Does a remote Brazilian island hold the key to Varroa tolerance?

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We left the Brazilian city of Recife and had been flying East over the Atlantic Ocean for over an hour before the captain informed us we were going to land, despite any sign of land. The wheels came down on the 70 seated, ATR 72 twin-engine turboprop plane and we continued to descend. We were getting real close to the sea before the first sign of land suddenly appeared, then quickly disappeared in a wall of rain. A sudden down-draft pushed the plane towards the ground causing the pilots to rapidly abort the landing. In just a few seconds we were over the other side of the island and climbing steadily. The passengers were very quiet as we approached the runway for the second time, then a round of applause as we touched down. We had landed on Fernando de Noronha, a small island that is home to some very special honeybees. My work as a honeybee researcher has taken me to many unique places around the world in my quest to understand how the Varroa mite has become, and still remains the beekeepers number one enemy throughout the Northern Hemisphere. Beekeepers created the Varroa problem when European honeybees (*Apis mellifera)* were moved to Asia, thus providing the ideal opportunity for the Varroa mite to jump the species barrier from the Asian honeybee (*Apis cerana)* to *A. mellifera*, which it did over 70 years ago and as they say 'the rest is history'. After several trips to Hawaii (Martin, 2010) we were able to finally show how the Varroa mite was changing the viral landscape in which our bees live (Martin et al. 2012). It is now becoming clear that the role of a small group of viral pathogens, especially Deformed Wing Virus (DWV) lies at the very heart of the Varroa problem. The mite has introduced a new viral transmission route i.e. directly into the blood, which can lead to the premature death of the bee and eventually the colony. However, despite the death of millions of mite infested colonies throughout the Northern Hemisphere the same problem has not been seen in African or Africanised bees, which appear to have always been naturally

tolerant to the mite. But why? Is it possible that the Africanised bees hold the key to providing a long term solution to the Varroa problem, or could 'Mother Nature' have already provided a solution?

I along with several other teams are all trying to understand why a very small number of European honeybee populations around the world are surviving despite being infested with Varroa. So as part of this quest I had arranged with my Brazilian collaborators to visit the very remote island of Fernando de Noronha. This tiny island covers 18 km^2 and lies 350km off the coast of Brazil and is classified as a UNESCO World heritage site, due its importance in terms of it's marine life and as a seabird breeding site. It is home to 2000 spinning dolphins, a large hawksbill turtle population and is an important nesting ground for many ocean going seabirds such as Boobies, Noddies, Tropicbirds and Magnificent Frigatebirds. The island was first discovered by the Portuguese in 1503, even visited by Darwin in 1832, but the very dense vegetation prevented much progress. Between 1897-1957 the island's main role was as a prison. It was used as a base by the Americans in the 2^{nd} world war before becoming established as a marine nature reserve in 1988 and World Heritage Site in 2001. The numbers of visitors to the islands are controlled and it is a very expensive place to visit, but boasting several of the best beaches in Brazil and possibly the world, well off foreigners and Brazilians flock to the island each year to spend a few days enjoying the clear waters and pristine beaches. Very few people notice the special yellow honeybees flying around the gardens seeking out pollen and nectar.

In the early 1980's the infamous Africanised honeybees, or killer bees, were spreading through South America. So it was decided to establish a European honeybee queen rearing centre on the island, thus providing a supply of gentle European queens that could be used to dilute out the aggressive Africanised traits which were sweeping through Brazil. So in 1984, 20 colonies of Italian honeybees (*A. mellifera ligustica*) were established on the island (DeJong & Soares, 1997). Subsequent molecular testing has confirmed that the established colonies were 100% European and even after 20 yrs, the beekeepers on the island are still able to handle the bees without gloves or a veil, which is very different to the situation on mainland Brazil. However, unseen by the researchers the insidious Varroa mite had hitched a ride across to the island with the original colonies and had become established in all colonies, with worker brood infestation rates of around 20%. Thus, a natural experiment has now being running for 24 yrs. During that time the island beekeepers

have never conducted any type of Varroa control and their colonies survive in good health. A feral population soon became established on the island and provides a source of honey to the locals who have learnt that the bees are not so aggressive. Furthermore, bees with deformed wings have never been seen despite Varroa populations that persist in colonies in the thousands.In European honeybees such levels normally lead to the death of the colony. So could it be the climate? Most Varroa infested European honeybee colonies die over the winter period, when bees die but are not replaced by new ones. As the island has no winter is this important? Well yes and no. Yes, because it has been estimated that the constant birth and death of bees throughout the year increases the number of mites required to kill the colonies. However, if this was the entire story, why did the European honeybee colonies on Hawaii suffer huge losses when Varroa arrived in 2007? The climates in Hawaii and Fernando de Noronha are similar both allowing all year round production of bee brood. Could it be race (haplotype) of Varroa? Anderson & Trueman (2000) originally described two main haplotypes of Varroa; the Korean/Russian haplotype that was linked with colony collapse and the less virulent Japan haplotype, which was believed to be the reason Africanised bees were resistant. This turned out to be a red herring, since the Korean type now dominates the Africanised bee population in Brazil (Correa-Marques et al 2003) and despite this change the Africanised bees remain Varroa tolerant. We know the Japan type of Varroa is the only one on the island (Strapazzon et al., 2009), but it appears that the mites are reproducing well enough to maintain strong, stable populations. So could the bees on the island be hygienic and groom off the mites? In a neat experiment, newly mated queens from the island were taken to Germany where they were used to establish new colonies. However, there was no difference in the grooming behaviour or levels of mite damage between the colonies headed by queens from Fernando de Noronha or the local Carniolan (*A. mellifera carnica*) queens (Corrêa-Marques et al., 2002). Although not stated in the study it is assumed that the colonies either died or had to be treated, otherwise some mention of a resistant population would have been made.

However, the DWV role in this story is totally unknown. It is well established that DWV is a major player in the Varroa-honeybee story and that Varroa has driven changes in the DWV population that have led to increased virulence and eventually colony death in untreated colonies. So is DWV present in the bees and mites from Fernando de Noronha and if so what strains of DWV are being maintained in the

population? Well that's why we were visiting the island so soon we will be able to answer these questions. However, this may only be part of the story since even if DWV is present, why don't the mite populations build up over time to overwhelm the colonies? Interestingly, a similar phenomenon is seen in Africanised honeybees throughout their entire range, with mite populations fluctuating naturally between 2000-5000 during the year. Why and how this happens is still not understood. Whatever we find will be important since bees on Fernando de Noronha are the oldest known Varroa tolerant European honeybee population in the world and understanding the mechanism of tolerance will be important for all *A. mellifera* populations.

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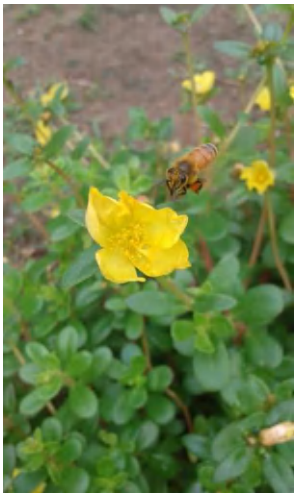

Image 1. Yellow Italian bee collecting pollen on Fernando de Noronha Photo by Stephen Martin

Image 2 Stephen Martin collecting samples, what an office! Photo by Emilene Correia-Oliveira

Image 3 Handling a frame of European bees on the island with the usual lack of protection. Photo by Stephen Martin

Image 4. Typical island scenery.
Photo by Stephen Martin