beekeeping had fallen in line with these free-living colonies. It occurred to me that if my approach had worked here with relative ease, then something was amiss in areas unsupported by such a population; the loss of natural selection from beekeeping was showing how much of an impediment we can be to our bees' adaptation to new problems.

Free living colony inhabiting a cracked trunk. Half in and half out the cavity.

What are Free Living Colonies?

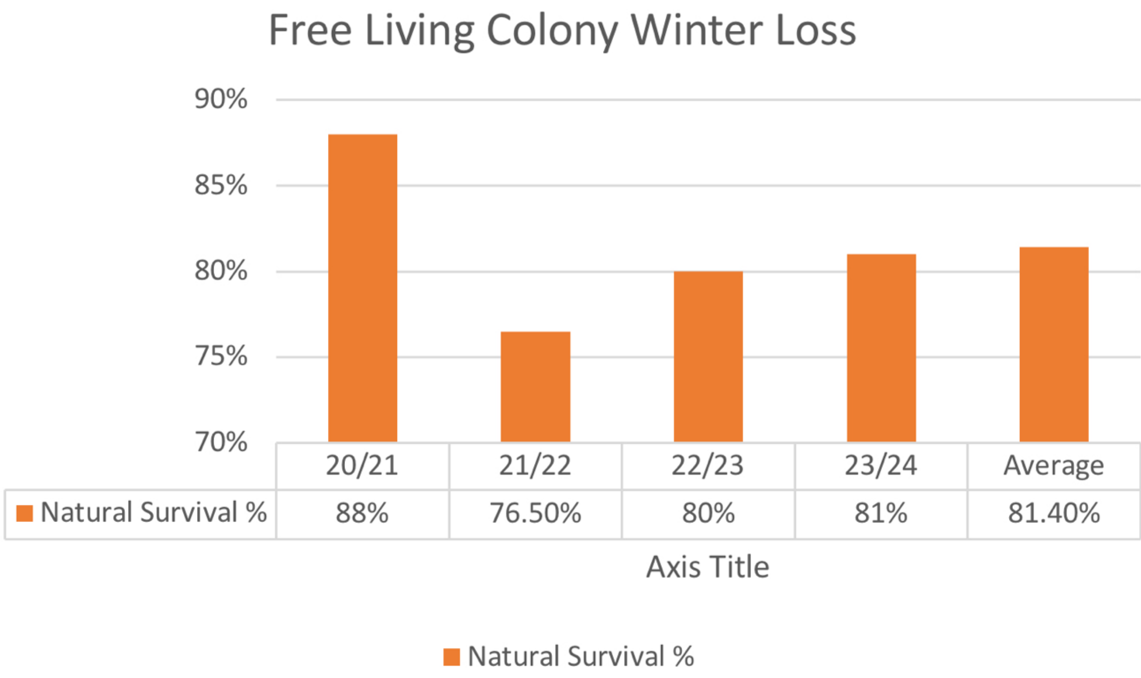
The term Free Living was coined by Keith Browne *et a*l 2020 at the Galway Honey Bee Research Centre **15, 16**. There are numerous free-living honeybee populations that exist and have developed varroa resistance in the UK and around the world **13**. More are being identified through the work of organisations like COLOSS's Survivors group and the HoneyBee Watch **17**. It's been a contentious issue to differentiate wild and managed colonies because of their mating habits and reproductive behaviours. They can travel far when swarming and to mate. Despite this contention there are major differences in the level of natural selective pressures to which free-living colonies are subject, compared to managed colonies. Managed colonies are also subject to more artificial selective pressures, often guiding adaptation/evolution away from a healthy equilibrium and towards greater disease virulence **5**. Combs are not changed regularly in free living colonies, there are no contraptions to help protect them from predators, they are not fed during inclement weather or dearths, queens aren't artificially replaced when they're lost or fail to mate, drones are not culled nor limited in production, their density dictated by competition for forage and availability of nest sites and they are never treated for pests or disease. It's sink or swim. Making persistent survivors' excellent *Varroa* resistant stock for beekeepers.

