Final Report

Enhanced National Bee Pest Surveillance Program

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Delivery partner:

Plant Health Australia

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MT16005

Project:

Enhanced National Bee Pest Surveillance Program (MT16005)

Disclaimer:

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Summary

The economic value of European honey bees (*Apis mellifera*; EHB) as both managed hives and unmanaged (feral) colonies, has been difficult to estimate, but figures from 2014-2015 have calculated their contribution to the Australian economy to be between $8.35 billion and $19.97 billion (Karasiński 2018). EHB has an important role in honey production, the provision of hive products such as pollen, propolis and wax, and the delivery of packaged and queen bees. EHB also provides significant pollination services and are the predominant pollinator for the estimated 35% of global crop production dependent on pollination (Klein et al. 2006). The crop value provided from the Australian honey bee (as a pollinator) has been calculated to be $3.85 billion (2014-2015) (Karasiński 2018).

Australia holds the enviable status of being free from many significant pests and diseases of honey bees that pose major threats to bee populations, the commercial bee industry and Australia's pollination reliant industries. Urban and regional communities also include growing numbers of hobby beekeepers and the general public who rely on, and are passionate about, healthy populations of honey bees. A key activity that assists Australia to maintain freedom from this range of pests and diseases, is surveillance in areas considered to be of highest risk for the entry and establishment of exotic bee pests.

Between 2016-2021, surveillance for bee pests has been delivered through this project (MT16005), which has funded the National Bee Pest Surveillance Program (NBPSP). Overall, the primary objective of the NBPSP is to act as an early warning system to detect new incursions before, or soon after, they establish. This project was established to continue and improve the nationally coordinated program for surveillance activities targeting exotic bee pests. Key outputs from this project were:

- Regular collection and national collation of surveillance data relating to honey bee pests.
- Data captured into the AUSPest*Check*™, a database that provides summary information on plant health status.
- Information provided for the National Animal Health Information System to assist meet Australia's international reporting obligations.
- Increase number of sentinel hives and catchboxes across Australia.
- Inclusion of surveillance for exotic bee viruses.
- Improved upon existing surveillance activities such as deployment of further remote catchboxes and increase in sweep netting activities at high-risk locations.

Project activities included employment of sentinel hives and floral sweeping for bees at key ports around Australia. Surveillance was undertaken for 18 pests, and the project deployed improved catchboxes to support detection of swarms at remote locations. System for enhanced data management and reporting were developed, and the project provided national coordination which improved collaboration and consistency of all surveillance activities.

Public summary

Between 2016-2021, surveillance for exotic bee pests has been delivered through MT16005, which has funded the National Bee Pest Surveillance Program (NBPSP). Overall, the primary objective of the NBPSP was to act as an early warning system to detect new bee pest or disease incursions, to provide the best chance of containment or eradication. Key outputs from this project were:

- Regular collection and national collation of surveillance data relating to honey bee pests.
- Data captured into the AUSPest*Check*™, a database that provides summary information on plant health status.
- Information provided for the National Animal Health Information System to assist meet Australia's international reporting obligations.
- Increase number of sentinel hives and catchboxes across Australia.
- Inclusion of surveillance for exotic bee viruses.

- Improved upon existing surveillance activities such as deployment of further remote catchboxes and increase in sweep netting activities at high-risk locations.

Surveillance was undertaken for 18 pests, and project activities included national coordination, deployment of sentinel hives and floral sweeping for bees at key ports around Australia. The project developed a range of new techniques and tools including improved catchboxes to support detection of swarms at remote locations, systems for enhanced data management, and diagnostic protocols.

Keywords
Bee surveillance; honey bees; surveillance; bee biosecurity; exotic pests

Abbreviations

Abbreviation/Word	Definition/Description
AHA	Animal Health Australia
AHB	Asian honey bee
BMSB	Brown marmorated stink bug
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWE	Department of Agriculture and Water and the Environment
DPIRD	Department of Primary Industries and Regional Development, WA
DPIPWE	Department of Primary Industries, Parks, Water and the Environment
EHB	European honey bee
Hort Innovation	Horticulture Innovation Australia
LAMP	loop-mediated isothermal amplification
NBPSP	National Bee Pest Surveillance Program
NI	Norfolk Island
NVMEP	National Varroa Mite Eradication Program
OIE	World Organisation for Animal Heath
OIE-WAHIS	OIE-World Animal Health Information System
PHA	Plant Health Australia
RCB	Remote catchbox
SOPs	Standard Operating Procedures
The Portal	Bee Surveillance Portal

Introduction

In addition to honey and wax production, valued at approximately $100 million per year (Plant Health Australia 2021), honey bees provide a major benefit to agriculture and the broader economy through pollination services to a range of agricultural and horticultural industries (Gordon and Davis 2003; Hafi et al. 2012). Of Australia's $30 billion agricultural production per annum, approximately $1.8 billion is estimated to be responsive to honey bee pollination (Keogh et al. 2010). These benefits are related particularly to 35 of the most pollination-responsive crops. When all agriculture is included, estimates are as high as $4–6 billion per annum (Department of Agriculture, 2011). Pollination-reliant industries that are represented by Horticulture Innovation Australia Ltd (Hort Innovation) include almonds, apple and pear, avocado, canned fruits, blueberry, cherry, lychee, macadamia, mango, melon, onion (for seed), papaya, passionfruit, prune, rubus, strawberry, summerfruit and vegetables (for seed).

Australia is currently free of many pests and diseases that cause significant impact to honey bee populations overseas, and the introduction of exotic bee pests, diseases and pest bees (collectively termed pests in this report) pose a serious biosecurity risk to honey bee populations and the pollination services they provide. The *Biosecurity Plan for the Honey Bee Industry* (PHA 2013) identified 14 pests ranked as the highest priority for the Australian honey bee industry.

Of these pests, Varroa mites are considered to be the highest potential overall risk, and it is accepted that, given its spread and colonisation in other countries, there is a very high likelihood Varroa might enter and become established in Australia (Keogh et al. 2010). For Varroa, the potential present value of losses estimated to producers and consumers from an unmanaged outbreak could be expected to range from $21.3–50.5 million per year or $630 million–1.3 billion over 30 years depending on the port of entry (Hafi 2012; Cook et al. 2007). However, if the spread of Varroa could be slowed through containment, it is estimated that the losses would range from $630 million–0.93 billion over 30 years. It is important to note that in addition to the pollination services provided by managed hives there are significant numbers of unmanaged honey bee colonies in most parts of Australia (Keogh et al. 2010). Establishment of Varroa will have significant impact on industries that currently benefit from pollination provided by these unmanaged populations.

Since 1995, at least 16 border interceptions of Varroa have occurred in Australia. Eradication of Varroa has not been successful in other countries where incursions have occurred, and to have any possibility of eradicating or containing an incursion of this pest in Australia, populations would need to be detected before they are able to spread and establish widely. Surveillance for early detection of new incursions of Varroa and other exotic pest threats is therefore a high priority biosecurity preparedness activity.

To improve our capacity and capability for early detection, the National Bee Pest Surveillance Program (NBPSP) was first established in 2013. This program is an industry-government partnership that undertakes surveillance across some of the highest risk ports. This project (MT16005) supported delivery of activities from 2016-2021 that safeguarded the honey bee and pollination industries (and the economies they support) in remaining free of serious bee pests, achieved through the delivery of a nationally coordinated bee pest surveillance program. The project improved and maintained capacity and capability for surveillance at high-risk ports and evaluated the most appropriate techniques for the 18 pests targeted in the program, forming the basis of a new program which will commence in January 2022.

Methodology

Surveillance activities

The project took a structured approach in implementing national activities for early detection of pests and collection of surveillance data, with delivery of surveillance activities by state and territory governments and overarching coordination provided by a project team in Plant Health Australia (PHA). The project team was responsible for establishing and managing contracts with all government parties, and two diagnostic laboratories (CSIRO and Bugs for Bugs Ltd.). In late 2019 PHA coordinated the inclusion of surveillance activities through in-kind arrangements with beekeepers on Norfolk Island (NI) (through the Commonwealth Department of Infrastructure, Transport, Regional Development and Communications). Throughout the project, surveillance has been undertaken at 33 seaports and airports (Table 1), with sites chosen based on risk assessments undertaken in the *Risk assessment of ports for bee pests and pest bees* (Caley et al 2013) report. This report identified ports according to the entry potential of Asian honey bees, using information and data available at the time. Ports which were not assessed in this report were given an unknown rating.

Table 1 Ports targeted for surveillance activities

Jurisdiction	Port	2013 risk ratings
Queensland	Brisbane	High
	Townsville	High
	Mackay	High
	Mourilyan	High
	Gladstone	High
	Cairns	High
New South Wales	Newcastle Port	High
	Port Kembla	High
	Port Botany	High
Australian Capital Territory	Canberra Airport	Unknown
Victoria	Port of Melbourne	High
	Geelong	Medium
	Portland	Medium
	Westernport	Unknown
Tasmania	Hobart	High
	Bell Bay	Medium
	Burnie	Medium
	Devonport	Medium
Northern Territory	Darwin	Medium
South Australia	Port Adelaide	High
	Wallaroo	Low
	Port Pirie	Low
	Whyalla	Low
	Adelaide Airport	Unknown

Western Australia	Fremantle	High
	Geraldton	High
	Bunbury	High
	Derby	Medium
	Esperance	Medium
	Albany	Medium
	Kwinana	Unknown
	Perth Airport	Unknown
Norfolk Island (NI)		Unknown

Pests targeted in the project included 15 exotic honey bee pests and three established pests (18 pests total) (Table 2). Surveillance activities and the pests these activities were most likely to detect are described in Table 3.

Table 2 Target pests

Status	Scientific name	Common name
Exotic	*Varroa destructor*	Varroa mite
	Varroa jacobsoni	Varroa mite
	Tropilaelaps mercedesae	Tropilaelaps mite
	Tropilaelaps clareae	Tropilaelaps mite
	Acarapis woodi	Tracheal mite
	Oplostomus fuligineus	Large African hive beetle
	Deformed Wing Virus – A	Deformed wing virus
	Deformed Wing Virus – B	Deformed wing virus
	Acute Bee Paralysis Virus	Acute Bee Paralysis Virus
	Slow Bee Paralysis Virus - Roth	Slow Bee Paralysis Virus
	Slow Bee Paralysis Virus - Harp	Slow Bee Paralysis Virus
	Apis dorsata	Giant honey bee
	Apis florea	Red dwarf honey bee
	Apis cerana (new strains)	Asian honey bee
	Bombus terrestris (new strains)	Large earth bumble bee
Established	*Aethina tumida*	Small hive beetle
	Braula coeca	Braula fly
	Apis mellifera (for potential pests they may carry)	European honey bee

Table 3 Surveillance activities used

Activity	Description	Pest targets
Sentinel hives	Live hives (colonies) of bees located at or near ports that are assessed for pests using techniques including acaricide (mite) treatments, sticky mat inspections, dissection of bees, visual inspection of hive, frames and workers	Varroa mites; Tracheal mites (*Acaris* spp.); viruses; Tropilaelaps mites (using bees collected from hives); Braula fly; Small hive beetle; Large African hive beetle; Maximum Residue Limit testing for acaricide chemicals in honey, exotic bee viruses
Acaricide treatments and sticky mats	Techniques used to dislodge and collect external mites from samples of bees	Varroa mites; Tropilaelaps mites, Braula fly
Alcohol wash, sugar shake and drone uncapping	Techniques used to dislodge and collect any potential external mites from samples of workers, or brood	Varroa mites; Tropilaelaps mites
Sweep netting	Sweep netting flowering plants or at sugar feeding stations to capture bees	Asian pest bees; Bumble bee; EHB (for potential pests they may carry)
Rainbow bee-eater pellets*	Collection of regurgitated pellets from Rainbow bee-eaters to assess for wings of EHB and exotic bee species	AHB; EHB (to identify populations in the area)
Pheromone ballooning*	Pheromones specific to Asian honey bee (AHB) drones attached to helium balloons. Inspection of any collected bees from around the balloons indicates the presence of an AHB colony in the vicinity	AHB; (*V. jacobsoni*)
Standard catchboxes	Empty boxes placed at ports which provide locations for swarms to establish	EHB (for potential pests they may carry)
Remote catchboxes	Empty boxes that can be monitored and closed should a new swarm enter the box.	EHB (for potential pests they may carry)
Swarm and nest capture	Swarms captured at ports are inspected to determine if they are carrying bee pests or are new pest bee species	Potentially the full range of bee pests and pest bees (with the exception of Braula fly, Small hive beetle, Large African hive beetle)

*New activities added in the 2020/2021 period for Northern Territory and Queensland.

