SCIENTIFIC NOTE

FIRST DETECTION AND INITIAL DISTRIBUTION OF *VARROA DESTRUCTOR* IN NEW SOUTH WALES, AUSTRALIA – THE FIRST 100 DAYS TOWARDS ERADICATION.

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Summary

The Australian honeybee industry faces many issues such as endemic pests and diseases, bushfires, floods, cost-price squeeze, climate change and exotic pest introductions. The pest *Varroa destructor* was previously absent from Australia, but was detected on 22 June 2022 in New South Wales. Here, we describe the first 100 days of detections, activities and responses. The response was initially funded by a national eradication fund of $65 million. If achieved, this would have been the first successful eradication of varroa mite in the world.

Key words
Honeybee, hive, euthanasia, destruction, sentinel, funding, plan.

INTRODUCTION

Australia exports many agricultural commodities, valued at more than A$25 billion in 2019/2020 (Plant Health Australia 2021). European bees (*Apis mellifera* L.) pollinate many of these crops, which were valued at A$14.2 billion in 2017 (Frost 2022; APAL 2022). Honey and beeswax production was valued at A$162 million (Plant Health Australia 2021). These industries are supported by approximately 25,000 registered beekeepers in Australia operating about 672,200 hives (Plant Health Australia 2021).

The honeybee industry must manage many endemic health disorders. These include American foulbrood (*Paenibacillus larvae*), Braula fly (*Braula coeca* Nitzsch), chalkbrood (*Ascosphaera apis*), European foulbrood (*Melissococcus plutonius*), nosema (*Nosema apis*), and wax moth (*Galleria mellonella* L.) (Oldroyd *et al.* 1989; Bourke 2020a,b, 2021; BeeAware 2023). Additionally, adverse effects of pesticides are a frequent problem (Frost 2020a).

Further, the Australian honeybee industry is threatened by the possible incursion of exotic pests. Australia is an island nation and is free from many pests that affect their trading partners (Anderson *et al.* 2017; Plant Health Australia 2021). However, the threat of incursion from exotic invertebrate pests and diseases is increasing annually: many incursions occur near major ports of entry because of the volume of freight (100 million tonnes arriving by sea) and the movement of humans in aircraft (9.3 million passengers) (Plant Health Australia 2021). Several exotic pests have established in Australia and adversely impacted honeybee activities including European wasp (*Vespula germanica* F.), small hive beetle *Aethina tumida* (Murray) and giant willow aphid, *Tuberolachnus salignus* (Gmelin) ((Brown 1979; Gillespie *et al.* 2003; Dominiak and Worsley 2018).

Until recently, Australia was the only major honey producing country free from varroa mites. The establishment of varroa mites in Australia was predicted to cost more than A$70 million annually (Saunders 2022a). Exotic bees and mites were detected in Australia in the past, including three detections of *Varroa jacobsoni* (Oudemans) (2016, 2019, 2020) (Plant Health Australia 2021). Most recently in February 2024, a single *V. jacobsoni* was detected in a sentinel beehive at the Port of Brisbane (Queensland Government 2024).

Early detection is key to the minimisation of any eradication cost (Anderson *et al.* 2017). Therefore, sentinel surveillance for many pests was established near major ports (Dominiak *et al.* 2013; Charlton *et al.* 2022). The National Bee Pest Surveillance program is an early warning system to detect new incursions of exotic bee pests, diseases and pest bees (BeeAware 2023). Sentinel hives and catch-boxes were established in at-risk ports and are inspected regularly (BeeAware 2023).

Varroa destructor (Anderson and Trueman 2000) is a major concern for Australia. If *V. destructor* became established in Australia, the European honeybee and the pollination services were predicted to initially decline by 90-100% (APAL 2022). Varroa mites feed on larvae, pupae and adult honeybees causing malformation and weakening the adults, and can transmit many viruses affecting honeybees. Heavy varroa mite infestations can develop in 3-4 years and cause many maladies, potentially resulting in colony breakdown and death of the hive (Plant Health Australia 2016). Rosenkranz *et al.* (2010) provided a detailed review of the biology and control of *V. destructor* and will not be covered in our paper.