Given the right environment and landscape, how bees populate an area also gives rise to differentiation from the managed population because of how swarms locate and occupy nesting sites **3, 10, 28, 29.** Research from Kohl and Rutschmann has shown that in their German beech forests **7**, scout bees originating from colonies outside the forest appear less likely to venture inward. They prefer to select the most "economical" nest sites, locations relatively close and accessible. Meaning the colonies already inside the woodlands will likely get first pickings of the nest sites within the forests. They also showed in another area that only 10% of the free-living colonies were surviving winter, nest sites re-occupied by swarms from the local managed population **8**. Ironic that the survival seen there is in the ballpark of natural resistance to *Varroa* found in naïve populations **14, 23** and highlighting how the managed population can disrupt the loss and recovery mechanism. I believe such areas of natural habitat and nesting sites should be kept free of beekeeping activity. Looking at the work of Kohl et al and Dubiać et al, and depending on population and habitat size, I'd suggest **at the very least** a 1km buffer zone with bordering managed colonies, preserving the area for the processes outlined here to be enacted by free living colonies. The smaller the free-living population and habitat in comparison to the managed population the larger the buffer zone should be. This can potentially give rise to a dominance of survivor queen lines occupying available nest sites, which is incredibly important following findings by Martin *et al* that queens confer resistance **36**. This trait heritability through queen lines goes toward explaining how populations which aren't entirely free from exposure to outside drone influence still manage to persist and establish mite resistant traits despite being open mated. A free-living forest population has the potential to replace losses if abundant enough and populate the area thanks to unrestrained reproduction, often exacerbated by smaller natural cavities. Beekeeping surrounding these areas should be adapted to support this 'system' by collecting swarms from free-living colonies and keeping colony densities low, taking on non treatment approaches, reproducing from successful colonies with high mite resistant capabilities and good survivorship qualities to produce splits and queens to replace colonies with low mite resistant and survival capabilities. My two cohorts, Steve and Rhona have done an excellent job showing how we can select bees with higher levels of resistance within our management and have explained the mechanisms. In my opinion, if *Varroa* resistance and colony persistence can occur in areas like the Arnot forest, Avignon, Belgrade and here where colonies are open mated with exposure to outside colonies drones, then the necessity for practices like instrumental insemination are not the answer. They may be one of many tools, but not tolerating colonies with limited survival ability is the solution.

It is a fact that whether there are numerous colonies or just one, natural selection acts upon all free-living colonies and given time, those which are resistant to *Varroa* and overall better survivors will present themselves by simply surviving. It's apparent to me that many beekeepers have yet to consider the rigours honeybees face, which shape their adaptation to climate, their environment, the ecosystem and the disease (parasite) landscape. Think about the interference to that very system our beekeeping management presents. Nature doesn't make a compromise. The best colonies didn't get a drop of syrup or one pollen patty, need only one treatment this year or stayed healthy by having their boxes boiled or burned.

A very logical minded beekeeper I know has the mantra "Honeybees are perfectly adapted to adapting". Is this true? Well let's consider a few things. Honeybees have a polyandrous, haplodiploidy mating system. Queens which fly further afield than drones for mating and DCA's which can carry male representatives from over two hundred colonies. They produce drone laying queens and workers when something goes wrong and with emergency queen cells, they more commonly select queens from rare patrilines helping to retain genetic material that would otherwise be lost **26**. They have polygenic (multiple gene) behaviours like hygiene and pollen collection which rely on additive genes **11, 12**. These genes increase or decrease in frequency depending on population level stressors causing behaviours to be more or less pronounced. Honeybees' high genetic recombination rates offering small evolutionary steps **31**, with multiple queens produced in a season offering more opportunity for successful genetic combinations to present themselves. Polyandry giving 'new' combinations of behaviours and abilities at the colony level, hopefully from the most successful survivors. Capabilities which allow them to repurpose existing behaviours in new situations **32, 33**. In a natural setting some of these behaviours or mechanisms can be enhanced. Small cavities can cause colonies to swarm without the production of a queen cell increasing the likelihood of the colony using emergency queen cells **27**. Well insulated and provisioned nests reducing stresses and workload **19**, giving greater opportunity for colonies to repurpose behaviours and actively use existing behaviours. Unfettered reproduction giving increased opportunity for proliferation of successful queen lines. This removal of the least fit, retaining as much genetic material as possible and proliferation of the fittest, most successful colonies is hugely under appreciated, if not ignored by a lot of beekeepers…..one of the most important aspects of honey bees survival and adaptation as an organism, which we fail to encapsulate within our management. Dr. Leslie Bailey wrote in his book Honey Bee Pathology "…the best beekeeping is the ability to exploit them and at the same time to interfere as little as possible with their natural propensities."

The IBRA funded pan European study in 2012 **14** showed that *Varroa* naïve colonies over a three-winter period faced an 85% loss. This came at approximately 10%, 35% and 40% losses by consecutive winters. Interestingly the mean of these annual losses is approximately 30%. Is it coincidence that in my mixed age apiaries the winter losses which diverged from local loss rates were similar? In the time I've monitored the free-living colonies their winter losses have averaged 18.6% in a range between 12% - 23.5%. It certainly appears a loss and recovery event has occurred and some kind of stability has been achieved as this closely resembles loss rates in the *Varroa* resistant populations of the Arnot forest and on the island of Gotland, 5-6 years post exposure to Varroa **23, 30**.



Winter survival of free-living colonies over four winters.