The project design for surveillance activities was based on recommendations from the *Review and Redesign of the National Bee Pest Surveillance Program* (PHA 2016) and the *Varroa Incursion Model* (Caley et al. 2016). These recommendations outlined that the greatest benefit to cost ratio to provide the highest likelihood of detecting and containing an incursion of *V. destructor* could be achieved through deployment of six sentinel hives inspected every 6 weeks at highest risk locations. Depending on the port risk rating, a range of activities were delivered by government jurisdictions. A high-risk port was required to deliver the full range of activities, with the volume of activities decreasing as the risk rating decreased (Table 4). This design structure was embedded across all states and territories for the five-year project.

Table 4 Activities to be completed based on the port risk

Port risk rating	Activities to be completed every 6 weeks
HIGH	6 sentinel hives, acaricides & sticky mats, testing for tracheal mites & exotic bee viruses*, 10 standard catchboxes, sweep netting, either sugar shake, alcohol wash, drone uncapping
MEDIUM**	6 sentinel hives, acaricides & sticky mats, testing for tracheal mites & exotic viruses, either sugar shake, alcohol wash, drone uncapping
LOW	4 sentinel hives, acaricides & sticky mats, testing for exotic viruses, either her sugar shake, alcohol wash, drone uncapping
UNKNOWN***	4 sentinel hives, acaricides & sticky mats, testing for exotic viruses, either sugar shake, alcohol wash, drone uncapping

*Surveillance for exotic bee viruses was performed twice per year across all ports.
**The exception was Australian Capital Territory and Northern Territory, as although ports in these two jurisdictions, were rated as medium risk, 10 catchboxes were deployed and sweep netting activities were performed in addition to all other medium risk activities.
***Norfolk Island arrangements involved frame/visual hive inspections and either sugar shake, alcohol wash or drone uncapping every four weeks

Changes in the NBPSP methodology over the course of the project

In late 2019, PHA was approached by the Commonwealth Department of Infrastructure, Transport, Regional Development and Communications to discuss inclusion of Norfolk Island, and the types of surveillance activities that could be undertaken on this external territory. In-kind arrangements were agreed between PHA and the Department, with delivery by volunteer beekeepers. Activities on the island were not the same as other jurisdictions, due to:

- the unknown risk rating for exotic pest entry,
- the pristine pest-free status of the honey bee population (i.e., no endemic pests such as small hive beetles, and American foulbrood),
- the unwillingness of volunteer beekeepers conducting the activities to use acaricides in their hives, and
- lack of diagnostic laboratory resources on the island.

Despite these limitations, hive inspections and other surveillance activities (including provision of data) were delivered every four weeks.

In the second half of 2020, the contract held between PHA and the Beekeepers Association of the ACT was terminated. The reasons for this included the withdrawal of commitments from the association due to lack of resources, capacity to deliver ongoing surveillance activities and issues with maintaining sufficient insurance. Initial findings of an assessment of pest entry risk at the ACT port “Canberra Airport” in 2020 rated the airport very low for entry of both EHB and AHB. This information was presented to the NBPSP Steering Committee for discussion, and it was agreed the ACT component of the NBPSP would be terminated. It was also agreed should any substantive changes to the risk status of this port occur, a reassessment for inclusion in the program would be considered.

In mid-2020, delivery of surveillance activities in the Northern Territory changed following result of preliminary findings in a review of port risks (DAWE, 2021) and the need to modify the program to include techniques designed to target the highest risk for Darwin i.e., the entry and establishment of Asian bee species. These changes comprised redirection of activities from sentinel hives to increased sweep netting and the inclusion of assessment of rainbow bee-eater pellet analysis.

In addition, in March 2021 activities in Townsville recommenced under the NBPSP after the successful conclusion of the National Varroa Mite Eradication Program (NVMEP) 2019/2021. At Townsville, rainbow bee-eater pellet analysis and aerial ballooning was also included (Table 3).

Data from all contracted activities was submitted to PHA on a 6-8 weekly schedule either via data spreadsheets or more recently through the online Bee Surveillance Portal (a satellite project undertaken through funding provided by the Department of Agriculture, Water and Environment (DAWE, Agricultural Competitiveness White Paper grant project)).

Governance

Overarching governance was provided by a Program Steering Committee. The committee consisted of representatives from the honey bee industry (Australian Honey Bee Industry Council), Commonwealth, state and territory governments, PHA, and Horticulture Innovation. The Steering committee met face to face and virtually a minimum of twice each year to provide strategic direction and guidance to the project.

During the project, the committee met 14 times. In the first two years of the project, the Steering Committee met as a standing agenda item as part of an industry focused bee biosecurity steering committee meeting:

- 20 June 2016 (face to face/teleconference)
- 28 September 2016 (teleconference)
- 5 December 2016 (face to face/teleconference)
- 7 March 2017 (face to face/teleconference)
- 13 July 2017 (face to face/teleconference)
- 25 October 2017 (face to face/teleconference)
- 15 May 2018 (face to face/teleconference)

In the last three years of the project a specific bee surveillance steering committee was formed and held the following meetings:

- 30 October 2018 (face to face/teleconference)
- 30 May 2019 (face to face/teleconference)
- 21 Nov 2019 (face to face/teleconference)
- 27 May 2020 (teleconference)
- 10 Sept 2020 (Microsoft Teams) – a special meeting to discuss the NBPSP Review (Glanville, 2020) report
- 19 Nov 2020 (Microsoft Teams)
- 9 June 2021 (Microsoft Teams)
- 2 Dec 2021 (Zoom)

Foundational documents created at the start of the project included a detailed Annual Operating Plan, Monitoring and Evaluation Plan, and Stakeholder Engagement Plan. These documents assisted with the development and implementation of the project to ensure it met its objectives.

Outputs

This project delivered a national surveillance program for the early detection of honey bee pests. In addition, the project evaluated techniques for new pest threats, including adopting tools and procedures as they emerged and/or were developed. The development of new tools and resources was supported through collaboration with satellite projects with DAWE which greatly improved early detection capabilities, capacity, and national reporting.

Major outputs from the project included:

1. Regular collection and national collation of surveillance data relating to honey bee pests.
2. Data captured into the AUSPest*Check*™, a database that provides summary information on plant health status.
3. Information provided to the National Animal Health Information System to assist meet Australia's international reporting obligations.
4. An increased number of sentinel hives and catchboxes across Australia.
5. Development of protocols for sample collection and detection of exotic bee viruses.
6. Enhancement and deployment of remote catch boxes.
7. Inclusion of specific techniques to improve detection of Asian bee species at high-risk locations.
8. Development of Standard Operating Procedures to improve consistency of surveillance techniques being used across Australia.

Collection of surveillance data

This project has collected significant amounts of surveillance data as described below.

From 2016, the NBPSP targeted at total of 13 external and internal mites, beetles, and exotic bees, and from 2017 the program was expanded to include exotic 5 bee viruses (i.e., 18 pests in total). When the program commenced in 2016, there was 109 sentinel hives, 75 catchboxes, no remote catchboxes and 13 locations for sweep netting (Table 5). Through the efforts by jurisdictions the program increased the number of surveillance activities including deployment of an additional 57 sentinel hives by the end of 2021 (Table 6).

Table 5 Volume of operational/deployed surveillance activities at the start of the project

	Surveillance activities (2016)			
	Sentinel hives	**Standard catchboxes**	**Remote catchboxes**	**Sweep netting sites**
QLD	21	12	0	4
NSW	23	0	0	1
ACT	6	0	0	0
VIC	23	49	0	1
TAS	12	0	0	0
NT	6	0	0	1
SA	12	14	0	5
WA	6	0	0	1
NI	0	-	-	-
Total	***109***	***75***	***0***	***13***

Table 6 Volume of operational surveillance activities in the final year of the project

	Surveillance activities (2021)			
	Sentinel hives	**Standard catchboxes**	**Remote catchboxes**	**Sweep netting sites**
QLD	30	60	5	6
NSW	18	30	4	3
VIC	22	34	1	2
TAS	23	19	4	1
NT	4	10	-	1
SA	22	19	5	5
WA	43	30	4	3
NI	4	-	-	-
Total*	***166***	***202***	***23***	***21***

*Note ACT was removed from the NBPSP in 2020

Originally data was provided in the form of excel spreadsheets, however since 2020 (with the support from a DAWE satellite project), data has been captured by government jurisdictions using an online tool. This tool, termed the Bee Surveillance Portal, provided improved program management and data reporting to assist with uploading data to AUSPest*Check*™, the national data aggregation system. Data collected has also been provided annually (or as requested) to Australian Government via joint-reporting with Animal Health Australia (AHA) to assist meet Australia's international reporting obligations (reports are available in the *Animal Health in Australia (Systems) Reports* and *Animal Health Surveillance Quarterly Issues* www.animalhealthaustralia.com.au/industry-publications/ and via the World Organisation for Animal Health (OIE) www.wahis.oie.int/#/dashboards/country-or-disease-dashboard, (Figure 1).

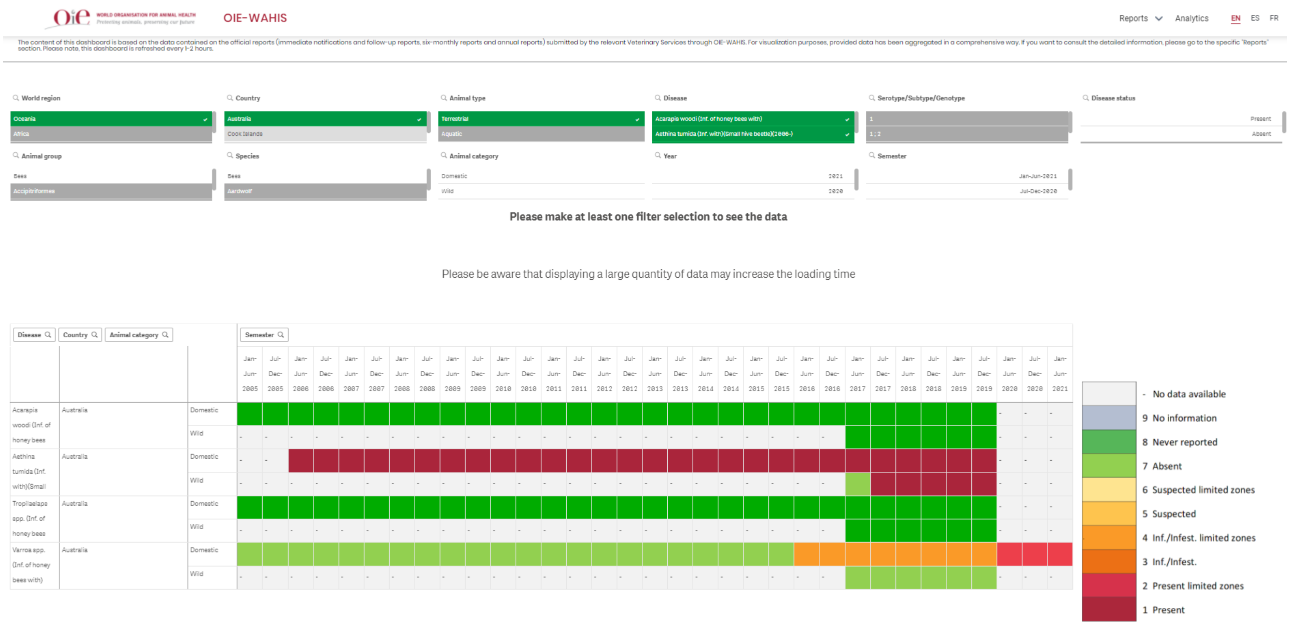


Figure 1 Surveillance data reported to the OIE as part of Australia's international reporting obligations. Data presented by the OIE-World Animal Health Information System (OIE-WAHIS) is focused on small hive beetle, tracheal, tropilaelaps and varroa mites, and American and European foulbrood (not presented in figure). Data collected from the NBPSP provides information into this international reporting database.