New Zealand and Australia were amongst the last two beekeeping countries free from *V. destructor* until April 2000 when the parasitic mite was detected in hives at Auckland in the north island of New Zealand (Iwasaki *et al.* 2015). The mite was likely to have been present undetected for 3-5 years. This late detection allowed local dispersal and disadvantaged New Zealand authorities. Surveillance found that *V. destructor* was spread throughout both main islands and therefore it was decided in July 2000 that eradication was unlikely to succeed (Iwasaki *et al.* 2015). Biosecurity New Zealand conducted a series of workshops to educate beekeepers on varroa mite detection and control. In Australia, *V. destructor* was found on dead bees in a ship's cargo hold at Melbourne in June 2018; a live honeybee colony was found in a wooden crate and killed. The ship originated in Texas (Phillips 2020).

On 22 June 2022, *V. destructor* was detected during routine surveillance in two of six sentinel hives at Tomago near port of Newcastle, New South Wales (NSW) (Bourke 2022: Kirkwood 2022; Saunders 2022a). Mites were found on sticky mats placed in sentinel hives to trap external parasites. Here, we report on the first and subsequent detections and initial activities between 22 June and 30 September 2022 (100 days) in an attempt to eradicate *V. destructor* from NSW. Unfortunately, the program was unsuccessful (Moriarty 2023) but the initial steps towards eradication recorded here should inform other arthropod incursion responses.

THE FIRST WEEK OF THE RESPONSE

The initial actions followed Australia's normal emergency response. NSW reported the detection of *V. destructor* to the Consultative Committee on Emergency Plant Pests (CCEPP) (Anderson *et al.* 2017; Charlton *et al.* 2022). Originating in 2005, the Emergency Plant Pest Response Deed (EPPRD) (known as "the Deed") is a long-standing agreement signed by many industries including honey-related and pollination-reliant industries (GPA 2022). The Deed is managed by Plant Health Australia (PHA) and is updated as different industries sign or if pests are re-categorised. Varroa mite was a Category 3 Emergency Plant Pest in schedule 13 of the Deed (GPA 2022). The CCEPP agreed that eradication should be attempted.

After the detection on 22 June, all six sentinel hives at the three Newcastle Port sites were euthanised that evening by NSW DPI Bee Biosecurity Officers (who also manage the hives under the protocols of the National Bee Pest Surveillance Program (NBPSP)). Under the current funding agreement, the NBPSP funds one site (Port Botany) but NSW DPI still managed the other two ports (Newcastle and Port Kembla) that were considered higher risk and had assigned sentinel hives under the previous agreement that ran until end 2021. If those sentinel hives had not been operational in 2022, it likely would have been many months before *V. destructor* was discovered. Without detection, it is likely that infested hives would already have been moved to major pollination events and spread mites further afield. Pollination services to almonds and blueberries collectively require over 215,000 hives and these are distributed to south-western and north-eastern NSW orchards (Frost 2020b). Such wide dispersion of hives would have made arresting the spread of *V. destructor* highly unlikely.

The day after detection (23 June), all bees and sections of comb containing brood were removed from suspect hives and sent to the NATA-accredited EMAI NSW Department of Primary Industries diagnostic laboratory for further analysis. Two Nanopore DNA sequencing methods, PCR amplicon sequencing and Cas9-targeted sequencing, confirmed *V. destructor* was present in some samples (McFarlane *et al.* 2024).

An eradication plan was launched on 24 June (two Days After the First Detection (2 DAFD)) lead by NSW Department of Primary Industries, working with other agencies and industry organisations (Saunders 2022b). On 26 June (4 DAFD), a State-wide emergency order was issued under the Biosecurity Act 2015 (Saunders 2022c). This order required a standstill of all bees and beehives (Kirkwood 2022): under the legislation, any intentional movement of hives from a biosecurity emergency zone risked a A$2.2 million fine and potentially jail time (Parliament of Australia 2022).

There were four tiers of emergency zones (Saunders 2022c). A 10 km emergency zone (called the "red zone") was proclaimed around each infected site and all bees (commercial, recreational and feral) were to be eradicated within this zone. Additionally, all hives within the red zone were scheduled for destruction (Frost 2022). A second tier, 25 km around each of the infested sites ("purple zone"), was subjected to official monitoring and inspection of hives, including feral hives where known. In the third tier ("yellow zone"), all beekeepers were required to notify NSW DPI of the number and locations of hives within 50 km of any infested site (Saunders 2022c). It was illegal to move bees and hives within red, yellow and purple zones (Frost 2022). The fourth tier was the rest of NSW ("blue zone") that was not covered by any of the other three zones.

