Senate Rural and Regional Affairs and Transport References Committee

Questions on Notice – Wednesday, 23 March 2011
Joint Private Briefing
CANBERRA

Inquiry into the science underpinning the inability to eradicate the Asian honey bee

Question Number	Page No's.	Witness	Question asked by	Answered
1-5	-	DAFF	Committee	31/03/11
1	-	DAFF	Committee	31/03/11

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1	-	BSG (DAFF)	Committee	31/03/11
1-2	-	Dr Anderson, CSIRO	Committee	06/04/11

Senate Rural Affairs and Transport References Committee and House of Representatives

Joint Private Briefing - Asian Honey Bee incursion

Wednesday 23 March, 2011

Questions on Notice

The Committee would be grateful for the following information and documents:

1. Details regarding the membership of the Asian Honeybee National Management Group, the Consultative Committee on Emergency Animal Disease and the Consultative Committee on Emergency Plant Pests, the technical expertise of each member and the relationship between these entities in relation to consideration of the containment and or eradication of the Asian Honeybee;

2. As per above, the genesis of the decision to transfer to CCEPP the primary responsibility for consideration of the incursion and the date at which the transition occurred;

3. A copy of a report prepared by Dr Evan Sargeant presenting scientific analysis of the presence of the Asian Honeybee in the Cairns region;

4. A copy of a report prepared by Dr Roger Pascin, Principal Veterinary Officer, Epidemiology, Department of Primary Industry Victoria;

5. A copy of a CSIRO report provided to the National Management Group concerning likely pathways for the spread of varroa mite; and

6. Information relating to a swarm of asian honeybees at the Cairns Airport in the week beginning 14 March 2011.

In addition, the committee would appreciate the following information and documents:

1. The representatives of the honey bee industry and related industries who are signatories to the EADRA.

2. Information around the various meetings that have been conducted, including CCEAD, CCEPP, NMG and Risk assessment group/s. The Committee would like information regarding dates, attendees, and any minutes/notes/reports that are available.

Senate Rural Affairs and Transport References Committee and House of Representatives

Joint Private Briefing - Asian Honey Bee incursion

Wednesday 23 March, 2011

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Question:

Details regarding the membership of the Asian Honeybee National Management Group, the Consultative Committee on Emergency Animal Disease and the Consultative Committee on Emergency Plant Pests, the technical expertise of each member and the relationship between these entities in relation to consideration of the containment and or eradication of the Asian Honeybee.

Response:

The management structure for Asian honeybees follows the requirements of the Emergency Plant Pest Response Deed (EPPRD) – a legally binding agreement between the Australian Government, state and territory governments and plant based industries that are signatories to the deed.

Decisions under the EPPRD are made by a National Management Group (NMG), comprised of the chief executive officers of the Commonwealth and state/territory departments of agriculture and primary industries, representatives of affected peak industry bodies, Plant Health Australia and a representative of the Department of Sustainability, Environment, Water, Population and Communities. The Australian Honey Bee Industry Council represented its industry at the Asian Honey Bee National Management Group. Other pollination reliant industries, were approached at the peak representative level to join the response, but declined.

The NMG takes into account technical advice from the Consultative Committee on Emergency Plant Pests (CCEPP).

The CCEPP for Asian honeybees was comprised of Chief Plant Health Managers from each state and territory, the Chief Plant Protection Officer of the Department of Agriculture, Fisheries and Forestry, a representative of the Australian Honey Bee Industry Council and Plant Health Australia. Members of the CCEPP have lengthy experience in assessing and eradicating emergency plant pests and diseases.

Prior to transitioning to the CCEPP, the Consultative Committee for Emergency Animal Diseases (CCEAD) meeting as the Consultative Committee for Asian Honey Bees (CCAHB) was responsible for the provision of technical advice to the NMG. The CCEAD for Asian honeybees comprised Chief Veterinary Officers from each state and territory, the Chief Veterinary Officer of the Department of Agriculture, Fisheries and Forestry and Animal Health Australia. Members of the CCEAD have lengthy experience in assessing and eradicating emergency animal diseases.

It is standard practice for CCEAD members to co-opt technical experts to attend the CCEAD meetings and provide technical input. Throughout the CCEAD meetings, various technical experts from each of the jurisdictions participated in the technical discussions.

In addition, representatives would have sought advice from additional jurisdictional experts prior to attending the meeting.

Question:

As per above, the genesis of the decision to transfer to CCEPP the primary responsibility for consideration of the incursion and the date at which the transition occurred.

Response:

On the initial detection of Asian honeybees in Queensland, it was agreed to manage the initial response activities under the provisions of the Emergency Animal Disease Response Agreement (EADRA) as Asian honeybees are hosts of *Varroa* mites. Further investigation with the detection and testing of Asian honey bee nests did not lead to any evidence of *Varroa* mites, *tropilaelaps* mites or tracheal mites (*Acarapis woodi*), all of which are listed under the EADRA as pests of bees.

At that time, Asian honey bees were not listed as a pest species and therefore were not covered by any cost sharing arrangements under the EADRA or the Emergency Plant Pest Response Deed (EPPRD).

In March 2009, Queensland prepared a response plan proposing national cost-sharing for the Asian honey bee response. The response plan was prepared against the requirements of the EADRA. In May 2009, Plant Health Australia, at the request of its members and as custodians of the EPPRD, commenced considering options to vary the EPPRD to specifically include bee pests and pest bee species.

In July 2009, the National Biosecurity Committee determined that the current, and any future incursion of Asian Honey bees, should be managed in accordance with the EPPRD as the potential impact of the bee was as a 'plant pest' rather than an animal disease. The decision was also reflective of the parties that may be impacted by an incursion of a bee pest or pest bee species, including the pollination reliant industries that are parties to the EPPRD.

In November 2009, the Primary Industries Ministerial Council (PIMC) agreed that the Asian honey bee eradication program should be managed in accordance with the EPPRD.

All parties to the E ADRA and the EPPRD, have agreed to transition bee pests to the EPPRD and to the inclusion of the Asian honey bee as a pest bee in the EPPRD.

Question:

A copy of a report prepared by Dr Evan Sargeant presenting scientific analysis of the presence of the Asian Honeybee in the Cairns region.

Response:

A copy of the requested report is provided at Attachment A.

Question:

A copy of a report prepared by Dr Roger Paskin, Principal Veterinary Officer, Epidemiology, Department of Primary Industries, Victoria.

Response:

A copy of the requested report is provided at Attachment B.

Question:

A copy of a CSIRO report provided to the National Management Group concerning likely pathways for the spread of Varroa mite.

Response:

The Department of Agriculture, Fisheries and Forestry believes that the report requested is a Rural Industries Research and Development Corporation sponsored report May 2010 titled *'Future Surveillance Needs for Honeybee Biosecurity'*. A copy of the report is provided at Attachment C.

This report was not considered by the members of the National Management Group as its focus is on incursions of *Varroa* mites (or other parasites of the European honey bee) and information on a model to assess potential surveillance systems, rather than pest bee species. The department is considering this report in the context of future activities for the Sentinel Hive program.

Question:

Information relating to a swarm of Asian honeybees at the Cairns Airport in the week beginning 14 March 2011.

Response:

The Department of Agriculture, Fisheries and Forestry understands that a feral swarm of Asian Honey bees was reported on or about 14 March 2011 after having been noticed by a member of the public at the Cairns domestic airport terminal. The department understands that the swarm was removed and destroyed under the guidance of Biosecurity Queensland.

Question:

The representatives of the honey bee industry and related industries who are signatories to the EADRA.

Response:

Signatories to the EADRA are:

- The Commonwealth of Australia
- The State of Queensland
- The State of New South Wales
- The State of Victoria

- The State of South Australia
- The State of Tasmania
- The State of Western Australia
- The Northern Territory of Australia
- The Australian Capital Territory
- The Australian Chicken Meat Federation Inc
- The Australian Egg Corporation Limited
- Australian Dairy Farmers Limited
- The Cattle Council of Australia Inc
- Australian Pork Limited
- The Sheepmeat Council of Australia Inc
- Woolproducers Australia
- The Australian Lot Feeders' Association Inc
- The Goat Industry Council of Australia
- The Australian Honey Bee Industry Council Inc
- Harness Racing Australia
- Equestrian Australia
- The Australian Racing Board
- The Australian Horse Industry Council.

Signatories to the EPPRD are:

- The Commonwealth of Australia
- The State of Queensland
- The State of New South Wales
- The State of Victoria
- The State of South Australia
- The State of Tasmania
- The State of Western Australia
- The Northern Territory of Australia
- The Australian Capital Territory
- The Almond Board of Australia Inc
- Apple and Pear Australia Limited
- The Australian Banana Growers' Council Inc
- The Australian Cane Growers Council Ltd
- The Australian Dried Fruit Association Inc.
- The Australian Honey Bee Industry Council Inc.
- The Australian Macadamia Society Limited
- The Australian Mango Industry Association Ltd.
- The Australian Olive Association Ltd.
- The Australian Onion Industry Association Inc.
- The Australian Plantation Products and Paper Industry Council
- The Australian Processing Tomato Research Council Inc.
- The Australian Table Grape Association Inc.
- The Australian Walnut Industry Association Inc.
- AUSVEG Ltd.
- Avocados Australia Ltd
- The Canned Fruit Industry Council of Australia Ltd
- Cherry Growers of Australia Inc

- Citrus Australia Ltd
- Cotton Australia Ltd
- Grain Producers Australia Ltd
- Nursery and Garden Industry Australia Ltd
- Queensland Fruit and Vegetable Growers Ltd
- Ricegrowers Association of Australia Inc
- Strawberries Australia Inc
- Summerfruit Australia Ltd; and
- Wine Grape Growers Australia Inc

Question:

Information around the various meetings that have been conducted, including CCEAD, CCEPP, NMG and Risk assessment group/s. The Committee would like information regarding dates, attendees, and any minutes/notes/reports that are available.

Response:

The Consultative Committee on Emergency Animal Disease met by teleconference on the following dates to consider Asian honey bees:

- 27 November 2008
- 19 March 2009
- 21 May 2009
- 25 June 2009
- 3 September 2009
- 11 December 2009
- 10 February 2010
- 23 April 2010; and
- 21 June 2010.