Figures 2-6 provide screenshots of outputs of data collation in AUSPest*Check*™. In these screenshots, each circle represents the numbers of data points for the activities conducted for each targeted pest, and where large numbers of data points are present at each location, circles are expressed as 1000+ points. Within the AUSPest*Check*™ system itself, greater resolution can be seen than is represented in these screenshots, and additional reports can also be generated from the data, by zooming into specific locations and/or by filtering on data fields such as date ranges.

By November 2021, over 69,000 data points had been uploaded to AUSPest*Check*™ from the NBPSP. This does not include all NVMEP data collected between 2016 and 2021 from Townsville, or swarm capture data reported from the Australian Government National Border Surveillance Team. At the start of December 2021, many jurisdictions were still in the process of completing final contracted milestone activities and these data results have not been submitted to PHA, due to delays in receiving diagnostic analyses. These final results are expected to be collated by February 2022.

The following sections provide a breakdown of information received for specific pests targeted in the NBPSP from 2016-2021.

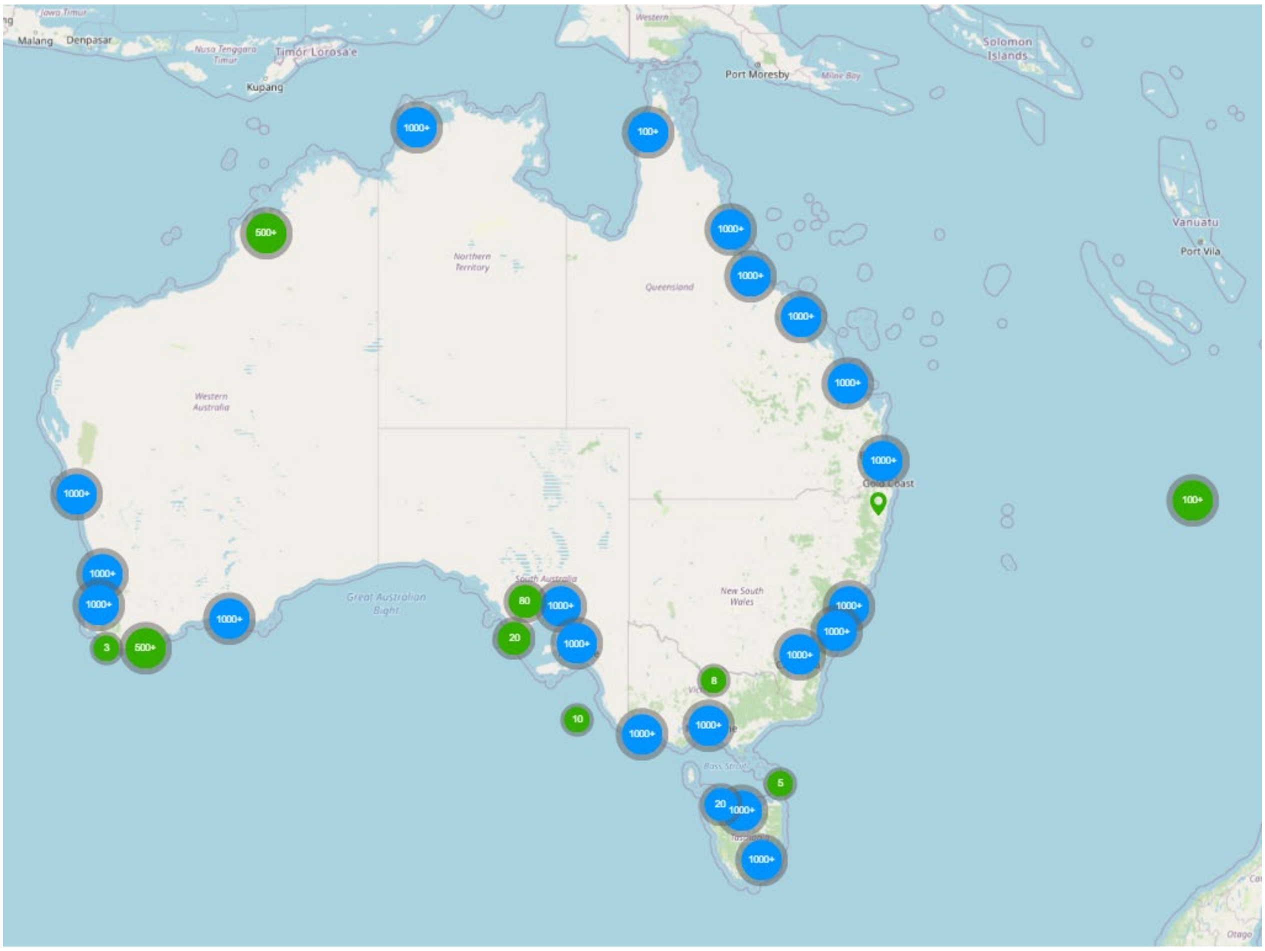


Figure 2 Map of surveillance records for the NBPSP.

Varroa mites

The highest priority pest targeted nationally was Varroa (*V. destructor* and *V. jacobsoni*). From the start of the Program to mid-2021, over 17,600 surveillance data points were generated for these two pests. Nationally, these species were covered by the most types of methods used (Table 3, Figure 3).

Figure 3 Surveillance data points for varroa mites (specifically V. destructor)

Exotic bee viruses

Varroa is a high priority pest, not only for the impact the mite has directly on European honey bees (EHB, *Apis mellifera*) but also for the viruses which can be carried, easily transmitted and spread by the mites throughout a colony. Surveillance for deformed wing virus (two strains), slow bee paralysis virus (two strains) and acute bee paralysis virus (one strain) was incorporated into the Program after the successful development of molecular diagnostics, including the development of these techniques into a National Diagnostic Protocol (completed by Dr John Roberts, CSIRO through a DAWE funded project). Surveillance for exotic bee virus commenced from 2017, and over this period at least 230 samples[1] of adult bees have been tested for the five virus strains each year, generating over 5,100 surveillance points. No viruses were detected during this period. Figure 4 highlights exotic bee virus surveillance coverage specifically for deformed wing virus (strain A).

[1] A sample of bees is collected from each hive at each location, which is pooled to form a port sample in the laboratory at CSIRO. This pooled sample is analysed for the presence of exotic bee viruses. At least 230 pooled samples have been tested.

Figure 4 Surveillance data points for deformed wing virus (strain A)

Tracheal mites

If left untreated, overseas experiences have shown that Tracheal mites will decimate an entire colony. Australia is free of this serious parasite which infests the breathing tubes of adult bees. Mites lay their eggs in the trachea and upon hatching the larvae feed on the bee's hemolymph. As this pest is an internal parasite, currently the best diagnostic tool available is through tracheal dissection and microscopic examination, which is a highly labor-intensive method. Molecular tests are currently being developed/being refined and these alternative methodologies should be investigated further for consideration in the national program to improve detection outcomes.

During this project, dissection and microscopic examination was delivered for all jurisdictions by Bugs for Bugs Ltd., except for Tasmania, where this assessment was undertaken by the Department of Primary Industries, Parks, Water, and the Environment (DPIPWE) laboratory. Since 2016 at least 990 bee samples (or a minimum of 29,700 individual bees) have been dissected and examined with no detection of tracheal mites (Figure 5).

Figure 5 Surveillance data points for Tracheal mite

European honey bees (EHB)

Despite having a relatively healthy established population of EHB, in Australia, EHB is targeted as priority in the Program due to the unwanted overseas pest introductions could carry. EHB are collected as swarms at ports, in catchboxes, as individual foraging bees during sweep netting activities, or during rainbow bee-eater pellet analysis. Since 2016, there have been over 490 positive detections of EHB at ports (Figure 6). These detections were mostly through sweeping netting activities; however, 51 swarms have been collected by state and territory jurisdictions on structures, cargo or in catchboxes. Additional swarm captures have been made by the Australian National Border Surveillance Team. These captured swarms were inspected and free of any associated exotic pests. In addition, in Townsville 10 surveillance events using rainbow bee-eater events detected EHB, and 6 events detected EHB in Darwin in 2021 (Figure 7). It is important to note that, aside from two swarms captured during the course of the project in Darwin, assessment of rainbow bee-eater pellets has been the only successful method for the detection of EHB for the Northern Territory. This is most likely due to the relatively rare populations of EHB in Darwin, and the main flowering resources being too high for sweep netting to reach.

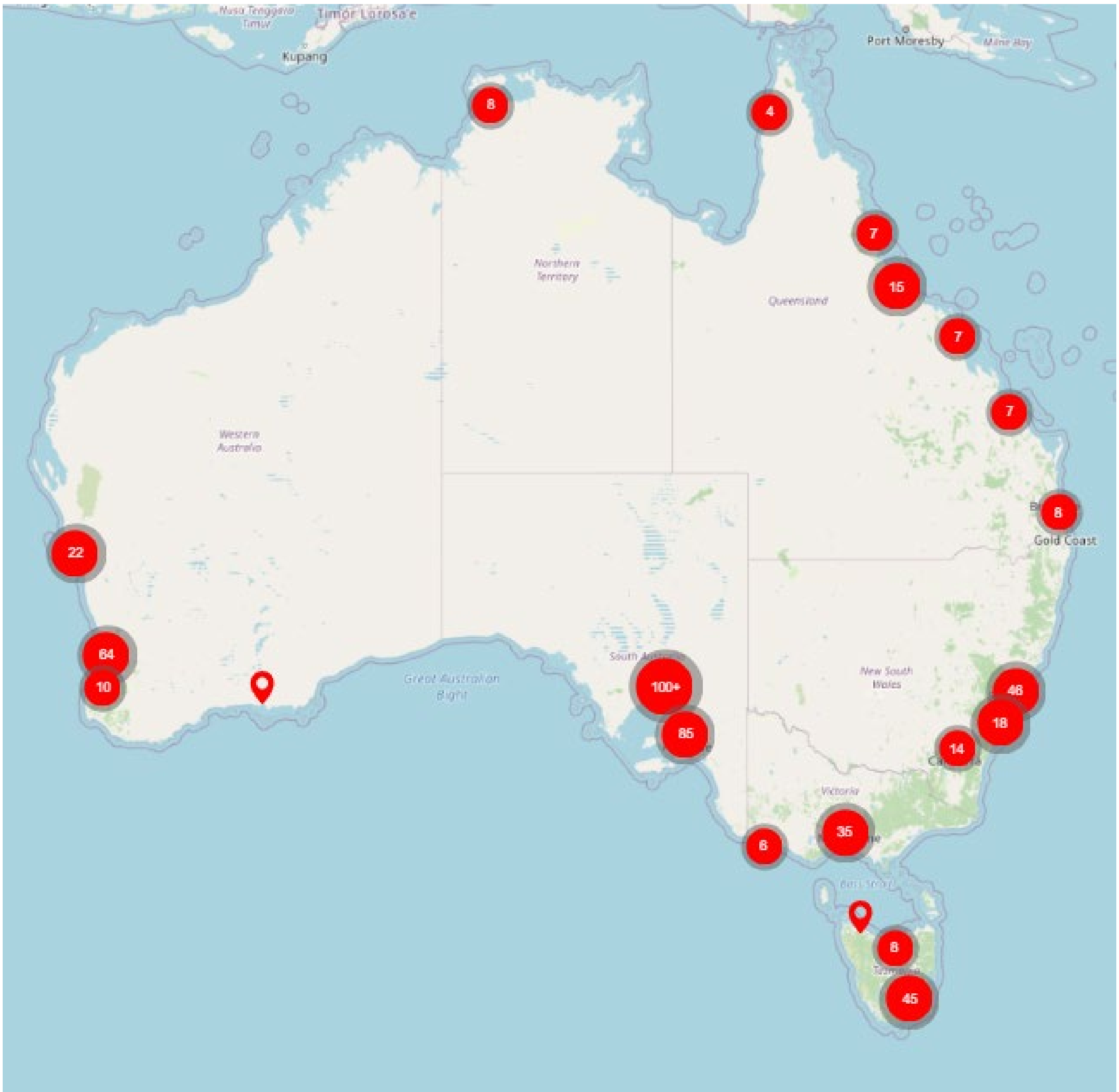


Figure 6 Positive detection of European honey bees since 2016. Activities such as swarm collection, sweep netting and rainbow bee-eater pellet analysis were used for these detections.