By 27 June (5 DAFD), bee euthanasia began within the red zone (Kirkwood 2022). By 12 July, more than 15 million honeybees had been euthanised (Saunders 2022d). Traceback procedures to identify connections between infected hives and trace forward procedures to detect yet unknown infestations began immediately (Kirkwood 2022). However by then, some hives had been moved from Newcastle to Trangie, about 450 km from the red zone (Kirkwood 2022). No varroa mites were detected in these Trangie hives but the bees were euthanised as part of the eradication plan protocols. Tracing activities detected additional infested premises in the Newcastle suburbs of Anna Bay, Heatherbrae, Williamtown, Mayfield, Tomago and Lambton (Anderson 2022). Varroa mite was found in premises at Nana Glen near Coffs Harbour on 25 July and initiated a new set of biosecurity zones (NSW DPI 2022) (see Figure 1 for locations). Additionally, the national exotic pest hotline (1800 084 881) was used as the free, central contact phone number for the public, commercial and amateur beekeepers to supply and receive the latest information (Plant Health Australia 2016; Kirkwood 2022).

COST AND NUMBER OF INFECTED PREMISES IN THE INITIAL RESPONSE

After the initial detection, the response followed the plant biosecurity surveillance cycle of delimiting survey and assessment of feasibility to eradicate (Anderson *et al.* 2017). By 9 July (17 DAFD), the National Management Group (NMG) endorsed the National Response Plan to eradicate *V. destructor* from NSW (Saunders 2022e). The overall budget for the first 100-days of the proposed eradication plan was A$65 million (Parliament of Australia 2022). Briefly, the five main activities in the first 100 days were to (1) delimit the infestation by surveillance, (2) eradicate all bees within 10 km of an infested premise, (3) eradicate known feral colonies from 10-25 km of an infested premise, (4) conduct surveillance of managed colonies within 10-25 km of an infected premise, and (5) facilitate a total standstill of all hives within NSW. Subsequently, the August standstill was lifted for some low-risk areas and the movement of hives was permitted following procedures such as alcohol washing to detect mites, verification that hives were not sourced from eradication or surveillance zones, the completion of online training, and application and approval to move (Saunders 2022f). Additionally, hives arriving for the almond pollination were monitored using sticky mats (Saunders 2022f). Hives were moved to service the almond pollination season in Victoria and no mites were detected in Victoria (AHBIC 2022). As part of the Deed, it was agreed to compensate beekeepers for the destruction of hive boxes and bees, which was projected to cost A$18 million (Saunders 2022e).

As the program developed, the number of identified infested premises increased because of tracing activities and increased surveillance. Originally, there were two infested premises on 22 June 2022, nine infested premises (6 DAFD), 38 by 12 July (20 DAFD), 43 by 25 July (33 DAFD) and 59 (40 DAFD) (APAL 2022; Parliament of Australia 2022). At the 100 DAFD, there were 100 infested premises (AHBIC 2022). By the first 100 days, over 115,000 hives had been sampled for the mite (Saunders 2022f). Additionally, 11,500 hives had been euthanised with the hive destruction program finished in the Nana Glen, Narrabri, Denman, Jerrys Plains and Wards River zones (AHBIC 2022). At 100 DAFD, the NSW Government remained confident that the State could become the first jurisdiction in the world to eradicate Varroa mite (Saunders 2022g). Unfortunately after spending A$101 million, eradication was deemed unfeasible and the program transitioned to management in September 2023 (Moriarty 2023). Details of the program's components will be published in future papers.