The Scientific Advisory Panel advising the members of the CCEAD in its consideration of Asian honeybees met by teleconference on 26 October 2009 and 30 November 2009. Membership of the Scientific Advisory Panel included representatives of the Commonwealth and state and territory government, CSIRO, the Australian Honey Bee Industry Council and Plant Health Australia.

The Plant Health Australia convened Categorisation Group (comprising representatives of the Commonwealth government, the state and territory governments, CSIRO and the Australian Honey Bee Industry Council) met to consider the categorisation of Asian honey bees under the provisions of the EPPRD on 22 March 2010.

The Consultative Committee on Emergency Plant Pests met by teleconference to consider Asian honey bees on:

- 29 October 2010
- 25 January 2011.

The Asian Honey Bee National Management Group considered Asian honey bees on the following dates:

- 28 January 2010
- 17 March 2010
- An out-of-session paper circulated in July 2010
- 3 September 2010
- An out-of-session paper circulated in October 2010
- 29 November 2010; and
- 31 January 2011.

The Asian Honey Bee Coordination Group (established to consider what actions against the bee, if any, will continue beyond 31 March 2011) has met by teleconference on:

- 15 March 2011
- 29 March 2011.

Communiqués of the Asian Honey Bee National Management Group meetings held on 3 September 2010 and 31 January 2011 have been issued and are publicly available on the DAFF website. A copy of the communiqués is provided at Attachment D.

A copy of the Consultative Committee on Emergency Plant Pests (CCEPP) paper to the National Management Group meeting of 31 January 2011, outlining the technical feasibility of eradication, is provided at Attachment E .

Senate Rural Affairs and Transport References Committee

Inquiry into the science underpinning the inability to eradicate the Asian Honey Bee

Public Hearing – Thursday, 24 March, 2011

Question on Notice

Re: Dr Denis Anderson, CSIRO

The Committee would appreciate receiving information regarding the positions Dr Denis Anderson has held on the DAFF CCEAD and CCEPP Committees and the role he played in meetings, discussions and decisions in relation to the eradication program (Asian Honey Bees).

Could the Committee please have copies of correspondence, minutes, advice etc between Dr Anderson and the CCEAD/CCEPP Committees regarding his official position on these DAFF Committees.

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Could the Committee please have copies of correspondence, minutes, advice etc between Dr Anderson and the CCEAD/CCEPP Committees regarding his official position on these DAFF Committees.

Response

Dr Anderson was a member of the Scientific Advisory Panel which advised the members of the Consultative Committee on Emergency Animal Disease (CCEAD) in its consideration of Asian honeybees. The Scientific Advisory Panel met by teleconference on 26 October 2009 and 30 November 2009. Membership of the Scientific Advisory Panel included representatives of the Commonwealth and state and territory governments, Plant Australia, the Australian Honey Bee Industry Council and CSIRO.

Meeting records from the Scientific Advisory Panel referencing comment from CSIRO include the following:

> ***SAP TC01 (26 Oct 2009) – FINAL minutes:***
>
> *<u>Bee survival in rainforests</u>*
>
> *The effect of drought and lack of permanent water supply in some rainforest areas was discussed. The foraging limit of the AHB is 3km and they are likely to carry water less distance than this. CSIRO indicated that the temperature affects the ability of the bees to carry/ travel to water. Extreme temperatures prohibit travel to water. But the water requirement of the bees is greatly dependent on the food source, e.g. nectar is 90% water so additional water requirements are low.*
>
> *Biosecurity Queensland indicated that in their experience there was no A. mellifera or A. cerana through the higher altitude rainforest. CSIRO indicated that in other countries there were different biotypes of A. cerana at higher altitudes. In both Borneo and Sulawesi, A. cerana was found at lower altitudes (<400 m) and altitude may provide a barrier to dispersion of the A. cerana. Bees in the A. cerana group live across a wide spectrum of climate. The incursion around Cairns involves the Java strain which has an inclination towards more tropical environments and therefore is probably eradicable in Cairns.*

SAP TC02 (30 Nov 2009) – DRAFT minutes:

8.4.2 Microsatellite testing

The panel discussed the need to increase microsatellite testing to look for 24 loci instead of 8. Qld suggested that by increasing the number of loci tested for this would improve understanding of relatedness of new detections to previous detections. CSIRO suggested that increased testing of loci would only be necessary to identify new incursion strains of AHB however varroa mite infection is a good proxy for new incursion as there is very low genetic variation within AHB.

Dr Anderson was also a member of the Plant Health Australia convened Categorisation Group (comprising representatives of the Commonwealth government, the state and territory governments, CSIRO and the Australian Honey Bee Industry Council) which met to consider the categorisation of Asian honey bees under the provisions of the EPPRD on 22 March 2010. Records of the categorisation group meeting are held by Plant Health Australia which has advised that only summary data is retained, not referenced to individual participants.

Dr Anderson attended the first meeting of the Consultative Committee on Emergency Plant Pests for its consideration of Asian honey bees on 29 October 2010. No comments from Dr Anderson are recorded in the meeting records.

Dr Anderson has also attended meetings of the Asian Honey Bee Coordination Group held on 15 March 2011 and 29 March 2011. The meeting record of 15 March 2001 reference the following contributions from Dr Anderson:

The following issues were also raised by Trevor Weatherhead from the Australian Honey Bee Industry Council:

Work would need to be carried out on identifying the viruses being carried by A. cerana javana so that Australian beekeepers would know what to expect. The Queensland Department had indicated, to Trevor Weatherhead, they are looking to do some work in this field. Dr. Denis Anderson indicated he had carried out some work with A. cerana javana overseas and they were carrying new viruses.
Dr. Anderson advised that the banning of live bee exports from Australia to the USA was as a result of the fear of Australian European bees getting new viruses from the Asian bees and then these viruses being introduced into the USA via the live bee exports. The Chair undertook to investigate and report back to the group at its next meeting….

…Comments from government sources that the pest was a concern for tropical regions only and would not spread past Brisbane. The Chair advised that she had been unable to confirm the department's comments on this issue but that she understood that the science is yet to be fully determined of where Java genotype of Apis cerana may become endemic in Australia but modelling indicates that it could naturalise to tropical and coastal regions. Dr. Denis Anderson indicated that, based on evidence of the types of environments that the Java genotype of Apis cerana had

recently colonised in New Guinea, that it was likely, in his opinion, that the bee would spread well past Brisbane into temperate regions.

In addition to the involvement outlined above, Dr Anderson is also a co-author of the Rural Industries Research and Development Corporation sponsored report of May 2010 titled *'Future Surveillance Needs for Honeybee Biosecurity'*. The department is considering this report in the context of future activities for the Sentinel Hive program. A copy of the report is provided at Attachment A.

Dr Anderson has also assisted the Department of Agriculture, Fisheries and Forestry by providing expert advice on honey bee health issues in relation to the import and export of bees.

At the invitation of the Department of Agriculture, Fisheries and Forestry, Dr Anderson attended a teleconference held in October 2010 with representatives of the United States Department of Agriculture that was called in response to rumours of a ban by the United States on the import of Australian honey bees. The Asian honey bee incursion in far-north Queensland and the health status of managed European honey bees in Australia were discussed at this teleconference.

Dr Anderson is also contracted by the Department of Agriculture, Fisheries and Forestry to write technical reports on specific diseases of quarantine importance for the review of queen honey bee imports.

Dr Anderson was also supported by the Department of Agriculture, Fisheries and Forestry to visit the United States in 2007 to assess colony collapse disorder, and contracted by the department in 2008 to carry out a survey of mites and diseases of bees in Papua New Guinea and Indonesia, which led to the discovery of a new type of varroa mite on European honeybees in Papua New Guinea.

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In addition to the involvement outlined above, Dr Anderson is also a co-author of the Rural Industries Research and Development Corporation sponsored report of May 2010 titled *'Future Surveillance Needs for Honeybee Biosecurity'*. The department is considering this report in the context of future activities for the Sentinel Hive program. A copy of the report is provided at Attachment A.

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Stage 2 Report

Review of likely eradicability of Asian honeybees (*Apis cerana*) in Queensland

Prepared for:
Biosecurity Queensland, Department of Employment, Economic Development and Innovation

25 October 2010

By: Dr Evan Sergeant

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Contents

Abbreviations

AHB	Asian Honey Bee
BQ	Biosecurity Queensland, Department of Employment, Economic Development and Innovation
DEEDI	Department of Employment, Economic Development and Innovation
IP	Infected Place (usually a nest or swarm)
PID	Positive identification (identification of one or more *A. cerana* bees at a location, not associated with a swarm or nest)
RA	Restricted Area for *A. cerana,* declared in an approximately 60 km radius around Cairns and district

Executive Summary

An established nest of Asian honeybees (*Apis cerana*) was first detected in North Queensland in 2007. A response was immediately implemented to establish the extent of the incursion with a view to eradicating this exotic bee species and any exotic parasites they might carry. By the end of 2007 the infestation was thought to have been eradicated and operations were scaled back to "proof of freedom" surveillance. However in July 2008 a nest was discovered 7 km south of the previous findings which led to further detections in the Cairns area. Since then a response has been maintained by Biosecurity Queensland, DEEDI, to detect and eliminate *A. cerana* nests. By 30 September 2010, 230 IPs (59 swarms and 171 nests) were detected and destroyed. This report presents the results of the analysis and interpretation of data collected during the response, with a view to determining the feasibility of successful eradication of this pest.

AHB detections continued sporadically until mid-2009, when numbers started to increase. During 2010, numbers of IPs detected have increased substantially, correlated with the increase in staff numbers during that time. AHB has now spread mainly south and west from Cairns, with foci detected at Mareeba, Lake Eacham/Atherton, Innisfail and south of Cairns between Gordonvale and Innisfail. Spread has also occurred to Yarrabah (east of Cairns) and the suburbs to the north of Cairns. However, all IPs detected to date (except for a single nest at Innisfail, just outside the RA) have been within the declared Restricted Area. Detection of nests and swarms during the incursion has relied on public reporting, supported by BQ surveillance, using a variety of methods. BQ has maintained an intensive surveillance program, which has increased with the availability of additional staff since early 2010, resulting in the dramatic increase in detections.