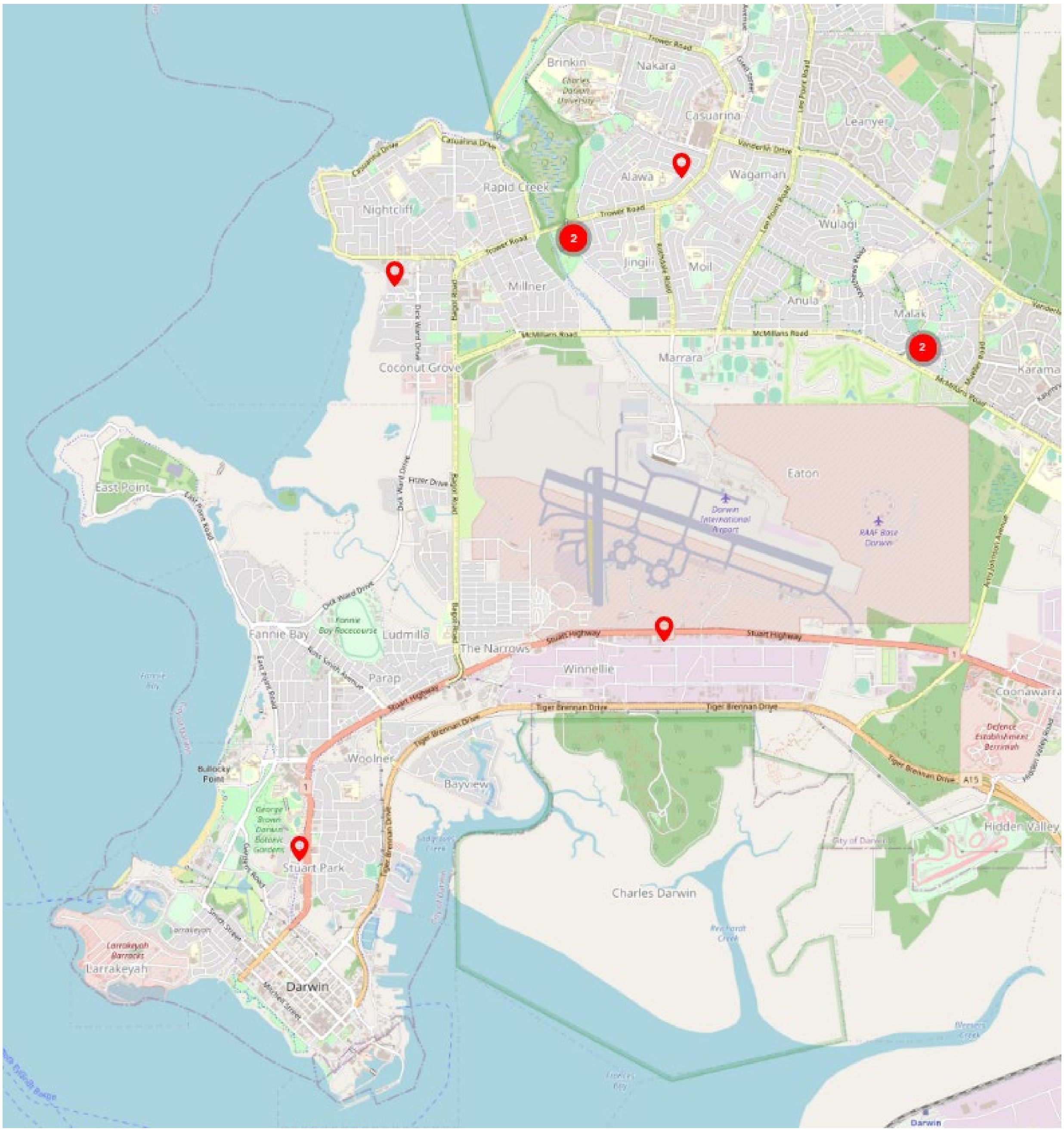


Figure 7 A selection of positive detections of European honey bees in the Northern Territory since 2016.

Asian honey bees

Asian honey bees (AHB, *Apis cerana*) are one of the top 10 pests on The National Priority Plant Pest list (Department of Agriculture, Water and the Environment, 2019). The threat of AHB to Australian honey bee populations has remained a key priority for the honey bee industry. AHB hitchhikes on boats and sea freight very readily, as evidenced by the established population in Cairns, several interceptions at sea ports and incursion responses in Townsville between 2016 and 2020. While standard catchboxes were not thought to be a suitable technique for attracting AHB, it is interesting to note that 12 of the 15 AHB swarm captures (Figure 8) have been in standard catchboxes (all within Cairns' region), the remaining were captured during sweep netting events. This finding supports continued use of catchboxes as a relatively low-cost option for surveillance for AHB.

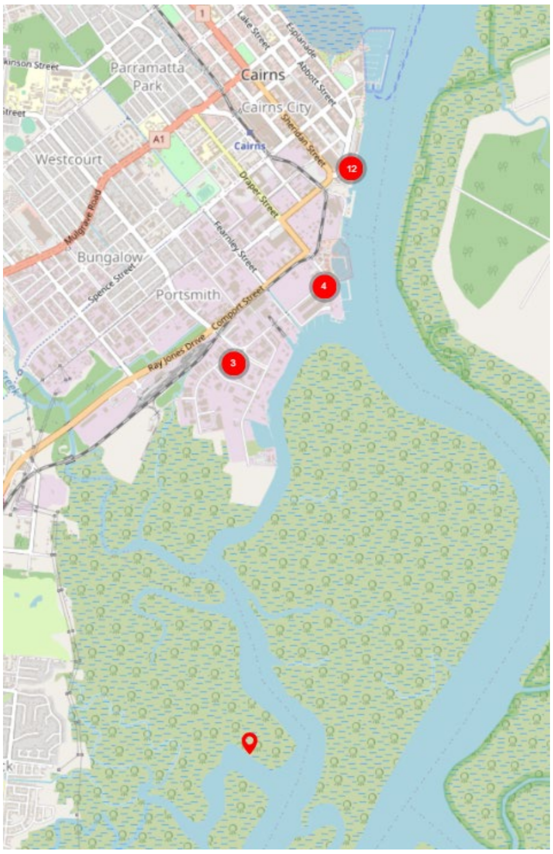


Figure 8 Selection of the positive detections of Asian honey bees in Cairns since 2016.

Collaboration with other projects

This project has actively collaborated with other organisations and projects to provide benefit for biosecurity preparedness.

1. **The Australian Governments' *Agricultural Competitiveness White Paper* (government's plan for stronger farmers and a stronger economy) grant 2017-2020.**

This grant supported a range of enhancements to increase the chance of early detection of bee pests and comprised the six projects outlined below.

a. Establishing virus surveillance

This activity developed and implemented protocols to ensure diagnostics for exotic bee viruses is undertaken consistently and accurately in Australia. The project targeted five key viruses (acute bee paralysis virus, deformed wing virus (two strains) and slow paralysis virus (two strains)). Diagnostics protocols were developed by CSIRO and included sampling and assessment methods which were incorporated into the NBPSP in bi-annual surveys of sentinel hives deployed at seaports and airports (Figure 4).

b. Improving AHB surveillance

Asian honey bees continue to pose a risk to Australia, with new incursions occurring frequently at the Australian border. To improve preparedness for AHB, flowering plants around 14 high risk ports were identified to species level along with the documentation of their flowering times. This work aimed to improve the efficacy and sensitivity of sweep netting, which is used for early detection of AHB in the program. Based on this information, booklets were developed containing floral maps and plants lists for those ports (Figure 9).

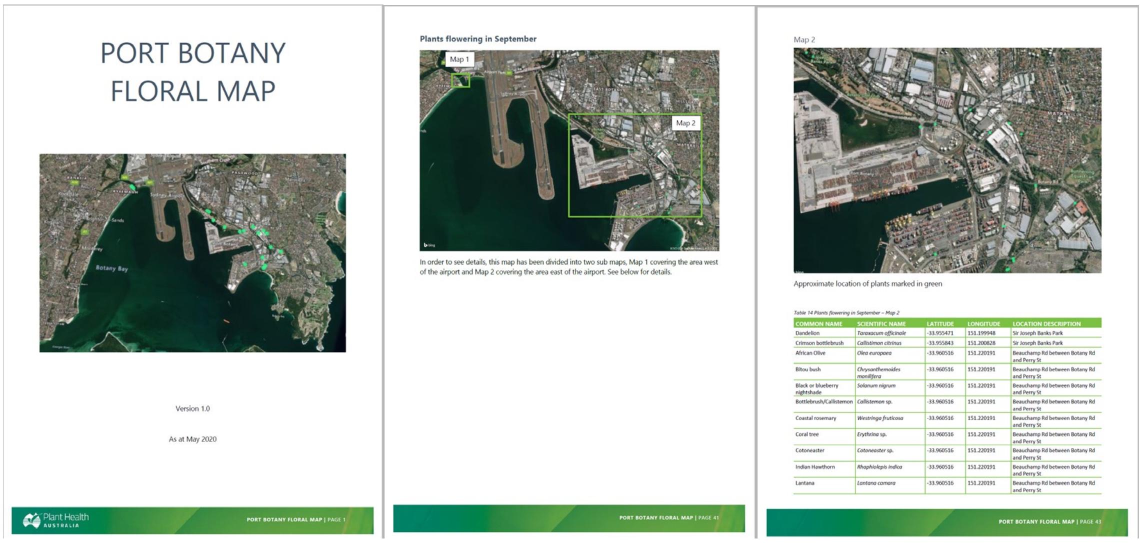


Figure 9 An example of the floral data captured for Port Botany for September period

c. Improving data capture and management

To improve reporting and accuracy of data collection and collation in the program, the Bee Surveillance Portal (the Portal) was developed through an online platform (Figure 10). This tool allowed input of data for all aspects of the NBPSP 2016-2021 and was used by those involved in the program activities. The development of this online system improved jurisdictional data collection and collation, which up until 2020 was heavily managed through emails and excel spreadsheets. This ensured national consistency, building confidence in Australia's pest status claims, and providing real-time information critical in biosecurity response situations. The Portal also collected information important for program management e.g., dates relating to the use of acaricides, the types of acaricides used and results from Maximum Residue Level (MRL) testing of honey collected from treated hives. The online tool developed has allowed the NBPSP to feed into AUSPest*Check*™.