Assessing Free Living Colonies

In looking to use free living survivor colonies as a base for breeding *Varroa* resistance, an individual colony does give finite opportunity to discover which are able to survive. It is important to monitor regularly and at specific points in the season. Which can require some knowledge. It is arguably more important to assess persistence and survivorship in isolated, individual colonies than within a population. As a population you have multiple opportunities for selection and replacement, a level of relatedness – population level resistance. An individual may not be supported by multiple other surviving colonies BUT they can be great indicators of local population level resistance to the mite and if they survive long term they could offer a great source of genetics. Colonies can die and be replaced quickly, so observation and using local knowledge is essential. Colonies need to be checked at four points minimum during a season: post winter before swarming, spring after swarming, mid summer at colony peak and autumn heading into winter. If you can, checking them as often as possible to avoid missing a colony being replaced. Understanding how colonies in a natural setting behave is also important to observations. This is particularly applicable to established colonies (older than one winter), they often have plenty of stores and an organised nest cavity. This can lead to them being reluctant to fly in adverse weather or periods of predation. Older queens also raise less brood later in the season and so can appear less busy. Swarming can be affected by prevailing weather conditions. This year many colonies failed to swarm during the oil seed rape and hawthorn flows but instead they took advantage of the later blackberry and lime flows. I had noticed halfway through my nest checks that empty nest sites were not being occupied and there was no scouting behaviour. In good years they may swarm prolifically at both points. You may also get false positives and negatives of survival if you only observe whether honeybees are present or not. Scout bees, robbing bees and dying colonies can give the impression a colony is active. It's imperative to learn and observe their behaviours to be identified at the nest entrance. Watch for hawking, pollen in their baskets, heavy abdomens (the angle of their bodies in flight), defensive behaviours, washboarding, propolis wall construction, undertaker bees, bearding etc. A good pair of binoculars can help you differentiate these activities, and they can indicate an active colony over a failed one. Conversely in autumn when colonies are full of ivy honey you may not see any bees. They'll be fat with stores and relish staying indoors when the weather is borderline between good and bad. Yet come spring, you find an active colony, well before swarming has started. The necessity for water and fresh resources forcing them into action. I am discussing this on the presumption that your observed colony is like many of 'mine', at great height. Occasionally they may be lower and if you're real lucky they can be nearer ground level. Being able to take samples of the contents of the nest floor is very helpful. Those rare colonies can give fantastic insights into the colonies activities and often allow you to observe the results of some of the behaviours described in the previous two articles. As Steve Riley has mentioned, in times of busyness, hygienic behaviours can be reduced. The opposite is true when conditions lead to a lack of foraging activity, nest and brood maintenance becomes common and after periods of cold or wet weather you may well be able to view an uptick in brood removal with undertaker bees flying off or even dropping afflicted pupal bodies.

Removed pupal body in the bottom of a nest cavity.

Of the colonies I monitor twelve have passed their 3rd winter. Five of which have now passed their 4th winter (5th season). This doesn't account for any survival periods before I discovered them. The benchmark for gauging if a colony is *Varroa* resistant appears to be when they've survived their third winter (4 seasons+). This has been my assumption from a number of scientific papers. The same IBRA study mentioned earlier showed that of all losses, 62% were not attributed to *Varroa*. That's a lot of things which can kill a colony and quite some feat to survive without the influence of *Varroa*. With an inability to quantify the exact mechanisms of varroa resistance, survivorship is the most reliable metric we have. The beauty of this scenario is that it encapsulates all behaviours, all mechanisms involved **21**. Including selective pressure on diseases and mites. The less specific the selection, the more inclusive of all parts, all behaviours it is. The only possible limitation here is that a natural process does not include 'us', our hives, our interference, our management and requirements. So having monitored a colony, caught its swarms or sweet talked the specialist who removed them, you have choices to make. Continue with providing a platform similar to which they've become accustomed or take on an amalgamation of the information brought forward in these three articles. Whatever suits you and your colonies best in your situation. We must have plasticity in our management, a broad spectrum, diversity and that is afforded by knowledge. No two colonies, seasons, situations are alike. Similarly, Varroa resistance across a semi naïve population, performance against the mite, can be variable until established. However, it is there!

Bait box naturally occupied by a swarm from the forests.

Looking to the Future

Our honeybee population is predominantly no longer supported by a natural system. The industrialisation of beekeeping has facilitated the loss of genetic diversity needed for adaptation and removed selection for fitness **35**, I believe we need to reassess our situation and change our approach. After thirty-two years minimal progress has been made towards *Varroa* resistance in the managed sector. In contrast, where honeybee populations are subject to natural selection, they have overcome the *Varroa* mite problem. We need to select colonies that are more resistant to *Varroa* and embrace natural selection as best we can. In particular to protect honeybees right to live as a wild entity **34**, preserving these remaining pockets of genetic diversity and locally adapted colonies. These vestiges of honeybees' natural habitat especially tree cavity nest sites which are shared by other species as part of a larger ecological role. In doing so, we can ensure through management and conservation the continual adaptation of our honeybees to the pressures of a changing world **9**.

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