Seven indicators of likely eradicability of the incursion were identified and considered:

1. Extension of the incursion outside the RA
A. cerana has shown an ability to colonise and establish nests or swarms in a wide variety of locations and situations, including in vehicles, boats, containers and machinery, allowing spread to occur over considerable distances. To date, there has not been any identified spread to areas beyond the RA (other than Innisfail). Should such spread be detected it would indicate likely failure of eradication, unless there was strong evidence that the spread event was recent and that further local spread had not yet occurred.

2. Presence of undiscovered foci of infection within the RA
Currently, the extent of infection within the RA appears to be well defined. Detection of new, well established foci of infection in areas previously thought to be free of AHB would indicate failure of existing surveillance and probable failure of eradication.

3. Establishment of A. cerana within the rainforest
Currently *A. cerana* is thought not to persist within the rainforest, but will colonise at the margins so it can forage outside. Discovery of established nests within the rainforest would undermine this assumption and indicate probable failure of eradication.

4. Continued occurrence of isolated PIDs without detection of nests
There have been a small number of instances of single or small numbers of isolated PIDs being detected in an area and being unable to be traced to a nest (due to the failure to find additional bees to enable beelining). Continued occurrence of isolated PIDs in the absence of detectable nests would suggest that there are persistent undetected nests and swarms, leading to likely failure of eradication.

5. Numbers of detections
The numbers of nests and swarms detected have increased dramatically during 2010, reflecting the substantially increased staff numbers in the same period and the introduction of targeted sweeping, floral sweeping and bee traps since July 2010. Continued high numbers of detections in coming months would indicate an increasing bee population and likely failure of eradication. Conversely, decreasing numbers of detections could indicate likely success in eradication, but should be interpreted with caution due to the potential for confounding the issue due to a natural seasonal decline in numbers of bees foraging and hence numbers detected. Additional data over coming months is required to determine whether numbers will trend upwards or down.

6. Percentage or absolute number of swarms detected
The number of swarms present (and hence the number detected) is a function of the numbers of nests present, assuming that the efficiency of swarm detection remains unchanged. Therefore, a downward trend in the numbers (or percentage) of swarms each month would indicate potential for eradication, while an upward trend would indicate likely failure. Again this needs to be interpreted with care if seasonal effects are likely to be important. Currently, there is a downward trend since June 2010, but more data is required to confirm this trend.

7. Age of nests detected
Age of nests detected is another approximate guide to potential success of the eradication program. If the program is succeeding, we would expect to see the average age of detected nests getting progressively younger, to the extent that eventually nests will be consistently detected at an early age, before they have an opportunity to swarm, leading to eventual eradication. There is a slight downward trend in the mean age of nests detected since the beginning of 2010, although this is interrupted by an upward jump in August and September, associated with increased surveillance activity. Additional data is required to determine whether this trend will resume its downward direction or whether mean nest age will stay high, and also whether the range of ages will become narrower over time.

Conclusion and Recommendation

Based on the available data, eradication of AHB appears to be still feasible. However, given the widespread distribution of the incursion and the continuing detection of older nests and isolated bees which cannot be linked to a nest, successful eradication is not certain.

It is recommended that the current program continue for another six months to allow a clear trend in the above indicators to develop, with re-evaluation of progress at that time.

Background

An established nest of Asian honeybees (*Apis cerana*) was first detected in North Queensland in 2007. A response was immediately implemented to establish the extent of the incursion with a view to eradicating this exotic bee species and any exotic parasites they might carry. By the end of 2007 the infestation was thought to have been eradicated and operations were scaled back to "proof of freedom" surveillance. However in July 2008 a nest was discovered 7 km south of the previous findings which led to further detections in the Cairns area. A response plan was subsequently submitted to the Consultative Committee for Asian honeybees and to date has been based upon the principles of the AUSVETPLAN disease strategy. Up until June 2009 the response was fully funded by the Queensland Government and from then on through a national cost-sharing agreement until December 2010. Continuation of cost-sharing post-December 2010 depends on demonstration that eradication of the incursion is feasible.

AusVet Animal Health Services has been retained by Biosecurity Queensland to undertake a review and analysis of the surveillance data and make recommendations as to likely eradicability of the incursion. This review has been done as a 2-stage process. The first stage comprises a site visit to the Cairns incident control centre, a review of available surveillance data and development of a plan for completion of stage 2. Stage 2 includes an analysis and interpretation of the data collected in stage 1, to provide guidance on whether or not the incursion is still eradicable.

This report presents the results of the analysis and interpretation of data under stage 2 of the investigation.

Deliverables

Project deliverables were specified for the two stages as:

1. An interim report delivered at the completion of Stage 1, describing the data available and outlining proposed analyses (completed).
2. A final report will be provided at the completion of stage 2, providing detailed analysis of the data and recommendations as to likely eradicability and on any other issues identified during the analysis, as appropriate (this report).

Methods

Site visit

A site visit to the Cairns control centre was undertaken from 13-16 September 2010. Key activities undertaken during the site visit included:

- Tour of parts of RA for familiarisation with operational aspects of the program and nest detection/destruction
- Identification and collection of data sources to be used and collection of copies of selected data
- Discussions with Wim De-Jong, Russell Gilmour and other staff at the control centre on:

- program operations and surveillance activities
- specific data requirements and aspects of data management related to the proposed analyses and
- *A. cerana* biology and potential for modelling the incursion

Data available

Data at Cairns is managed in a combination of systems, including Excel spreadsheets (IP and PID lists and details and negative surveillance data), Nor Sqcr (surveillance data up to August 2010) and BioSIRT (positive surveillance data from August 2010). ArcGIS is used for mapping based on these data sources.

The following data sources were obtained for analysis in stage 2:

- Excel spreadsheet of IPs location and destruction
- Excel spreadsheet of all positive identifications
- Excel spreadsheets of negative surveillance data
- Excel spreadsheet of surveillance data to 1 August 2010 extracted from Nor Sqcr
- Excel spreadsheet of positive surveillance data from BioSIRT
- Summary of field staff numbers from SitReps
- Other miscellaneous data and maps

Planned analyses

Proposed analyses to be undertaken as part of stage 2 were (subject to data availability):

- Analysis of spatial and temporal patterns of IPs and PIDs for outbreak
- Comparison and trends of numbers of swarms vs numbers of nests detected
- Analysis of age of nests detected and changes over time
- Comparison of detections between different surveillance methods
- Evaluation of surveillance coverage of the RA
- Evaluation of positive identifications not leading to subsequent nest detection
- Simulation modelling to estimate potential outbreak size
- Other analyses, as appropriate

Results

Overview of the response

The initial incursion was detected in Cairns port area in May 2007. Since then a response has been maintained by Biosecurity Queensland, DEEDI, to detect and eliminate *A. cerana* nests. By the end of 2007 the infestation was thought to have been eradicated and operations were scaled back to "proof of freedom" surveillance. However in July 2008 a nest was discovered 7 km south of the previous findings which led to further detections in the Cairns area. At this time the response was fully funded by the Queensland Government, which limited the number of staff that could be devoted to the response. For a time only sporadic detections were made but from mid-2009, numbers of detections started to slowly increase and in early 2010 national agreement was reached to fund the response until December 2010, allowing employment of additional staff specifically for the response. By 30 September 2010, 230 IPs (59 swarms and 171 nests) were detected and destroyed.

Detection of *A. cerana* nests and swarms relies on two primary surveillance mechanisms:

1. Public reporting

Throughout the response there has been very strong public support and a local educational and promotional campaign to encourage public reporting of unusual bees, nests or swarms by the general public. This has received strong support, with about 50% (117/230) detections being directly reported by the public (88% for swarms and 38% for nests).

2. Surveillance by Biosecurity Queensland staff

The other main means of detection is based on a range of surveillance activities undertaken by BQ staff. These activities include:

- Grid sweeping – inspection of areas based on a defined 2 x 1 km grid, with sweep netting of any bees or similar insects for identification.
- Targeted Sweeping – inspection of specific areas where *A.cerana* is known to occur, with sweep netting of any bees or similar insects for identification using a planned and mapped system.
- Bee-eater pellets – examination of regurgitated pellets of bee-eater birds at known roosts for presence of *A. cerana* wing fragments. This provides an indicator of bee activity (or lack thereof) in an area but is of little value for detecting nests or swarms.
- A variety of swarm and bee traps to attract and contain bees.
- Floral sweeping – recording of floral species where *A. cerana* was detected in early grid-sweeping data and analysis of this data has allowed targeting of specific floral species for sweep netting, with significant success.
- Revised bee trapping – based on problems and lack of success experienced with early traps, modified bee traps were developed and implemented from June 2010. These traps appear to be much more successful for the detection of forager bees than earlier attempts.
- Beelining – once a forager bee is detected, either by sweep netting or trapping, beelining is undertaken to identify the location of the nest(s) of origin of the bees.
- Odour detection dog – a dog has been trained and a dog handler appointed and both will commence surveillance in early November 2010.

Surveillance activities have occurred throughout the Restricted Area which covers a range of environments e.g. urban areas, coastal lowlands, rainforests and savannah etc.

Rainforests have proved the most difficult area for surveillance, due to density and terrain (mountains), but where possible rainforests have been surveyed. Some examples are:

- Rainforest behind Cairns (west) – by surveying 14.5 kilometres along a road that goes through rainforest to Copperlode Dam.
- Rainforest north west of Cairns through to Kuranda – by surveying at stops along the "skyrail" tourist attraction.
- Rainforest between Goldsborough Valley and Babinda – by surveying along an old forestry track and walking paths.
- Rainforest on the tablelands – by surveying old forestry tracks, roads through rainforest and walking paths.

No *A. cerana* activity was found in this surveillance.

Overall, 75% (108/144) of initial positive identifications were made by grid, targeted or floral sweeping.

Once detected, nests and swarms are immediately destroyed.

Temporal pattern of the outbreak

The first nest (IP1) was discovered in May 2007, as were an additional four IPs. In total, 7 IPs were detected by the end of 2007, 18 (including 2 swarms) by end of 2008 and 57 (16 swarms) by the end of 2009. During 2010, numbers have increased substantially, as shown in Figures 1 & 2, to a total of 230 by the end of September, of which 59 were swarms.