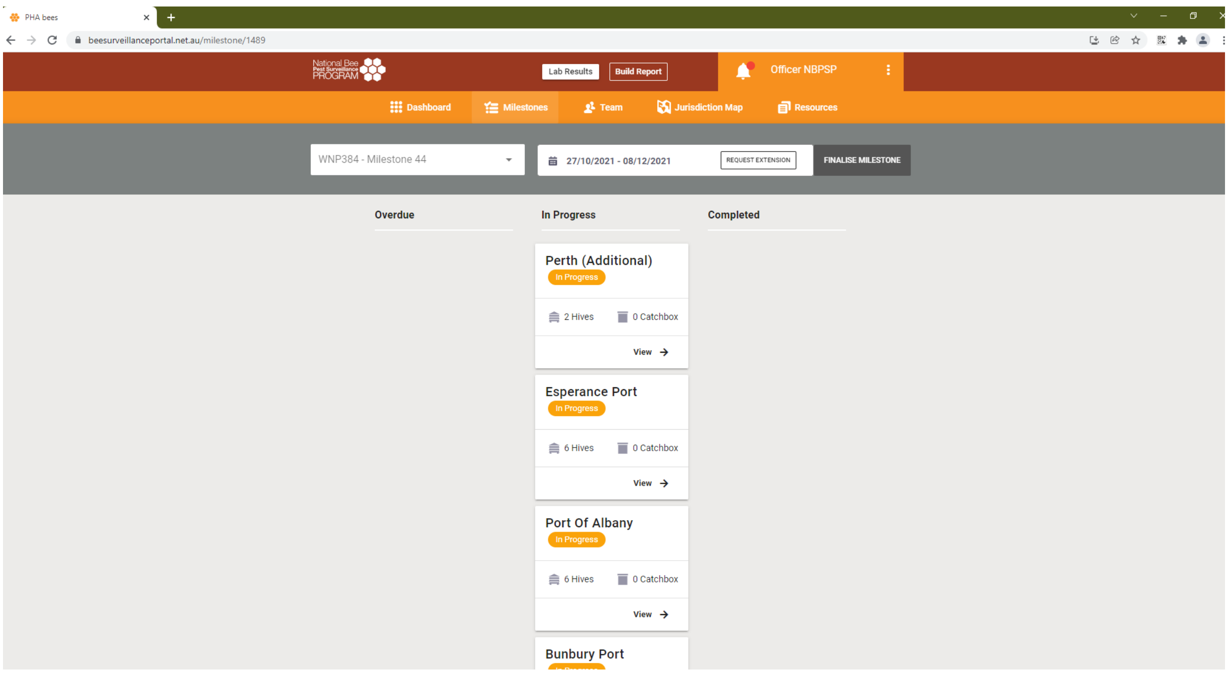


Figure 10 Snapshot of the Bee Surveillance Portal used for data collection and PHA NBPSP management.

The first iteration of the Portal has been a very significant step forward in ensuring apiary officers provide data to the required standard, however it was built to cover only the range and frequency of activities in the current program and assumed all jurisdictions would undertake exactly the same types of activities.

With the NBPSP concluding in December 2021 and, during negotiation with partners on a new version of the program, it has become clear that different activities and frequency of delivery of these activities will be required to better address pest risk and take into account seasonal variation across jurisdictions. An important example is the use of new surveillance tools and techniques such as rainbow bee-eater pellet analysis. Data collection from these new methods currently cannot be entered into the Portal. Other examples are modifications to frequency of surveillance activities, the bulk upload of data from sugar shake blitzes carried out by NSW with amateur beekeepers, the central collation of swarm capture data from our ports of entry or the inclusion of surveillance activities from our external territories such as Norfolk Island. These activities cannot be included into the current Portal, and effort is required to facilitate their capture into AUSPest*Chec*k™ to support Australian pest free status.

At its core, the current Portal was built using a software stack that is normally used for informational websites. As such, while originally cheap to build, the site is complex, and there are limitations around the maintenance and flexibility to reengineer the application to keep it functional and stable. PHA will be working with program partners in the new NBPSP commencing in 2022 to identify funding to support redevelopment of the Portal.

d. Upgrading and deploying new remote catchboxes

Catchboxes (empty bee hives) deployed around ports are usually manually inspected for the presence of bee swarms. As part of enhancements in 2020-2021, a proof-of-concept remote surveillance device was tested (Figure 11), resulting in upgrades to 28 remote catchboxes (Figure 12). These remote catchboxes notify apiary officers and PHA in real time if a swarm has entered and will allow users to remotely close the catchbox to capture a swarm. These catchboxes expanded surveillance to cover remote locations and provide increased sensitivity for early detection of bee swarms at high risk or remote sites.

Figure 11 Design of the RCB-Original (2014 design)

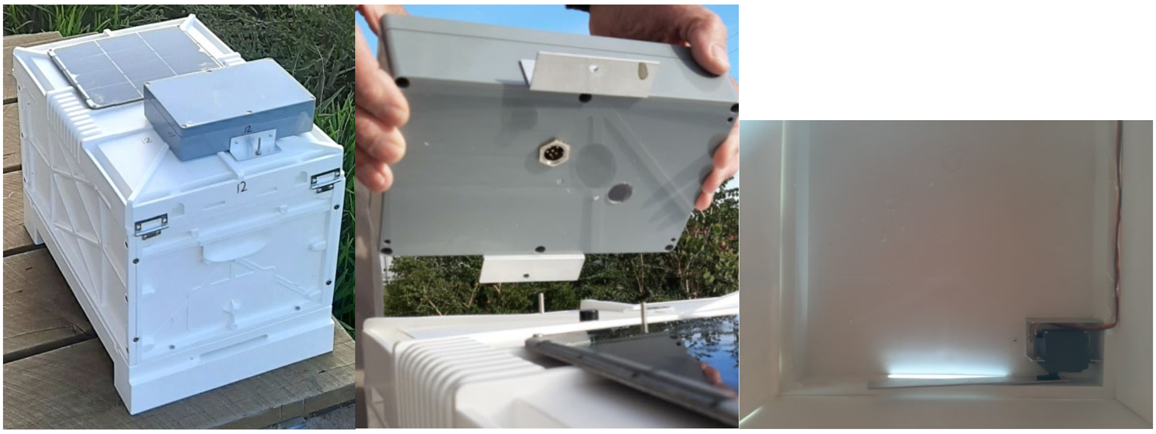


Figure 12 Design of the RCB-V2 (2020 design). The box is the industry preferred Nuplas catchbox, the solar panel is half the size of the original, the electronics are in a detachable weatherproof box, and the internals of the catchbox have been simplified, with minimal (as possible) wiring.

In addition, PHA developed a separate website application which is being used for reporting and monitoring of the Remote Catchboxes. This website manages connectivity to the deployed boxes and send email alerts directly to our apiary officers when newly arriving swarms are detected (Figures 13 & 14).

Figure 13 Landing page for the Remote Catchbox website

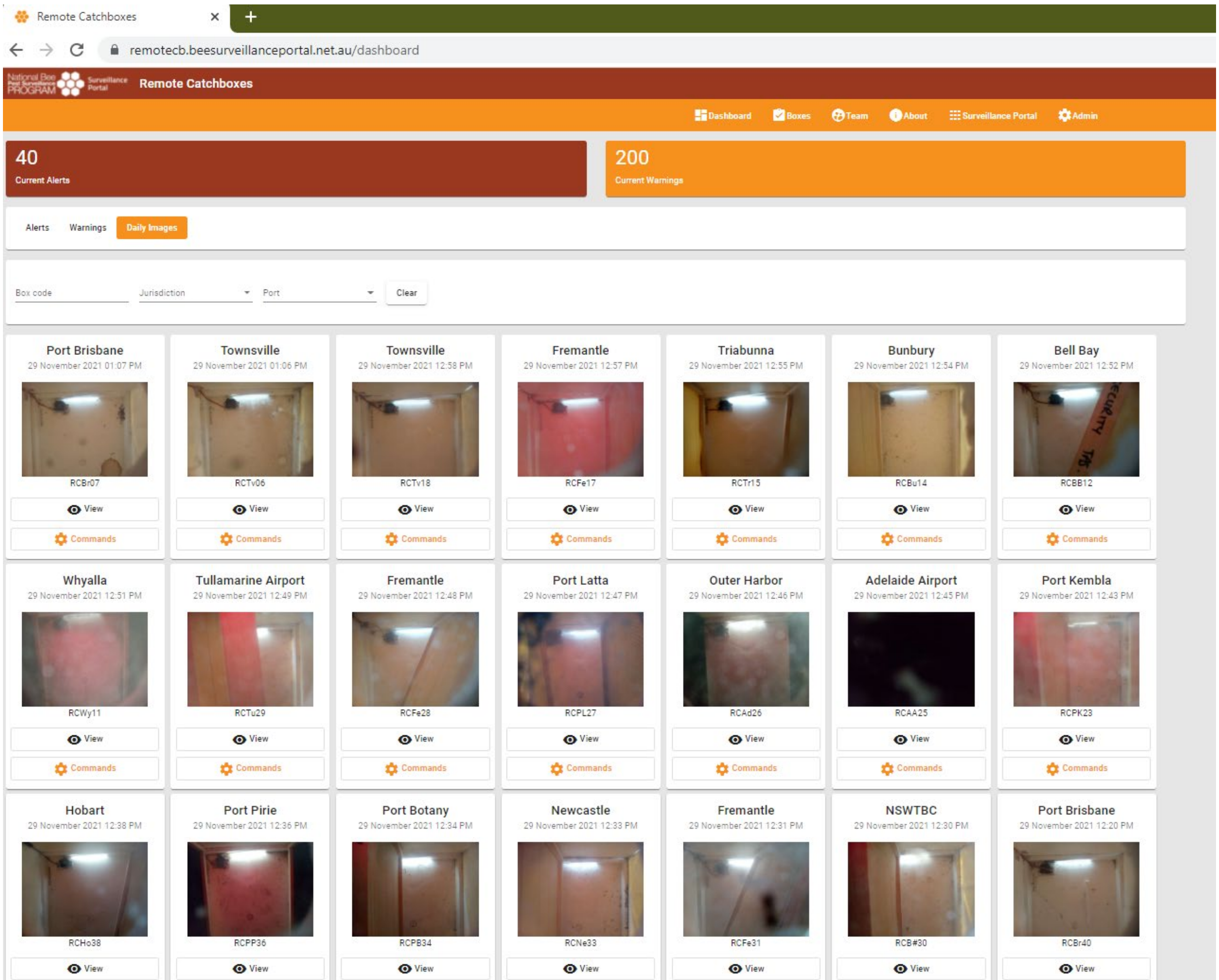


Figure 14 Daily images provided to the website for each of the deployed remote catchboxes

The remote catchboxes were the first of their kind deployed into the NBPSP, however improvements are needed to ensure sensitivity in early detection of new swarms potentially carrying Varroa. Remote catchboxes have been identified as useful surveillance tools for covering remote sites along the Australian coastline, as they allow PHA and apiary officers to observe whether a swarm has entered an empty catchbox, and close the hive remotely. In the current system, 28 remote catchboxes were deployed. Over the last 18 months of deployment further important improvements have been identified that would enhance their usability and robustness for deployment in the field.

e. Asian hornet surveillance

Asian hornets are significant predators of honey bees and can cause human health concerns. To evaluate techniques to improve surveillance for Asian hornets at high-risk sites, traps were deployed at four ports (Darwin, Brisbane, Port Botany, Melbourne/Tullamarine). This work tested the performance of an overseas commercial trap, a simple, locally made version of this trap and a commercial Asian hornet lure under Australian conditions. While no Asian hornets were captured over the 12-month trial period, deployment and use of traps for surveillance and early detection was deemed unsuccessful due to the large amount of by-catch (Figures 15 & 16) and the deterioration of the lure in Australia. Consultation with industry and government on the importance of surveillance for Asian hornets and other hornet species such as giant Asian hornets identified that while surveillance for these pests was considered a high priority, efforts should focus on improved awareness for port workers and in areas surrounding high risk sites.