DISCUSSION

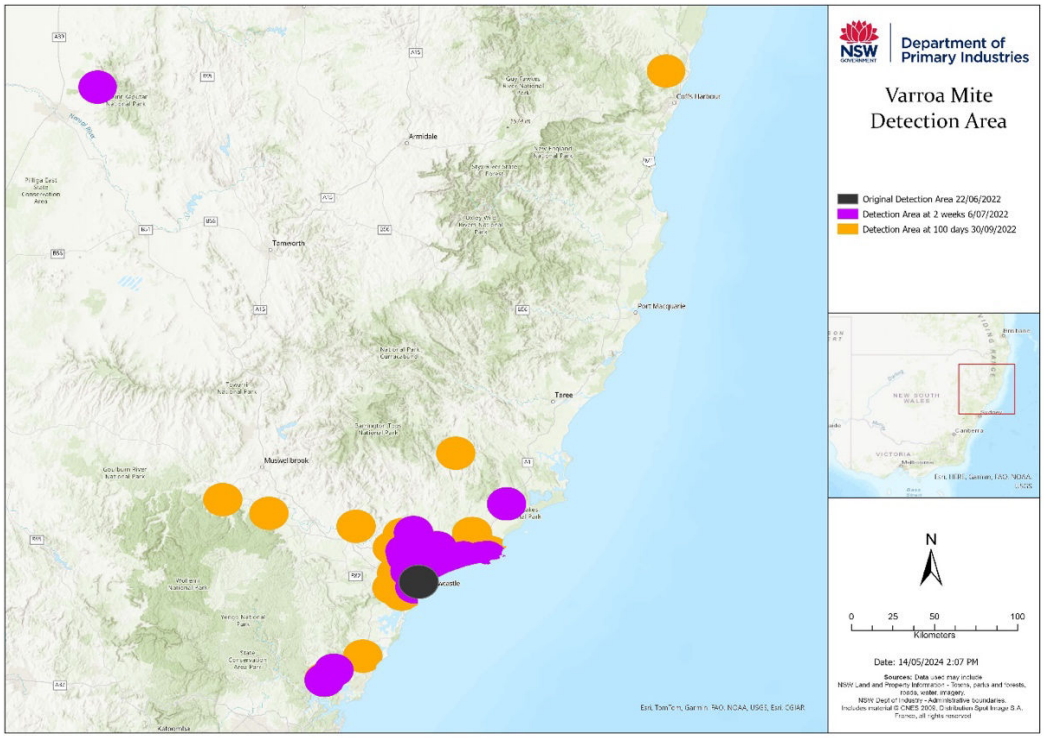
Australia is an island nation and has a good history of dealing with detection of exotic insect pests and often their eradication when deemed feasible, as it was for *V. destructor*. Additionally, Australia has a well-developed mechanism for responding to exotic detections via the CCEPP (Anderson *et al.* 2017) and the signed funding Deed. The Deed lists incursion threats at a national level, and funding of eradication arrangements and categorises are predetermined. For each incursion, an NMG is formed (containing

Australian and international experts) to provide the best technical guidance for any response, including eradication (Charlton *et al.* 2022), transition to management (Dominiak *et al.* 2009) or noting of an incursion where no action is to be taken (Hales *et al.* 2017).

The decision to attempt eradication was contingent on essential criteria including that *V. destructor* can be managed using existing techniques (see Bomford and O'Brien 1995 for essential and desirable criteria for eradication feasibility). *Varroa destructor* eradication has not been successful in other parts of the world but the Australia program benefited from more recent techniques not used in other programs. There were direct benefits to the apiary and pollination dependent industries of eradicating varroa mites from Australia. Also, the eradication of *V. destructor* would preclude the threat of many viruses entering into the Australian honeybee industry as several viruses in honeybees have spread around the world with varroa mite infestations. These maladies might explain colony collapse disorder in some countries (Iwasaki *et al.* 2015).

Here, we reported on the first 100 days of activity when the program was hopeful of achieving eradication. Unfortunately in September 2023, the NMG decided that eradication was no longer feasible and the response transitioned to management (Moriarty 2023). If varroa eradication had been successful, Australia would have been the first country to eradicate a varroa incursion. Australia would have remained the last source for varroa-free bee breeding stock and queens, an export industry that was worth M$2 annually (Clarke and Le Feuvre 2021). Despite the eradication being unsuccessful, the Australian mechanisms could inform other countries responding in exotic arthropod incursions.

Figure 1. Varroa mite detections in New South Wales between 22 June and 30 September 2022.



ACKNOWLEDGEMENTS

Nick Geoghegan and Peter Fleming reviewed a pre-submission version of the manuscript. Catherine Phillips identified the suspect samples. Several anonymous journal reviewers further improved the submitted manuscript. NSW Department of Primary Industries funded the formulation of the manuscript but there was no specific grant.

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Submitted 11/3/2024 Accepted 30/9/2024