Figure 1. *A. cerana* nests and swarms detected and approximate field staff numbers by calendar quarter

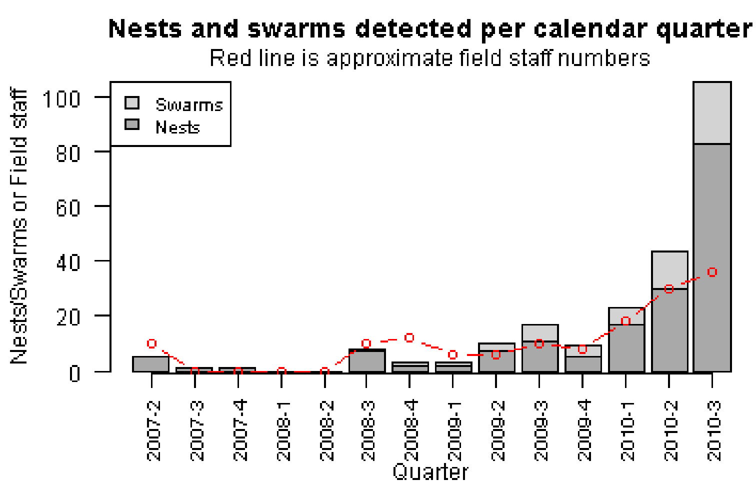
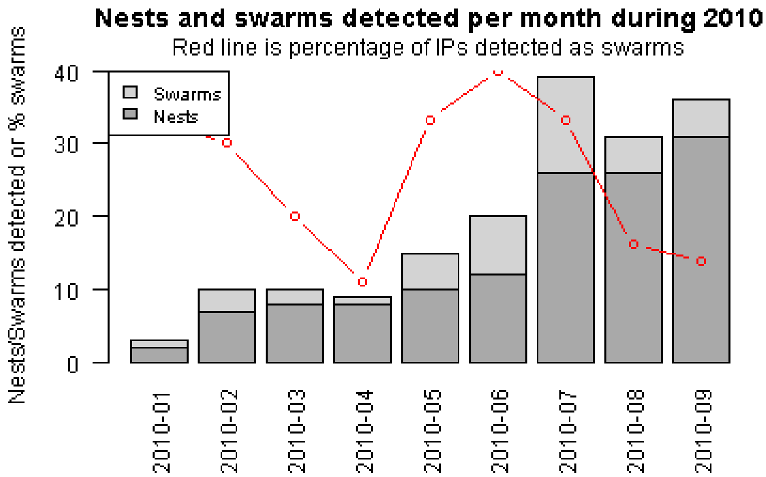


Figure 2. *A. cerana* nests and swarms detected and percentage of detections as swarms by month during 2010.

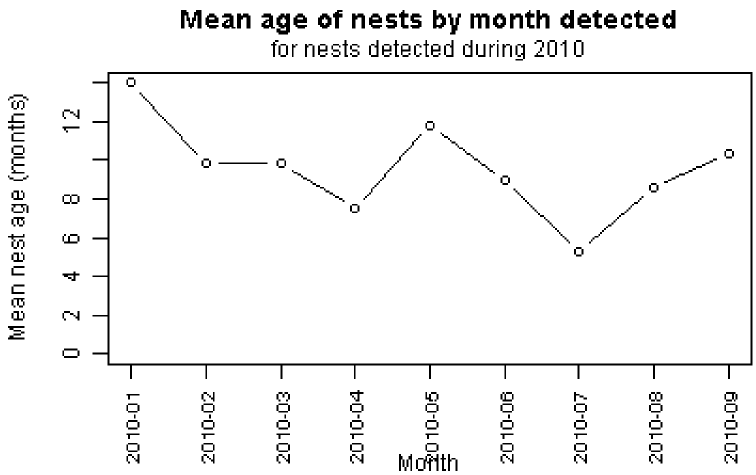


As is apparent from Figure 1, the rapid increase in the numbers of detections during 2010 has coincided with a substantial increase in field staff numbers over the same period. The major increase in detections in the third quarter of 2010 also coincided with the introduction of improved surveillance methods for detection of nests, particularly improved bee traps, targeted sweeping and "floral sweeping" from mid 2010. Inspection of the data also suggests that there may be some seasonality to detections, with more detections occurring during the middle of each year. However the low numbers of detections prior to 2010 make this difficult to interpret, as does the correlation with field staff numbers.

Although overall numbers of IPs detected increased dramatically during 2010, both the absolute numbers and the proportion of IPs that were swarms declined during August and September, compared to previous months, providing a possible early indicator of success. However, additional data over a longer period would be required to confirm this trend.

Where possible, nests were collected and examined following destruction to determine approximate nest age. Ages ranged from a few weeks to a maximum of about 2 years (detected in August 2010). Of 135 nests that were aged, 85% (114/135) were aged as being 12 months or less, while the remaining 15% (21/144) were estimated as between 13 and 24 months of age. Mean age of nests destroyed each month since January 2010 is summarised in Figure 3, and shows a general downward trend to about July, followed by an upward kick in August and September.

Figure 3. Mean age of nests detected each month during 2010



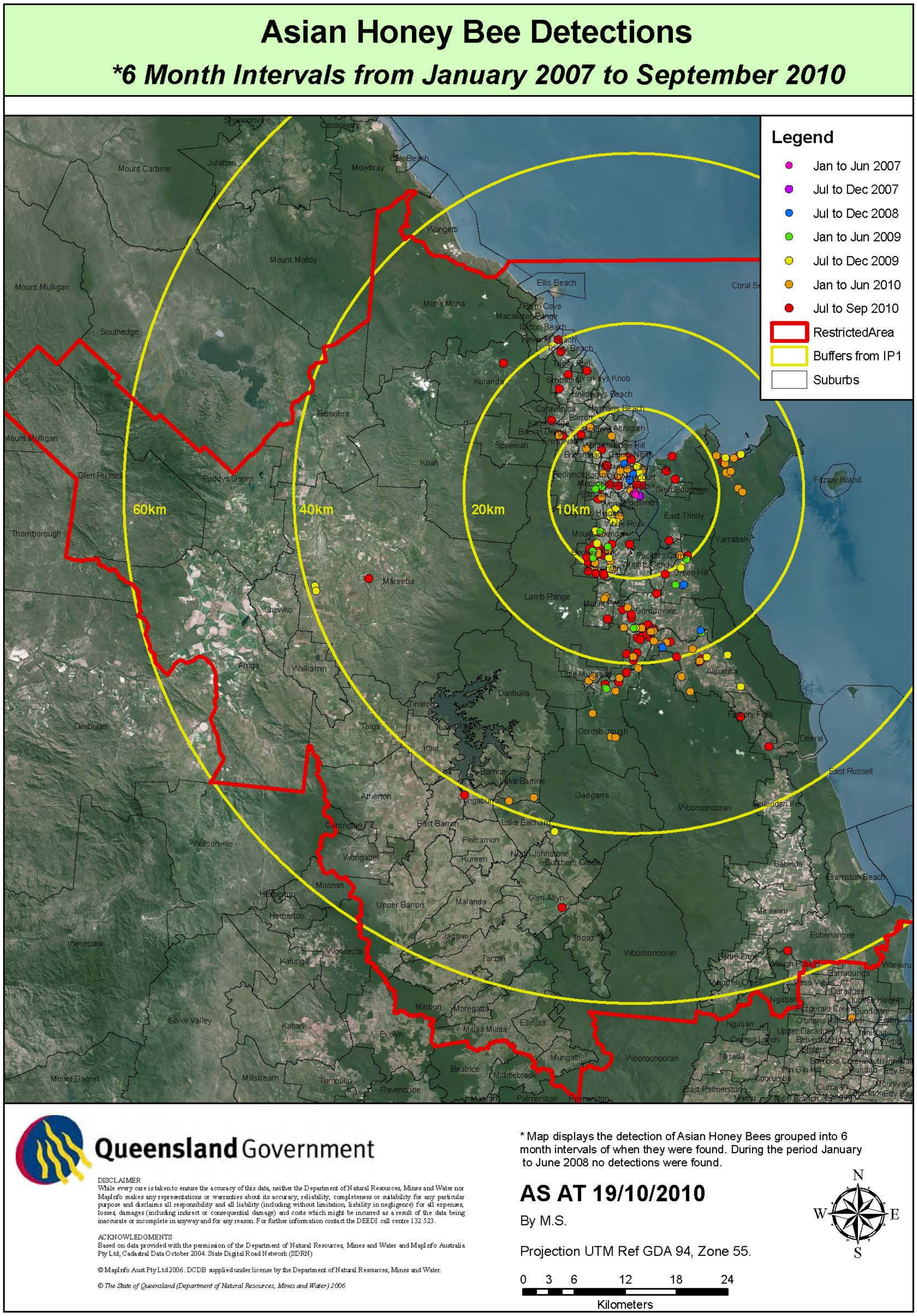
Spatial patterns of the outbreak

The locations of all IPs detected are displayed in Figure 4, summarised according to the period in which they were detected., In addition, detections during each six-monthly period are shown in Appendix 1. All of the early IPs detected were located within a few kilometres of IP1, in and around Cairns City. It wasn't until the second half of 2008 and early 2009 that IPs were detected up to 20 km away in the Green Hill (IPs 8 & 9) and Aloomba areas (IP 18 and 19), south of Cairns along the Bruce Highway.

Up to mid 2009, detections remained localised to Cairns City and within 20-25 km south of the city along the Bruce Highway and into the Goldsborough valley. However, in the second half of 2009, the first IPs outside this area were detected at Mareeba, 40 km west of Cairns (IPs 40 and 43, August 2009) and Lake Eacham, 45 km south-west of Cairns, where a single swarm (IP 57) was detected in December 2009. In the first half of 2010, the infested area extended further up the Goldsborough Valley and additional outlying nests were detected at Lake Eacham (IPs 73 and 114, March and June 2010) and Innisfail (70 km south of Cairns and outside the Restricted Area; IP 84, April 2010). In addition, a single PID was detected at Atherton, about 8 km west of the closest known IPs at Lake Eacham. A small number of detections also occurred at Yarrabah, to the east of Cairns in late 2009, extending southwards during 2010. Similarly, a small number of detections occurred to the north of Cairns for the first time in June 2010, with increasing numbers detected in the second half of the year.