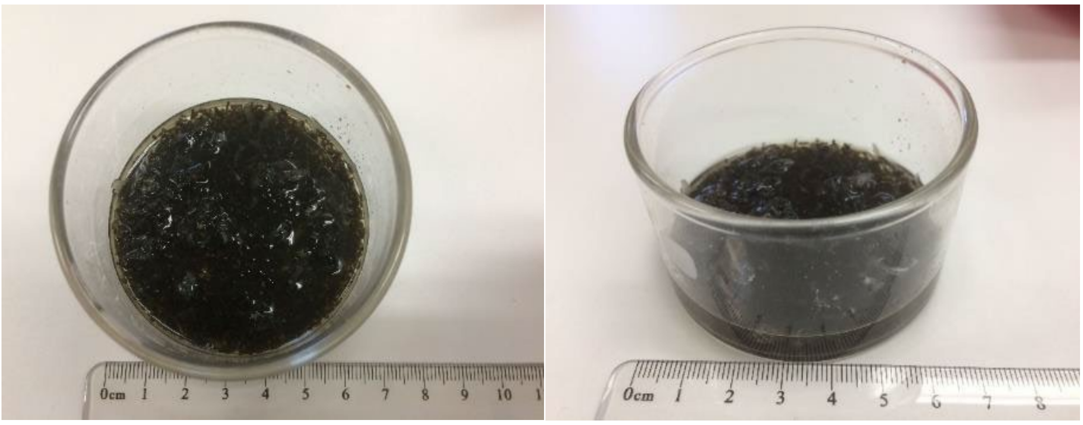


Figure 15 Typical contents of one trap (from Brisbane). Photo: Chris Palmer

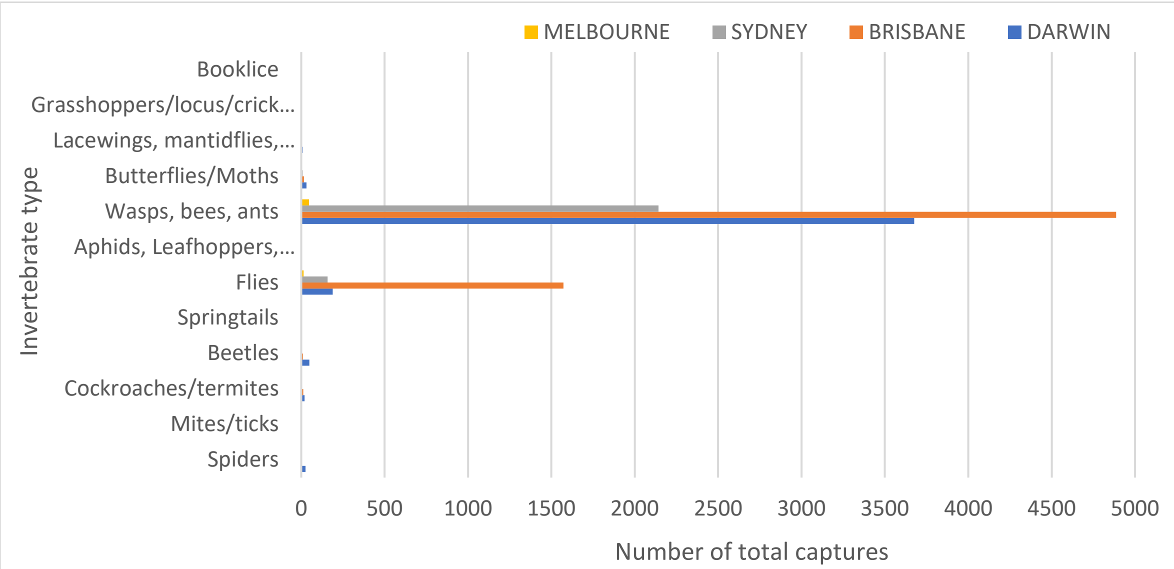


Figure 16 Total number of specimens captured in traps (combined commercial and non-commercial trapping types) across the four port locations. Over 12,900 specimens were capture. Across the four ports, 12 invertebrate types were represented, including nine insect orders and three non-insect arthropod orders. The top three orders of captured invertebrates were from Hymenoptera (wasps, bees and ants; 10,757 specimens), Diptera (flies; 1,933 specimens) and Coleoptera (beetles; 66 specimens).

DAWE undertook a risk assessment for the Giant Asian hornet and Asian hornet in 2020 and identified the most likely risk pathway for entry into Australia is an overwintering (mated) female that hitchhikes in or on goods (containers, machinery, pottery etc.). This is similar to the Brown marmorated stink bug (BMSB) entry pathway (overwintering hitchhiker), and DAWE identified that managing the risks for entry of BMSB will also mitigate the risks of Asian hornets and Giant Asian hornets. DAWE suggests post border surveillance focus for Asian hornet and Giant Asian hornets should be in places where you would find BMSB, given the hitchhiking nature of both. The trapping trial undertaken through the NBPSP showed that there is no specific trap or lure suitable for early detection for these hornets, however awareness and circulation of information on the hornets were recommended, given the size and visibility of the hornets most likely will not go unnoticed. Information can be circulated to the DAWE Border Surveillance Team, seaport and airport staff/stevedores and with beekeepers (through Bee Biosecurity Officers deployed in all state departments of agriculture).

Capacity and capability building

Collaboration with other projects

This project has actively collaborated with other organisations and projects to provide benefit to the industry's biosecurity preparedness.

1. **The Australian Governments' *Agricultural Competitiveness White Paper* (government's plan for stronger farmers and a stronger economy) grant 2017-2020.**

This grant sought to support a range of enhancements that would increase the chance of early detection of bee pests. Of the six projects part of this grant, the following were specifically targeted to building Australia's capacity and capabilities in responding to new incursions and improving early detection.

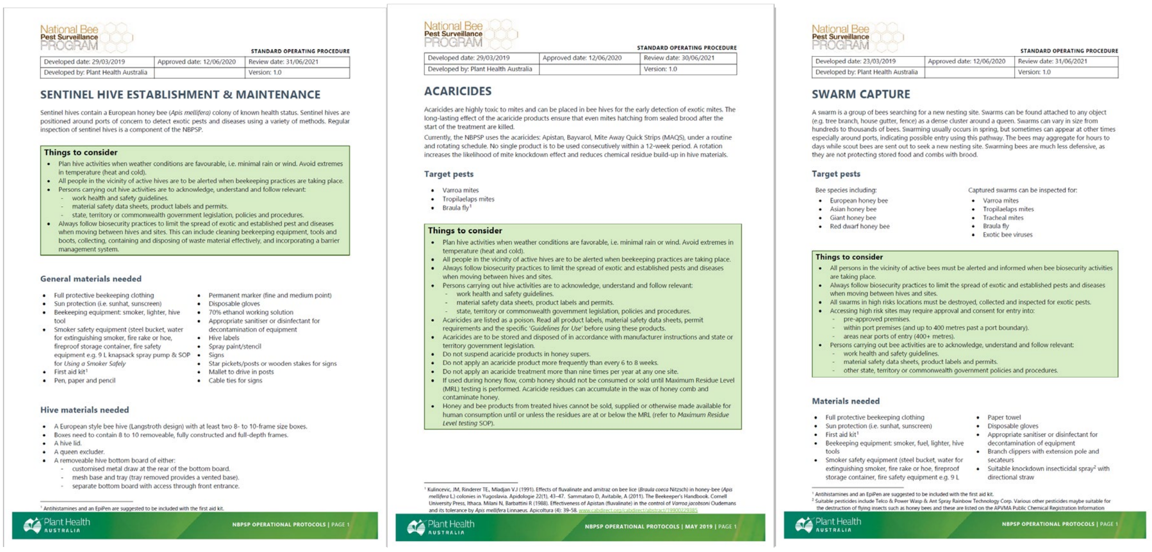
a. National Diagnostic Protocol – exotic bee viruses

This project enabled capacity building in bee virus diagnostics within CSIRO and at AgriBio in Victoria. and developed protocols for sampling, processing, and molecular diagnostics to become more streamlined and robust for quick uptake by new users.

Early engagement with staff at AgriBio, Victoria enabled this lab to establish virus assays and strengthen Victoria's capability with several opportunities. AgriBio have tested several bee samples showing wing deformities from Victorian hives, which were found to be negative for exotic viruses. In addition, collaboration has occurred as part of a separate project funded by Hort Innovation, providing bee virus diagnostics for imported honey bees. Having this capability at AgriBio allowed CSIRO to validate and verify the tests. Further consideration for establishing and maintaining bee virus (and other pathogens) diagnostics at multiple labs is needed and CSIRO have been in discussion with Department of Primary Industries and Regional Development (DPIRD) about establishing bee virus diagnostics in Western Australia. Travel restrictions have prevented any progress on this, however DPIRD are looking to host John Roberts in early 2022 to provide training for virus testing. Lastly, a National Diagnostic Protocol for the molecular detection of exotic honey bee viruses was drafted and is currently out for review and when finalised will be a valuable resource for building new lab capability.

b. Reviewing and updating operational protocols

To improve national consistency in the methods undertaken in the NBPSP, an Operations Manual consisting of 19 Standard Operating Procedures (SOPs) has been developed, reviewed, and updated. Information for these SOPs has been collated from apiary officers, diagnosticians, and overseas researchers, to ensure all activities related to bee surveillance are relevant, consistent, and written in a meaningful format for use in the NBPSP or in an incursion response (Figure 17).


National Bee Pest Surveillance PROGRAM

STANDARD OPERATING PROCEDURE

Developed date: 29/03/2019	Approved date: 12/06/2020	Review date: 31/06/2021
Developed by: Plant Health Australia		Version: 1.0

SENTINEL HIVE ESTABLISHMENT & MAINTENANCE

Sentinel hives contain a European honey bee (*Apis mellifera*) colony of known health status. Sentinel hives are positioned around ports of concern to detect exotic pests and diseases using a variety of methods. Regular inspection of sentinel hives is a component of the NBPSP.

Things to consider
- Plan hive activities when weather conditions are favourable, i.e. minimal rain or wind. Avoid extremes in temperature (heat and cold).
- All people in the vicinity of active hives are to be alerted when beekeeping practices are taking place.
- Persons carrying out hive activities are to acknowledge, understand and follow relevant:
  - work health and safety guidelines.
  - material safety data sheets, product labels and permits.
  - state, territory or commonwealth government legislation, policies and procedures.
- Always follow biosecurity practices to limit the spread of exotic and established pest and diseases when moving between hives and sites. This can include cleaning beekeeping equipment, tools and boots, collecting, containing and disposing of waste material effectively, and incorporating a barrier management system.

General materials needed
- Full protective beekeeping clothing
- Sun protection (i.e. sunhat, sunscreen)
- Beekeeping equipment: smoker, lighter, hive tool
- Smoker safety equipment (steel bucket, water for extinguishing smoker, fire rake or hoe, fireproof storage container, fire safety equipment e.g. 9 L knapsack spray pump & SOP for *Using a Smoker Safely*
- First aid kit[1]
- Pen, paper and pencil
- Permanent marker (fine and medium point)
- Disposable gloves
- 70% ethanol working solution
- Appropriate sanitiser or disinfectant for decontamination of equipment
- Hive labels
- Spray paint/stencil
- Signs
- Star pickets/posts or wooden stakes for signs
- Mallet to drive in posts
- Cable ties for signs

Hive materials needed
- A European style bee hive (Langstroth design) with at least two 8- to 10-frame size boxes.
- Boxes need to contain 8 to 10 removeable, fully constructed and full-depth frames.
- A hive lid.
- A queen excluder.
- A removeable hive bottom board of either:
  - customised metal draw at the rear of the bottom board.
  - mesh base and tray (tray removed provides a vented base).
  - separate bottom board with access through front entrance.