Finally, between July and September 2010, IPs were detected further south along the Bruce highway from Cairns, at Deeral, 35 km south (IPs 144 and 221) and Waugh's pocket, 60 km south (IP 212). Additional IPs were also detected at Lake Eacham (IP 150) and Mareeba (IP 179), as well as at Glen Allyn (south of Lake Eacham, IP 169). An isolated PID, which was the remnant of a dispersed swarm resulting from a public notification, was also detected at Malanda, about 9 km west of the nest at Glen Allyn.

Figure 4. ***A. cerana*** **detections during each six-monthly period from January 2007 to September 2010**



In summary, the great majority of detections have been in the immediate vicinity of Cairns City or within 20-30 km to the south of the city along the Bruce Highway or in the Goldsborough Valley. Outlying detections have occurred to the east in the Yarrabah area, which is largely surrounded by rainforest, to the south at Deeral, Waugh's Pocket and Innisfail and to the west on the tablelands at Mareeba, Lake Eacham, Atherton, Glen Allyn and Malanda. The infestation also appears to be slowly moving northwards from Cairns. Most of the detections outside the main area in and to the south of Cairns have occurred during 2010, except for Mareeba and the first detection at Lake Eacham, which were detected in late 2009.

Surveillance

As mentioned, the main surveillance activities for detection of nests and swarms, other than public notifications are grid or targeted net sweeping, floral sweeping and bee traps. Grid sweeping has been used throughout the response, as have various forms of lures and traps. However, targeted sweeping (targeted at known *A cerana* infested areas), floral sweeping (targeted at known preferred floral hosts) and modified bee trapping (improved over previous methods) only commenced from June/July 2010. Figure 5 shows the temporal pattern of surveillance activity from July 2009 to September 2010 and Figures 6 and 7 show the distribution of sweep activity (grid, targeted and floral combined), and bee traps, respectively, during 2010. Understandably, surveillance activity is correlated with staff numbers during the period (see Figure 1 for approximate staff numbers). Since April, the mean number of sweeps per month has been in the range of 4,000 to 5,000 plus.

Figure 5. Monthly surveillance activity from July 2009 to September 2010

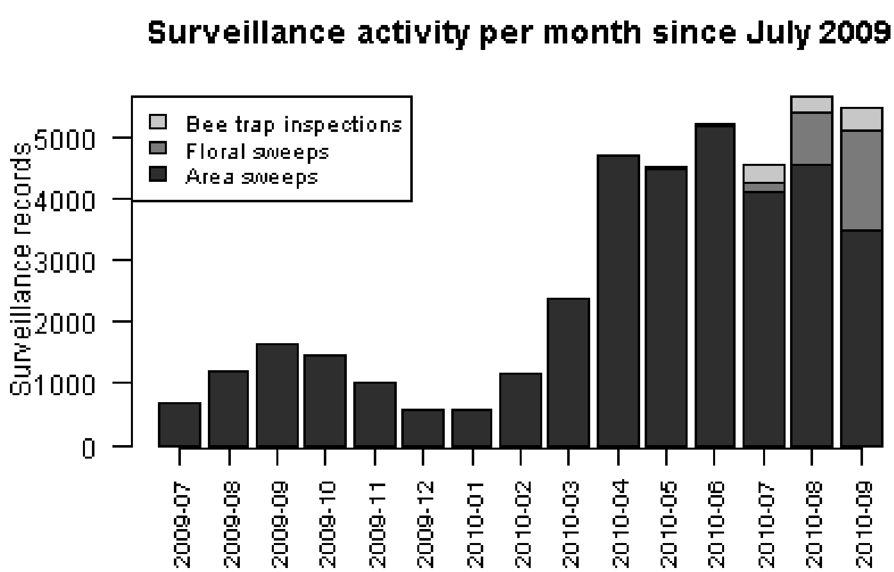


Figure 6. Distribution of AHB grid and floral sweeping activity from January to September 2010, by month

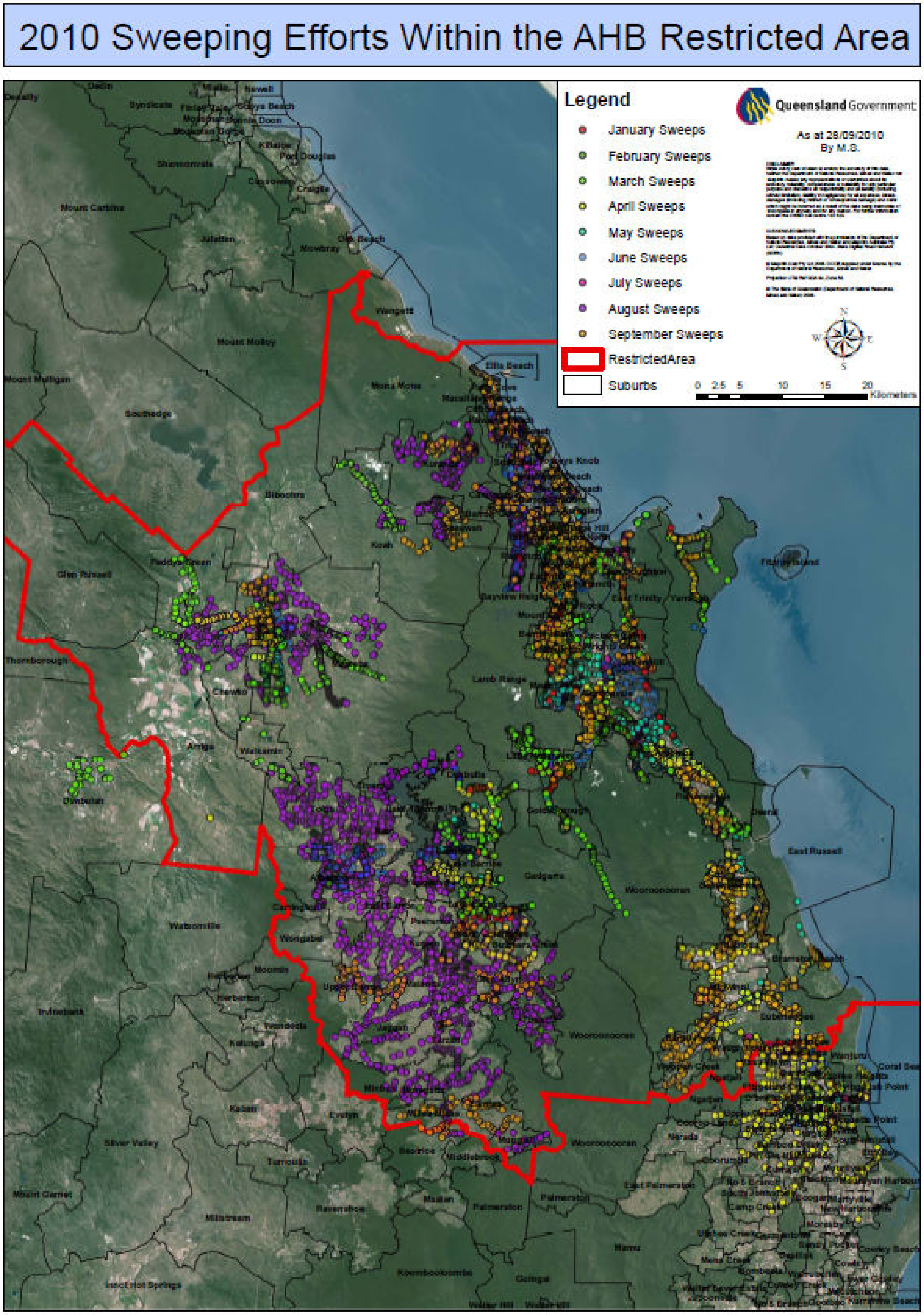
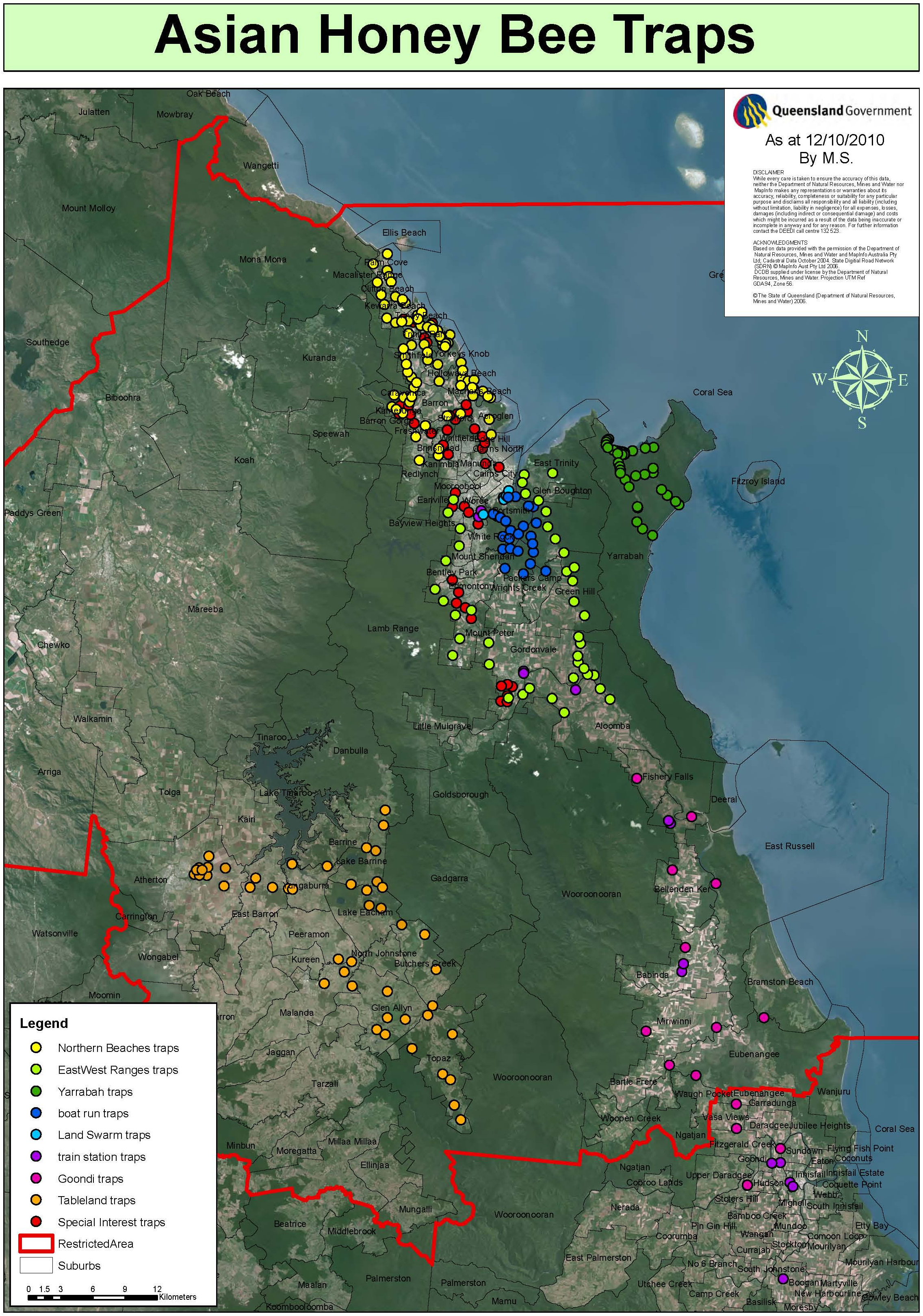


Figure 7. Distribution of AHB bee traps from June to September 2010

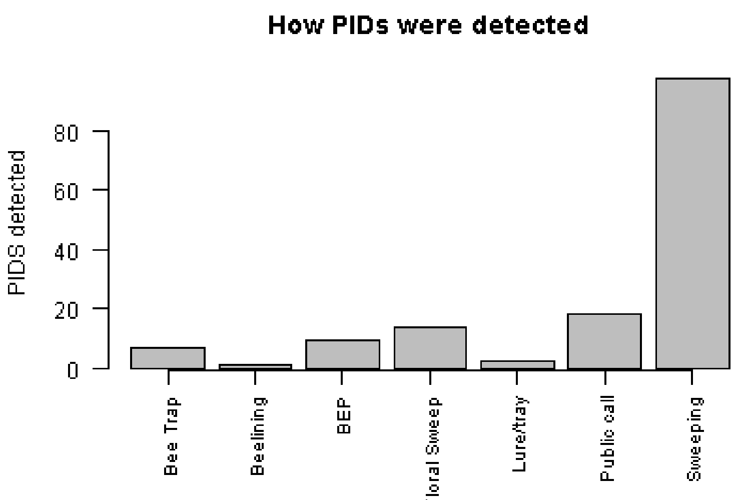


As can be seen, surveillance efforts have been widespread throughout the RA, but particularly focussed in areas where bees are known to be active (around Cairns), where isolated IPs and PIDs have been detected and in built up areas generally. In recent months, a substantial effort has been put into sweeping and bee traps in the Mareeba, Atherton, Malanda, Lake Eacham and Glen Allyn areas on the tablelands, the area between Innisfail and south of Cairns and also the beach suburbs to the north of Cairns.

Also obvious from the distribution of surveillance activities is the fact that there are large areas of mainly tropical rainforest where only limited surveillance has been undertaken. This is based largely on the assumption that *A. cerana* is unlikely to establish and persist in the rainforest ecosystem because of the lack of a reliable year-round feed source to maintain a nest, as well limited surveillance in some areas. To date, the only nests found in the rainforest have been within a few hundred metres of the forest edge and have been detected by picking up foragers feeding on plants at or outside the forest margin. Lack of surveillance in these areas is compounded by poor accessibility into the rainforest, particularly with the unusually wet winter and spring experienced this year.

Not surprisingly, grid sweeping is responsible for the greatest number of detections (Figure 8). However, proportionally, bee traps (0.6% of trap inspections positive) and floral sweeping 0.6% positive) have been more effective than grid sweeping (0.3% positive) in the period since July 2010, when modified bee traps and floral sweeping were introduced.

Figure 8. Numbers of *A. cerana* positive detections by method of detection



Summary of specific geographic areas

To assist in understanding and interpreting the incursion, the outbreak has been subdivided into a number of discrete areas, each of which is summarised separately below. Detailed maps of the areas are provided in Appendix 2.

Mareeba (IPs 40, 43 and 179)

A single swarm and a nearby nest (thought to be the origin of the swarm) were detected near Mareeba (40 km west of Cairns) in August 2009. This nest was thought to most likely have been accidentally transported to Mareeba from the Cairns area. Ongoing surveillance was undertaken in the area, but no additional *A. cerana* were detected until a PID and associated nest were identified in August 2010. This nest was >12 months old and was suspected of being the source for IP43, discovered 12 months earlier. No further sightings have been made since, despite intensive surveillance activity during August and September.

Lake Eacham, Malanda, Atherton and Glen Allyn (IPs 57, 73, 114, 150, 169 and PIDs Malanda and Atherton)

This area is to the south-west of Cairns, on the southern end of the Atherton Tablelands. The initial detection in this area was IP57, a swarm detected south of Lake Eacham in December 2009. Ongoing intensive surveillance in this area since then has found additional detections at:

- Lake Eacham – IPs 73, 114 and 150 (March, June and July respectively), between about 5 and 12 km from IP57.
- Glen Allyn – IP 169, August 2010, about 9 km south of IP57 and between 13 and 18 km from the other IPs
- PID Atherton, May 2010, about 8 km west of IP 150.
- PID Malanda, September 2010, about 9 km west of IP 169.

PID Atherton was a single bee detected in a house, while PID Malanda was the remnant of a swarm notified by the public. Ongoing surveillance has not detected any nests in the vicinity of either PID, or any additional detections in this part of the RA. The original incursion into this area was suspected to be by flight of one or more swarms directly across from the top of the Goldsborough Valley (IPs 62 and 66), a distance of about 30 to 35 km, with further local spread once established. This area remains a high priority for continuing surveillance because of the very scattered nature of the IPs found to date and the unexplained PIDs.

Note: an additional nest was detected in this area in mid October 2010.

Innisfail (IP 84)

IP 84 was detected at Innisfail, just outside the RA in April 2010. Despite intensive and ongoing surveillance in the surrounding area since the detection, no further detections have been made. This nest was assumed to be the result of being accidentally transported from the Cairns area. It was close to the rail line and stock handling area. It is worth noting that a number of swarms have been detected in the Cairns rail stock handling yards and a nest was detected at Deeral next to a train lay-by section of track. This remains a high priority for surveillance, particularly since the detection of another IP at Waugh's Pocket, about 10 km to the north in September 2010 (see below).

Waugh's pocket (IP 212)

A new IP (IP212) was detected at Waugh's Pocket, about 60 km south of Cairns in September 2010. This IP was in a narrow section of rainforest lying between and close to the Bruce Highway and the main Brisbane-Cairns railway line. This IP was about 12 km from the nearest known IP (IP84 at Innisfail) and 28 km south of the closest known IP in the Gordonvale-Deeral area to the south of Cairns. Surveillance since has not found any additional nests in the immediate vicinity. The source of this nest is unclear. It could have been an accidental transportation, or could have been a long-distance jump from further up the valley towards Cairns. Surveillance is continuing in this area as a high priority.

Aloomba/Deeral (IPs 36, 37, 144 and 221)

The first IPs detected in this area were IPs 36 and 37 (29 km south of Cairns), in August 2009, and for a long time this was the most southerly extent of AHB to the south of Cairns. Subsequently, IPs 144 (July 2010, 4 km) and 221 September 2010, 7 km) were detected further south in the Deeral area, in addition to IP 212 at Waugh's Pocket. Further intensive surveillance in the Aloomba, Deeral and Waugh's Pocket areas is continuing, to determine whether there are additional undiscovered nests in this area.

Goldsborough Valley (numerous IPs)

The Goldsborough Valley is a semi-rural valley running south-westwards from Gordonvale (south of Cairns) towards Atherton and Lake Eacham. The first IP detected in this area was IP 31 in June 2009. Since then additional IPs were detected in January-February 2010 (IPs 59, 62, 63, 66) and then sporadically since then. IPs 62 and 66, at the head of the valley, are the most south-westerly detections in this area to date. Surveillance in this area is continuing and new IPs are still being detected sporadically. Additional surveillance around IPs 62 and 66 and into the rainforest to the south has not yet detected any additional nests in the immediate area.

Yarrabah (numerous IPs)

Yarrabah is a settlement on the peninsula to the east of Cairns. Tis area is reasonably isolated, as it is surrounded by the bay to the north and rainforest on other sides and a mountain range to the west, separating it from the Cairns area. A road south through the rainforest provides access to the coast on the southern side of the peninsula. The first IP in this area (IP 48) was detected in September 2009. Since then there have been periodic detections through to September 2010, with about 15 IPs detected in the area to the end of September 2010. Most of the IPs have been within 1-2 km of the coast, although several were up to 5 km inland along the road to the south. In April 2010, two isolated PIDs were detected, further south, close to the southern coast and 2 to 4 km from the nearest known nest. Despite further surveillance in this area additional nests have not been detected.

Note: an additional nest (IP241) was detected close to one of the above PIDs in October 2010.

North of Cairns (numerous Ips and PIDs)

Up until June 2010, there was no evidence of AHB having established in the area to the north of Cairns, although only limited active surveillance was undertaken in this area prior to that time. During June, three IPs (IPs 107, 110 and 180) were detected just to the north of the city. Since then intensive surveillance has been undertaken and a total of 16 IPs have now been identified in this area. In addition, up to eight single PIDs have been identified which have not been traceable to nests (because additional bees to use for tracing could not be detected). This suggests that there could be a number of small and/or weak nests persisting unidentified in this area and intensive surveillance is continuing to try and identify them.

Note: two more nests were detected in this area during October 2010.

Cairns city and south to Gordonvale and Aloomba (numerous IPs)

This is the main outbreak area, containing the majority of IPs. Surveillance is continuing in this area on a daily basis with floral sweeping, bee traps and grid sweeping, and new nests are still being detected regularly, although numbers are declining.