[1] Antihistamines and an EpiPen are suggested to be included with the first aid kit.

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National Bee Pest Surveillance PROGRAM

STANDARD OPERATING PROCEDURE

Developed date: 29/03/2019	Approved date: 12/06/2020	Review date: 30/06/2021
Developed by: Plant Health Australia		Version: 1.0

ACARICIDES

Acaricides are highly toxic to mites and can be placed in bee hives for the early detection of exotic mites. The long-lasting effect of the acaricide products ensure that even mites hatching from sealed brood after the start of the treatment are killed.

Currently, the NBPSP uses the acaricides: Apistan, Bayvarol, Mite Away Quick Strips (MAQS), under a routine and rotating schedule. No single product is to be used consecutively within a 12-week period. A rotation increases the likelihood of mite knockdown effect and reduces chemical residue build-up in hive materials.

Target pests
- Varroa mites
- Tropilaelaps mites
- Braula fly[1]

Things to consider
- Plan hive activities when weather conditions are favorable, i.e. minimal rain or wind. Avoid extremes in temperature (heat and cold).
- All people in the vicinity of active hives are to be alerted when beekeeping practices are taking place.
- Always follow biosecurity practices to limit the spread of exotic and established pests and diseases when moving between hives and sites.
- Persons carrying out hive activities are to acknowledge, understand and follow relevant:
  - work health and safety guidelines.
  - material safety data sheets, product labels and permits.
  - state, territory or commonwealth government legislation, policies and procedures.
- Acaricides are listed as a poison. Read all product labels, material safety data sheets, permit requirements and the specific *'Guidelines for Use'* before using these products.
- Acaricides are to be stored and disposed of in accordance with manufacturer instructions and state or territory government legislation.
- Do not suspend acaricide products in honey supers.
- Do not apply an acaricide product more frequently than every 6 to 8 weeks.
- Do not apply an acaricide treatment more than nine times per year at any one site.
- If used during honey flow, comb honey should not be consumed or sold until Maximum Residue Level (MRL) testing is performed. Acaricide residues can accumulate in the wax of honey comb and contaminate honey.
- Honey and bee products from treated hives cannot be sold, supplied or otherwise made available for human consumption until or unless the residues are at or below the MRL (refer to *Maximum Residue Level testing* SOP).

[1] Kulincevic, JM, Rinderer TE., Mladjan V.J (1991). Effects of fluvalinate and amitraz on bee lice (*Braula coeca* Nitzsch) in honey-bee (*Apis mellifera* L.) colonies in Yugoslavia. Apidologie 22(1), 43–47. Sammataro D, Avitabile, A (2011). The Beekeeper's Handbook. Cornell University Press, Ithaca. Milani N, Barbattini R (1988). Effectiveness of Apistan (fluvalinate) in the control of *Varroa jacobsoni* Oudemans and its tolerance by *Apis mellifera* Linnaeus. Apicoltura (4): 39-58. www.cabdirect.org/cabdirect/abstract/19900229385

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National Bee Pest Surveillance PROGRAM

STANDARD OPERATING PROCEDURE

Developed date: 23/03/2019	Approved date: 12/06/2020	Review date: 31/06/2021
Developed by: Plant Health Australia		Version: 1.0

SWARM CAPTURE

A swarm is a group of bees searching for a new nesting site. Swarms can be found attached to any object (e.g. tree branch, house gutter, fence) as a dense cluster around a queen. Swarms can vary in size from hundreds to thousands of bees. Swarming usually occurs in spring, but sometimes can appear at other times especially around ports, indicating possible entry using this pathway. The bees may aggregate for hours to days while scout bees are sent out to seek a new nesting site. Swarming bees are much less defensive, as they are not protecting stored food and combs with brood.

Target pests

Bee species including:
- European honey bee
- Asian honey bee
- Giant honey bee
- Red dwarf honey bee

Captured swarms can be inspected for:
- Varroa mites
- Tropilaelaps mites
- Tracheal mites
- Braula fly
- Exotic bee viruses

Things to consider
- All persons in the vicinity of active bees must be alerted and informed when bee biosecurity activities are taking place.
- Always follow biosecurity practices to limit the spread of exotic and established pests and diseases when moving between hives and sites.
- All swarms in high risk locations must be destroyed, collected and inspected for exotic pests.
- Accessing high risk sites may require approval and consent for entry into:
  - pre-approved premises.
  - within port premises (and up to 400 metres past a port boundary).
  - areas near ports of entry (400+ metres).
- Persons carrying out bee activities are to acknowledge, understand and follow relevant:
  - work health and safety guidelines.
  - material safety data sheets, product labels and permits.
  - other state, territory or commonwealth government policies and procedures.

Materials needed
- Full protective beekeeping clothing
- Sun protection (i.e. sunhat, sunscreen)
- First aid kit[1]
- Beekeeping equipment: smoker, fuel, lighter, hive tools
- Smoker safety equipment (steel bucket, water for extinguishing smoker, fire rake or hoe, fireproof storage container, fire safety equipment e.g. 9 L
- Paper towel
- Disposable gloves
- Appropriate sanitiser or disinfectant for decontamination of equipment
- Branch clippers with extension pole and secateurs
- Suitable knockdown insecticidal spray[2] with directional straw

[1] Antihistamines and an EpiPen are suggested to be included with the first aid kit.
[2] Suitable pesticides include Tetco & Power Wasp & Ant Spray Rainbow Technology Corp. Various other pesticides maybe suitable for the destruction of flying insects such as honey bees and these are listed on the APVMA Public Chemical Registration Information

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Figure 17 A selection of the updated Standard Operating Procedures for Bee Surveillance

c. **Improving AHB surveillance**

An additional component to the development of floral maps to improve sweep netting surveillance activities, a literature review has been finalised which identifies elements for improved detection of AHB. The review builds on work initially documented by Koetz (2013) and has compiled the information gathered since AHB was first detected in Cairns in 2007, as well as work undertaken overseas where AHB has been managed for pollination. The review provides recommendations for potential future activities to support surveillance for AHB.

2. **Improving resources to ensure national consistency in delivery project**

Supported by a new grant provided by DAWE in 2021, PHA has been building on the work already undertaken in developing the 19 SOPs by providing further improved resources for personnel involved in bee surveillance activities. This will be achieved through the development of specific training videos and a quick reference guide for field use. This project will collaborate with the NSW DPI apiary officer who will be involved in delivering the bee handling activities for the video component of the project which will be undertaken in March 2022. In addition, 150 hard copies of the quick reference field guide will be printed. This guide and the training video will assist complete one of the recommendations of the NBPSP Review (2020). The videos and guide will be made available to all personnel involved in bee surveillance and any incursion responses.

Review of the NBPSP

In 2019 an independent review of the NBPSP was commissioned by the NBPSP Steering Committee and PHA. The purpose of the review was to evaluate the relevance, capacity, quality, and viability of the program, to assist inform a future program. The review was undertaken by a third-party consultant (Biosecurity Advisory Service, Glanville 2020) throughout early 2020 by interviewing relevant stakeholders from each Australian jurisdiction, Hort Innovation, PHA, the bee industry and CSIRO, as well as reviewing relevant literature, and conducting a high-level economic analysis. The final report was received in September 2020. An out of session steering committee meeting was held to discuss the recommendations.

Thirteen specific recommendations were reported by Glanville 2020 to address the key issues identified in the review and to ensure that this essential program continues to perform effectively in the future. Table 7 provides a summary of these recommendations as agreed by the Steering Committee after a consultation meeting in September 2020. Included are any relevant updates as of November 2021.

Table 7 Recommendations outlined in the 2020 NBPSP Review as supported by the Steering Committee

Recommendation	Detail	Update
1	Plant Health Australia should commence facilitation of discussions between appropriate beneficiary industries and governments for a new funding agreement for the NBPSP.	Discussions have taken place throughout 2021 and is also an ongoing action in the future program to identify and secure a long-term sustainable funding source.
2	For the next iteration of the NBPSP post 2021, a consolidated program plan should be developed to guide the delivery and future direction of the program.	A program plan has been developed for delivery of a new NBPSP commencing in January 2022.
3	The full costs, including all	Work has been ongoing by

	funding sources of the NBPSP should be documented in future program plans and budgets.	all parties to identify the true costs for delivery of bee surveillance.
4	In designing the next iteration of the NBPSP, opportunities should be explored taking into account (a) strategies to encourage a more professional approach for volunteer beekeepers delivering program activities; (b) efficiencies that may be gained within the program; and (c) any agreed program enhancements.	Discussions have been held with all government agencies regarding involvement of industry collaborators (volunteer beekeepers). At least two jurisdictions will continue to use industry collaborators in the new program.
5	The NBPSP should continue to support flexible management of the program within jurisdictions, but where volunteer beekeepers are utilised more needs to occur to ensure consistency of standards.	A flexible model which involves industry collaborators (volunteer beekeepers) is being supported. Jurisdictions are to manage risks and ensure appropriate training is provided.
6	The NBPSP should support development of a training guide and appropriate supporting materials to ensure consistent training across Australia.	19 standard operating procedures have been developed. A quick reference field guide is being developed with support training videos which will delivered by mid-2022.
7 & 8	The NBPSP Steering Committee should advocate for a formal study into the sensitivity of early detection surveillance methods, for incorporation into the program as they become available and are cost effective. This could include more active involvement of beekeepers and other novel detection methods	
9	Consultation with jurisdictions should be conducted into whether it is possible to fine-tune sentinel hive placements and sweep netting locations based on the biology of bees and local knowledge.	Identification of the highest risk ports has been informed by the DAWE port risk assessment in 2020. Identification of sweep netting locations is guided by floral maps of these ports. Hive placement at ports is

		guided by accessibility, security and proximity to cargo unloading areas.
10	Additional techniques for enhancing the early detection of exotic Asian honey bees, particularly those infected with varroa mites, should be considered for inclusion within the NBPSP.	Improvements to techniques for detection of bee pests and pest bees is a high priority, and should be considered within any future program.
11	A new risk assessment of potential entry points for bee pests and pest bees should be conducted to guide the design of the next version of the NBPSP.	The risk assessment was completed by DAWE in 2020 and has guided the design for a further 3 years. A re-assessment of ports should be undertaken every 3 years.
12	NBPSP managers should regularly explore the use of newer technologies to improve the sensitivity of detection, as well as reduce labour costs.	NBPSP managers continue to keep track of new technologies and diagnostics tools, and are aware of several research projects that may inform future activities.
13	A cohesive communications program or strategy should be developed for the NBPSP, including more communications about the value of the program and associated negative data, as well as promotion of early reporting by beekeepers.	NBPSP managers are working with jurisdictions, and stakeholders to embed targeted and frequent communications in the project that will operate between 2021-2024.

Outcomes

This project set out to deliver the following outcome:

Implementation of an enhanced national surveillance program targeting 18 pests, ultimately protecting, and improving the health of honey bees against pests, and safeguarding the pollinator-reliant industries.

This project has achieved:

- Over 76,000 surveillance records generated for 18 priority pests of honey bees.
- Improving the chances of eradication of new pests through early detection before they become established and spread to production areas comprising:
    - Surveillance across 33 ports ranging between high, medium, low, and unknown risk for potential establishment of bee pests and pest bees.
    - Surveillance activities undertaken at Norfolk Island, in recognition of the pristine honey bee population at this location as well as its close proximity to New Zealand, which increases the potential for a Varroa mite incursion hitchhiking to the mainland.
    - An improved understanding of methods of Asian hornet surveillance in Australia and increased awareness of Asian hornet threats amongst national border surveillance staff.

    - Development of techniques and protocols for detection of honey bee viruses.
    - Assessment and implementation of surveillance techniques specific to the threat of entry and establishment of Asian bee species in northern Australia.
- Further improved existing techniques and delivery of surveillance activities which increase the sensitivity in detection of exotic pests of concern, providing long term benefits for the honeybee and pollinator reliant industries. These included:
    - The development of 19 standard operating procedures to ensure a nationally consistent approach in activities to improve confidence in early detection.
    - New tools developed and implemented nationally including remote catchboxes to increase the coverage of surveillance for bee swarms in remote areas and assessment of rainbow bee-eater pellets to detect Asian bee species
    - Development of the first National Diagnostic Protocol for the honey bee industry (for honey bee viruses)
    - Networking and collaboration with key institutions to build capacity and capability for surveillance and diagnostics.
- Managing bee surveillance data in a way that is more efficient, meets national standards for reporting and is recorded in a system that can deliver feedback to a range of different target audiences:
    - Development and incorporation of the Bee Surveillance Portal (version 1) which has improved the arrangements for capturing, collating, sorting, curating, and sharing bee surveillance data.
    - Formal reporting into AUSPest*Check*™ and internationally to the OIE to improve transparency, collaboration and create stakeholder confidence on NBPSP delivery.

Monitoring and evaluation

Key evaluation questions	Relevant	Project-specific questions
Effectiveness		
1. To what extent has the project achieved its expected outcomes?	HIGH	Has the project improved upon and enhanced the National Bee Pest Surveillance Program, while maintaining the health status of European honey bees and safeguarding the pollination needs of Australia's agricultural industries?
Relevance		
2. How relevant was the project to the needs of intended beneficiaries?	HIGH	To what extent has the project met the needs of the honey bee industry in managing the health status and maintaining freedom of exotic bee pests and pest bees, and ultimately providing ongoing healthy bee colonies for pollination services?
Process effectiveness		
3. How well have intended beneficiaries been engaged in the project?	MEDIUM	To what extent were target industry levy payers engagement on the progress of the NBPSP achieved? Have regular updates on the NBPSP data collected, research outcomes been provided through linkages with industry and govt. communications?
4. To what extent were engagement processes appropriate to the target audience/s of the project?	HIGH	Did the level & type of project engagement with industry levy payers and various target audiences meet their preferred style? How accessible were communications and media releases to various audiences?
Efficiency		
5. What efforts did the project make to improve efficiency?	HIGH	What efforts did the project make to improve program management and delivery?
Other (if any)		
Include any project-specific question determined important for your project here	HIGH	How were new R&D initiatives developed through this program accepted by stakeholders? Have the new activities been rolled-out nationally?

Effectiveness

This project has been effective at maintaining the ongoing surveillance activities at ports throughout Australia, the first points of entry for exotic pests. This has been achieved through delivery of surveillance activities through government jurisdictions along with the collaboration with Australian Border Surveillance Teams and while also engaging/encouraging the industry to become involved in surveillance activities (such as on Norfolk Island). Diagnostic procedures for the detection of bee pests have also been developed and delivered through this project.

Measurement of project effectiveness in improving surveillance outcomes is evidenced through the regular collation of data and submission of this data into AUSPest*Check*™. Surveillance data collation has improved in both quantity and regularity of collation, from a base of only approximately 480 data points annually at the commencement of the project to over 125,000 data points in 2021. In addition, the program has been enhanced over the years in its effectiveness for early detection with an increase in 57 sentinel hives deployed, 127 more catchboxes and the rollout of remote catchboxes, and the incorporation of exotic bee virus diagnostics. The project has been coordinated by PHA to provide national consistency, improvements to collaboration between government jurisdictions and the honey bee industry, management of sample collection for diagnostic laboratories and collation of surveillance data.

Relevance

The honey bee industry is aware of its biosecurity risks and biosecurity is a significant topic of discussion and interest at industry events, highlighting the importance of biosecurity to growers and levy payers; as seen in a separate program management by PHA, the National Bee Biosecurity Program (NBBP). The NBBP has benefited from this project (MT16005) has it has been able to improve biosecurity awareness and skills for pest detection amongst beekeepers undertaking hive inspections and being aware of the importance of moving healthy hives to key pollination events (i.e., almond pollination annually). This project has improved the honey bee industry's biosecurity preparedness (through the establishment of improved diagnostic capacity nationally and coordinating surveillance activities with over 20 volunteer beekeepers nationally) and the industry's exotic pest surveillance system (by targeting activities at some of the highest entry points, improving data collection to support pest freedom claims), ultimately benefiting all beekeepers and the hives they operate either for commercial or non-commercial purposes. Benefits from this project to the honey bee industry have significant relevance and flow on effects for horticultural industries through provision of healthy hives that support pollination.

Process Effectiveness

The honey bee industry and relevant pollinator-reliant industries has received updates about the project through communiques available on the PHA website, and relevant media updates on projects developments in PHA Tendrils and BeeAware newsletters, and project updates in industry magazines. Project partners from government and the honey bee industry have been engaged through regular updates as well as participation on the NBPSP Steering Committee which provided a governance and monitoring role for project activities.

Provision of industry articles and updates provided for industry newsletters, were developed based on guidelines provided by these channels to meet the needs of their audiences.

Efficiency

This project has sought ways to improve the capacity and capabilities in government jurisdictions to conduct surveillance, including the collection and submission of samples and ensuring appropriate diagnostic tests are available. The project embedded a strong component of national management to coordinate and improve collaboration across all project partners. To achieve the project's required outcomes, efficiencies have been sought wherever possible. This has involved the significant linkage with a range of projects funded by the Australian government to leverage benefits and enhance surveillance and diagnostic activities. For example, this project tested and deployed remote catchboxes which provided improved surveillance in remote locations. The project also incorporated an online data and management website which aimed to improve efficiency of data collation and data quality and improve management of subcontracts with partners.

Other

MT16005 has embedded two significant research projects which aim to build stronger foundations for further R&D projects. Remote sensing technology (as seen in the remote catchboxes) was rolled out nationally, and is seen by jurisdictions as a way to improve their responsiveness to newly arriving EHB and AHB swarms. This is important for highly mobile swarms and to increase the likelihood of detecting exotic pests that can hitchhike on bees. Future R&D will be required to fine-tune these technologies and to incorporate other smart technologies being developed to improve management of bee health. The development of diagnostics assays, sampling techniques and the associated National Diagnostics Protocol for honey bee viruses is a significant step for the industry in preparedness and national capacity in detecting these potentially devastating diseases. Though this work has increased national capacity and capability through training undertaken at AgriBio, stakeholders acknowledge other labs need to be trained to cover surge capacity in responses. In addition, other molecular based tests which can detect multi-pests/pathogens from one sample should be further investigated. Rapid field tests and development of high throughput tests able to detect multiple pests from one sample has the potential to significantly improve efficiency and decrease the turnaround time for results, increasing our detection timeframe and likelihood of containment and eradication of a pest.

Recommendations

The delivery of MT16005 has resulted in the following recommendations:

1. Identification of a sustainable funding model to support a National Bee Pest Surveillance Program

A critical issue for the NBPSP is the identification of a sustainable funding model to support long-term delivery of this program into the future. Current mechanisms for funding the NBPSP have been from Australian Government and plant industry levies through Hort Innovation, with additional funding from the Australian Honey Bee Industry Council and Grains Producers Australia. The Hort Innovation investment model is not suited to delivery of an operational surveillance program that requires considerable flexibility across a large number of partners. Any future program will require a sustainable stream of resourcing support for operational delivery and adequate program coordination to ensure consistency of deliver by a range of parties. A future NBPSP will require:

- Discussions between all beneficiary industries and governments for a new funding agreement.
- A consolidated program plan to guide the delivery and future direction and investment of the program.
- Biennial review of costs associated with any future program.
- A more flexible management of the program within jurisdictions through development of annual workplans as an option to accommodate resourcing issues.
- A communications program or strategy that includes communication about the value of the program and associated data, as well as promotion of early reporting by beekeepers. This will aid in securing long term investment from industry beneficiaries.

2. Enhancing national surveillance efforts for honey bee pests

Despite the many successes of the NBPSP (2016-21), it is recognised further improvements have been identified to improve national surveillance outcomes. These include:

- Strategies to encourage a more professional approach for industry collaborators (volunteer beekeepers) delivering program activities.
- Enhanced post-border surveillance for exotic viruses and other biosecurity threats. The sentinel hive network has good geographic distribution but is limited in the number hives used for surveillance. Additional activities that test larger number of samples from commercial and non-commerical beekeepers would strengthen surveillance, particularly for claims of area freedom. This surveillance could take many forms such as working with beekeeping clubs to submit samples for testing, coordinating with bee biosecurity officers to collect additional samples during American Foulbrood (AFB) surveillance, and engaging with regional pollination events to increase sampling levels.
- Improved consistency and efficiency in sample collection by field staff. Consolidation of sample collection for surveillance of multiple targets would simplifying activities for field staff and make hive visits more efficient. Bee samples collected for virus testing are suitable for tracheal mite testing (particularly DNA testing), as well as potential for molecular tests for external mites, i.e., Varroa and Tropilaelaps.
- Ongoing consultation with jurisdictions to fine-tune sentinel hive placements and sweep netting locations based on the biology of bees and local knowledge.
- Additional techniques for enhancing the early detection of exotic Asian honey bees, including expansion of aerial ballooning and assessment of rainbow bee-eater pellets, and investigation of catchboxes more suited to Asian bee species.
- New technologies to improve the sensitivity of detection of bee pests, as well as reduce labour costs.
- Completion of a risk assessment of potential entry points for bee pests and pest bees every 3 years to ensure surveillance activities are being performed at priority locations for early detection.
- Improvement of remote catchboxes to make them more robust and integrate the remote catchbox website to the Bee Surveillance Portal.
- Redevelopment of the Bee Surveillance Portal to provide greater flexibility and functionality to support the differing activities being undertaken to target the differing risk profiles across jurisdictions delivering

the NBPSP.

3. Building capacity and capability for surveillance and diagnostics for bee pests

MT16005 maintained and improved the network of individuals undertaking surveillance and developed awareness and training material to increase capacity and capability. Continued work is required in this area however including:

- Development of awareness material and implementation of a communications program about bee pests and pest bees and hornets, specifically targeting urban or peri-urban communities in close proximity to ports of entry.
- Development and delivery of a training workshop(s) for morphological dissection of bees for tracheal mites and for molecular assessment for honey bee viruses.
- Investigation of requirement for additional training videos or support material to improve national consistency of delivery of surveillance techniques.

4. Improving diagnostics to support early detection of pest threats and to improve surveillance coverage

MT16005 and collaborative projects investigated and developed several areas of improved diagnostics for honey bee pests. Further work is needed to improve the efficiency and effectiveness of diagnostics to support early detection of new pests including:

- Development of high-throughput tests for the range of bacterial, fungal, viral and insect pests that impact bee hive health and horticultural productivity. This could also include the use of high-throughput sequencing approaches that would allow surveillance for multiple bee pest targets as well as detection of unexpected or emerging plant virus threats that may be carried in pollen by bees.
- Development of additional National Diagnostic Protocols for high priority pests of bees.
- Expansion of the existing National Diagnostic Protocol for honey bee viruses to include high-throughput RNA extraction to increase efficiency of diagnostic processes and support surge capacity in the event of an incursion.
- Development of loop-mediated isothermal amplification (LAMP) diagnostic assays to provide an option for rapid in-field testing for bee viruses and mites.
- Investigation of cold-storage for sample collection and transport to diagnostic laboratories to ensure high quality samples are received for testing honey bee viruses.
- Development of genetic tests for assessment of bees captured in catchboxes or swarms for the detection of *A. m. capensis* and *A. m. scutellate* to increase efficiency and effectiveness of surveillance outcomes and support surge capacity.
- Investigation of the development of diagnostics tests based on honey samples to target multiple bee pests, including viruses and mites.

Refereed scientific publications

No refereed scientific papers were prepared as part of this project.

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Intellectual property, commercialisation and confidentiality

No commercialisation or confidentiality issues to report.