Modelling the *A. cerana* population

One common approach to evaluating progress and potential scale of an incursion response is to use modelling. For AHB, we could model the population growth over time, including births into the population (swarming), and removals from the population (detection and destruction or nest/swarm failures) to arrive at estimates of the likely population (numbers of nests and swarms present) over time. Key issues to be considered in developing such a model include:

Issue	Comment
Starting time	When should the model start from, the estimated time of initial incursion, or the time of detection, or some other time to be determined?
Starting population	How many nests/swarms were present at the start of the modelled period? Presumably one, if modelling from the incursion date, but perhaps multiple nests if using a later date.
How frequently do nests swarm?	Suggested as being anywhere from 4 to 12 months and will depend on strength of the nest, feed availability and other factors. Anecdotally, *A. cerana* in nests Cairns appear to be swarming every 8-12 months and this is possibly seasonal, with swarming more likely in the winter/spring months than in summer/autumn
What percentage of swarms survive to establish a nest?	This is not known but would be affected by climate, availability of food sources and environmental factors, in addition to detection and reporting by the public resulting in swarm destruction.
How long does a nest survive?	Again, the likely survival of nests is unknown and would be affected by environmental, seasonal and other facors. However, the oldest nest discovered to date was estimated at about 2 years old. Several of the nests discovered appeared to be failing (or had failed). A suggested life span of 2-3 years appears not unreasonable.
What should be the internal time period of the model?	Should the model attempt to model events on a daily, weekly or monthly basis? Given the time scale of the outbreak and other factors, a monthly time period appears appropriate.
Surveillance activity	It is essential that nests and swarms that are detected and destroyed are included in the model, as this is a critical path for removal from the population
Seasonality, climate and	Are there seasonal and environmental effects that need to be

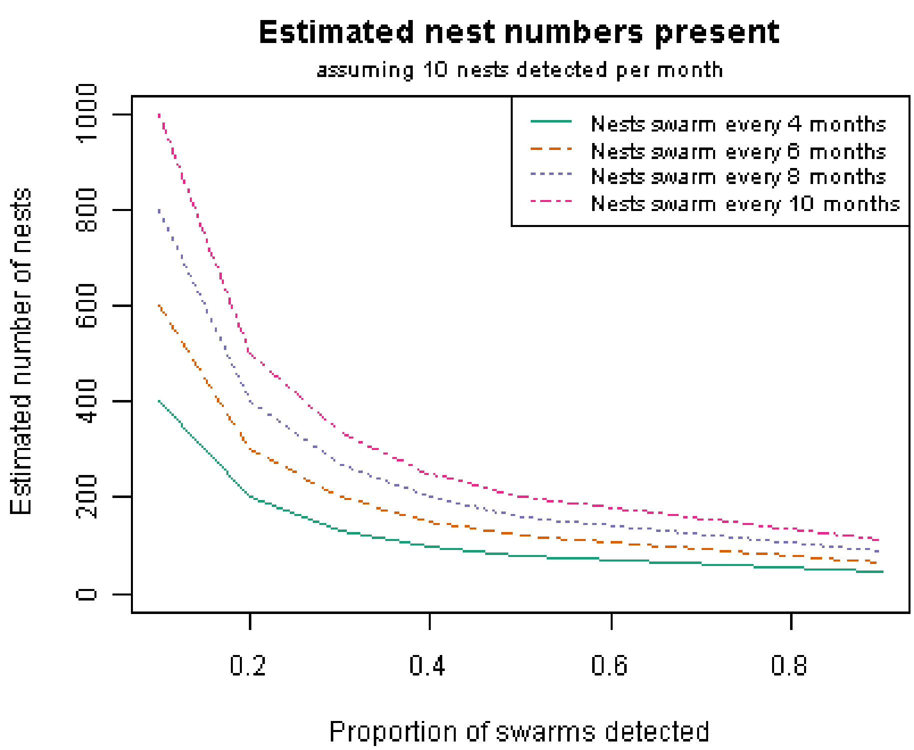
environment	included? This is still unclear but bee populations are likely to be affected by seasonal and environmental factors affecting feed availability and types.

Several different approaches were used in an attempt to model the AHB population over time. However all models were extremely sensitive to modest changes to some of the parameter values, particularly starting time, incursion size at the start and swarming frequency. As a result, model results varied from successful eradication (either already or within the next 6-12 months) through to several thousand undetected nests for small and realistic changes in the inputs.

An alternative model

To overcome the difficulties in the population model, an alternative, simpler, approach was used. In this approach, instead of trying to model the population over time, the one piece of hard data available was used to estimate the likely number of nests present at any given time. Essentially, if we know the swarming frequency and the number of nests present, we can predict the number of swarms that will occur on a daily or monthly basis. Conversely, given that we know the number of swarms detected each month and can estimate the efficiency of detection and the swarming frequency, we can estimate the number of nests present. Figure 9 presents summary results for such an analysis, based on 10 swarms detected per month (23 swarms were detected in the period July-September 2010, for a mean of about 8 swarms per month).

Figure 9. Estimated number of nests present assuming 10 nests detected per month for varying detection efficiency and swarming frequency



From Figure 9, and assuming a detection efficiency of 20% and swarming frequency of 6 to 8 months, there are an estimated 300 to 400 nests present, of which about 28 per month were being detected over the same period. Obviously, the true efficiency of swarm detection is unknown. However, 20% seems a reasonable (and possibly pessimistic) estimate. Halving this to 10% would double the estimated number of nests to 600 to 800, but would also mean that there were up to 90 swarms per month that were not being seen or reported, despite strong public support for notification and high levels of cooperation received.

Indicators of eradicability

In determining likely eradicability (or otherwise) of the infestation a number of issues need to be considered:

1. Extension of the incursion outside the RA

A. cerana has shown an ability to colonise and establish nests in a wide variety of locations and situations, including in vehicles, boats, containers and machinery. In addition, swarms can lodge temporarily in similar locations, enabling rapid dispersal over potentially long distances through movement of infested vehicles or materials. To date, spread to Mareeba and Innisfail have been attributed to accidental transport of nests or swarms. However, there has not been any identified spread to areas beyond the RA (other than Innisfail). Should such spread be detected it would indicate likely failure of eradication, unless there was strong evidence that the spread event was recent and that further local spread had not yet occurred.

2. Presence of undiscovered foci of infection within the RA

Currently, the extent of infection within the RA appears to be well defined. Detection of new, well established foci of infection in areas previously thought to be free of AHB would indicate failure of existing surveillance and probable failure of eradication.

3. Establishment of A. cerana within the rainforest

Currently *A. cerana* is assumed not to persist within the rainforest, but will colonise at the margins so it can forage outside. Discovery of established nests within the rainforest would undermine this assumption and indicate probable failure of eradication. To date only limited surveillance has been undertaken within the rainforest, with no nests detected.

4. Continued occurrence of isolated PIDs without detection of nests

As noted above there have been a small number of instances of single PIDs being detected in an area and being unable to be traced to a nest (due to the failure to find additional bees to enable beelining). This has occurred at Malanda, Atherton, the southern end of Yarrabah and in the beach suburbs to the north of Cairns. These isolated PIDs could be stray foragers that are a long way from their host nest, or could be an indicator of small and/or weak nests that are only foraging in small numbers. In either case the small numbers and inability to detect additional bees in the locality make nest detection difficult. Continued occurrence of isolated PIDs in the absence of detectable nests would suggest that there are persistent undetected nests and swarms, leading to likely failure of eradication.

5. Numbers of detections

The numbers of nests and swarms detected have increased dramatically during 2010. This obviously reflects an increase in the population over time, but also is attributable to the substantially increased staff numbers in the same period and the introduction of targeted sweeping, floral sweeping and bee traps since July 2010. A continued increase in numbers of detections in coming months would indicate an increasing bee population and likely failure of eradication. Conversely, decreasing numbers of detections could indicate likely success in eradication, but should be interpreted with caution due to the potential for confounding the issue due to a natural seasonal decline in numbers of bees foraging and hence numbers detected. Total numbers of detections have remained relatively stable from July to September 2010, with a slight increase in numbers of nests and a corresponding decrease in numbers of swarms. Additional data is required to determine whether numbers will trend upwards or down.

6. Percentage or absolute number of swarms detected

As discussed previously, the number of swarms present (and hence the number detected) is a function of the numbers of nests present, assuming that the efficiency of swarm detection remains unchanged. Therefore, a downward trend in the numbers (or percentage) of swarms each month would indicate potential for eradication, while an upward trend would indicate likely failure. Again this needs to be interpreted with care if seasonal effects are likely to be important. Currently, there is a downward trend since June 2010, but more data is required to confirm this trend.

7. Age of nests detected

Age of nests detected is another approximate guide to potential success of the eradication program. If the program is succeeding, we would expect to see the average age of detected nests getting progressively younger, to the extent that eventually nests will be consistently detected at an early age, before they have an opportunity to swarm, leading to eventual eradication. Assessing any trend in nest age is also complicated by the sometimes wide spread of nest ages in any month and the fact that a proportion of nests are in inaccessible locations and therefore unable to be aged. There is a slight downward trend in the mean age of nests detected since the beginning of 2010, although this is interrupted by an upward jump in August and September. Additional data is required to determine whether this trend will resume its downward direction or whether mean nest age will stay high, and also whether the range of ages will become narrower over time.

Conclusion and recommendations

Based on the above considerations, eradication of the current *A. cerana* incursion still appears feasible. However, given the scale and extent of the incursion, successful eradication is not certain. Given that the increased level of response has only been at full capacity for three months, it is also too early to predict the likelihood of successful eradication.

Of the indicators discussed above, there is a possibility (but no evidence of) spread of the incursion outside its existing distribution. Similarly there is a possibility but no evidence of either undiscovered foci of infestation in the RA or within the rainforest areas. Evidence from the numbers of detections, numbers of swarms detected and age of nests is inconclusive at this stage and all require more data over coming months to develop a clear trend. The most concerning evidence against eradicability is the occurrence of isolated PIDs for which nests have not been identified. Continuation of this phenomenon, particularly in larger numbers or in areas previously though to be clear would provide an indicator of likely failure of eradication.

Recommendation

It is recommended that continuation of the current program for another six months be considered, with re-evaluation at that time based on the above criteria.

Appendices

Appendix 1. Distribution of *A. cerana* detections during each six-monthly period from January 2007 to September 2010

Attached separately

Appendix 2. Distribution of IPs, PIDs and surveillance activities in selected geographic areas

Attached separately

Asian Honeybee incursion into Queensland: eradicable?

The Parameters

In assessing eradicability, a number of parameters may be used:

(1) Extent of spread/area covered
(2) Apparent rate of multiplication – also known as the estimated dissemination ratio. This is calculated from the number of new detections within a regular and constant time interval.
(3) Number of actual detections compared to the estimated number of colonies (based on their known reproductive rates).

All of the above are well-known epidemiological concepts; in this context, they will be applied to Asian honeybees (*Apis cerana*).

The Asian honeybee

A. cerana is thought of as being tougher and more prolific than the European honeybee (*A. mellifera*). Colony sizes are smaller; they are more adept at hiding colonies and avoiding detection; they rapidly abscond upon detection and easily re-establish in a new location; colonies are thought to divide and reproduce every 3-8 months.

They are easily able to "hitch rides" on trucks or trains and thus able to travel long distances to establish new colonies. Although in Queensland they are assumed not inhabit forested areas, it is known they are able to live in Asian forests.

Current extent – Queensland

Although the initial Asian honeybee detections were in Cairns – all within an area of a few hundred square kilometres – the situation over three years later is that colonies are now spread out over an area covering several thousand square kilometres. The ability to maintain a consistent and effective surveillance effort over such a large area is questionable.

Estimated Dissemination Ratio

In traditional epidemiology, an epidemic must maintain an EDR of more than one in order to sustain itself. For most of the past 3.5 years, the Asian honeybee EDR has been in excess of 1.5 and is now well over two. From an epidemiological perspective, this would be seen as a rapidly propagating, "out of control" epidemic.

It has been argued that the apparently high EDR is due more to increased detections than to a true increase in colony propagation. The increased detections have been attributed to the deployment of extra surveillance personnel and improved surveillance methods.

This, however, begs a number of questions:

- If surveillance has recently improved, how many hives went undetected during the earlier period of "poor" surveillance? There is a potential backlog – probably a very large one – of undetected nests that have been reproducing and generating yet more hives that have gone uneradicated. Given the huge area presently colonised by the bee and the relatively small surveillance area, they could be successfully continuing to replicate.

- If the increase in detections is due to a combination of both improved surveillance and a much increased “visibility” of bees due to their greater numbers, is the EDR not an indication of the tip of the iceberg? If better surveillance is leading to detection of an ever greater number of bee colonies, then the EDR is probably an indicator of an out-of-control situation; improved surveillance is simply reflecting reality.

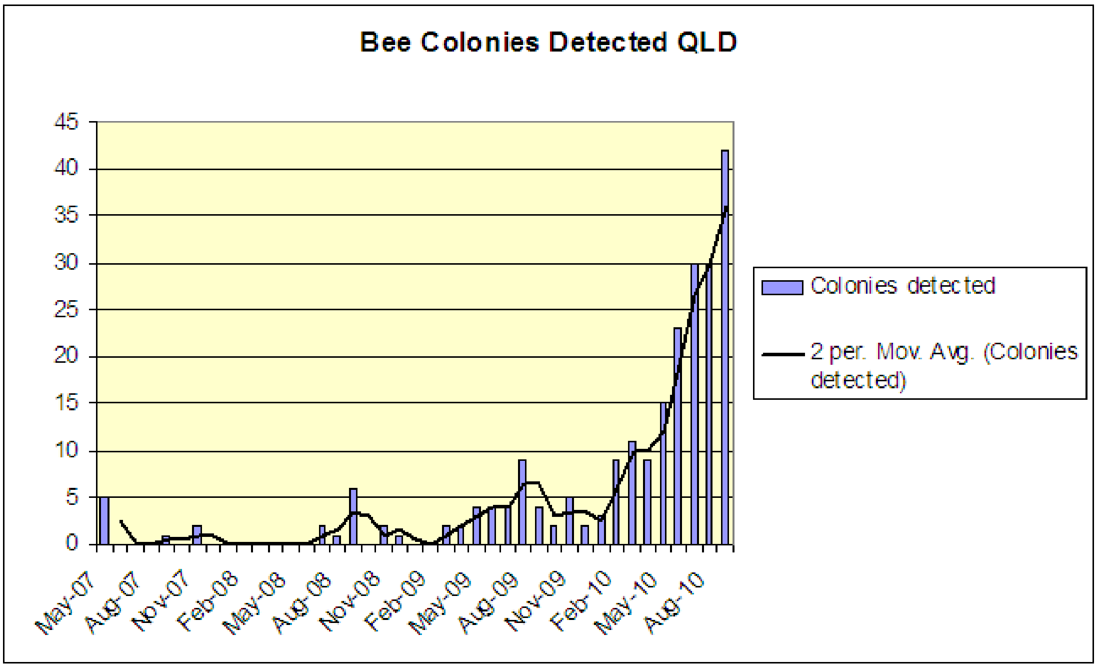


Fig. 1. Bee colony detections May 2007 to date. There has been a marked rise in detections over the past year.

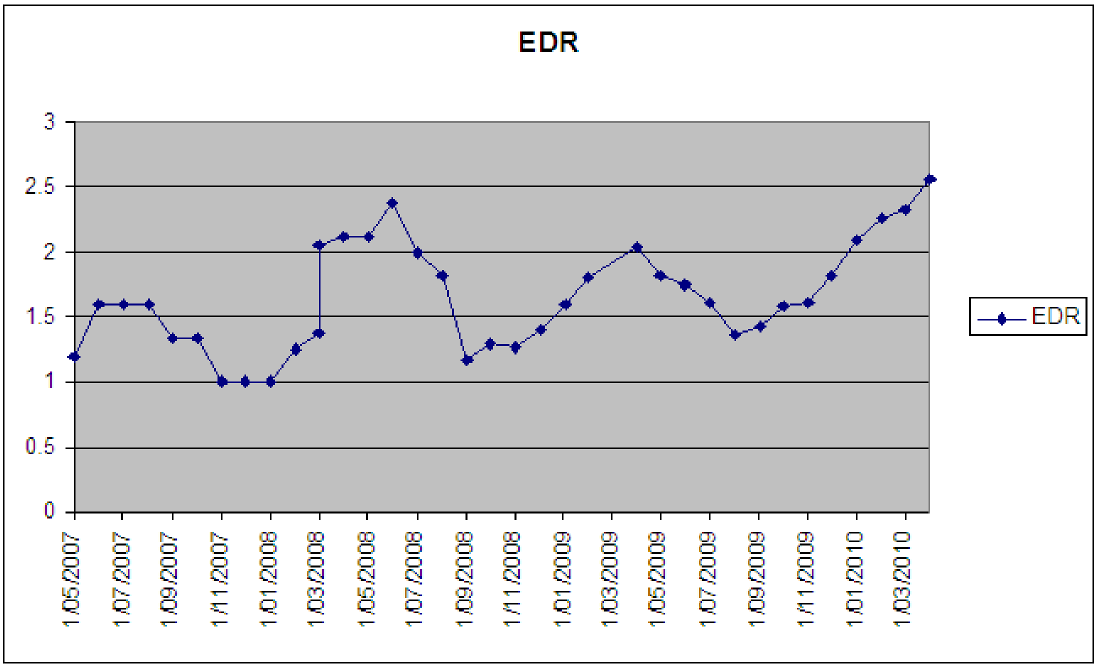


Fig. 2. Estimated dissemination ratio. This has been calculated by measuring the number of new colony detections in the preceding six-month period.

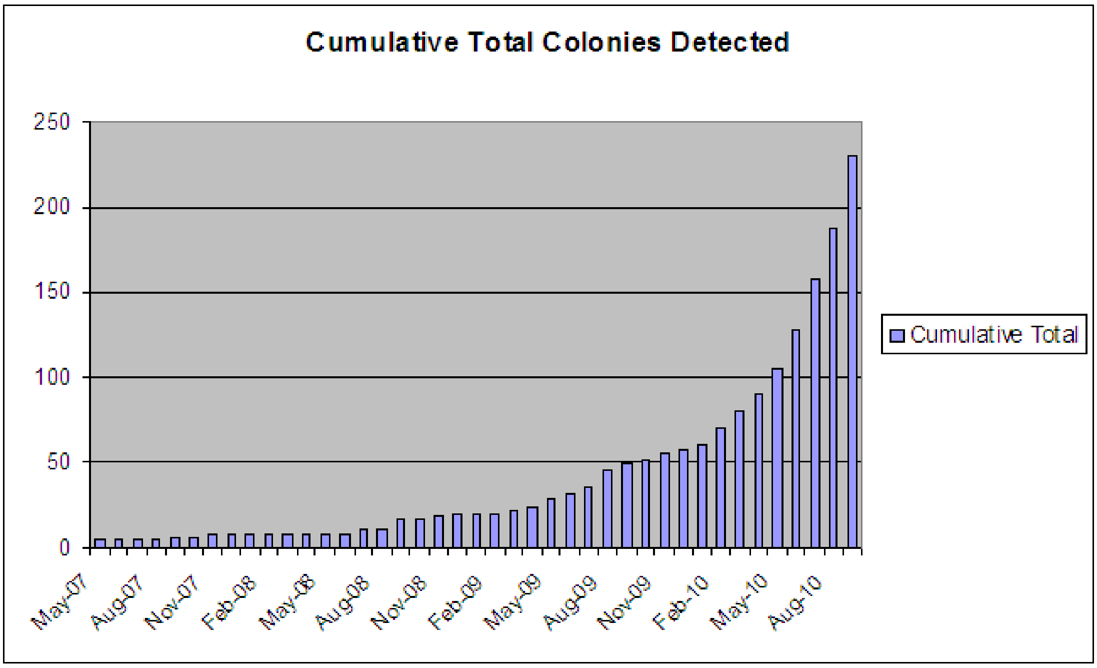


Fig. 3. Cumulative total detections. By the beginning of October, a total of 237 colonies had been detected.

Detections vs predicted colony numbers

It is possible to make a crude population model to predict the "true" number of colonies present and compare this with the number detected.

Although *A. cerana* has a high reproductive rate (one colony dividing every 3-8 months), not all new swarms will be viable. Should a colony generate 1.75 new colonies every 6 months, there should be well over a thousand colonies in existence at present: only about 230-250 have been detected to date.

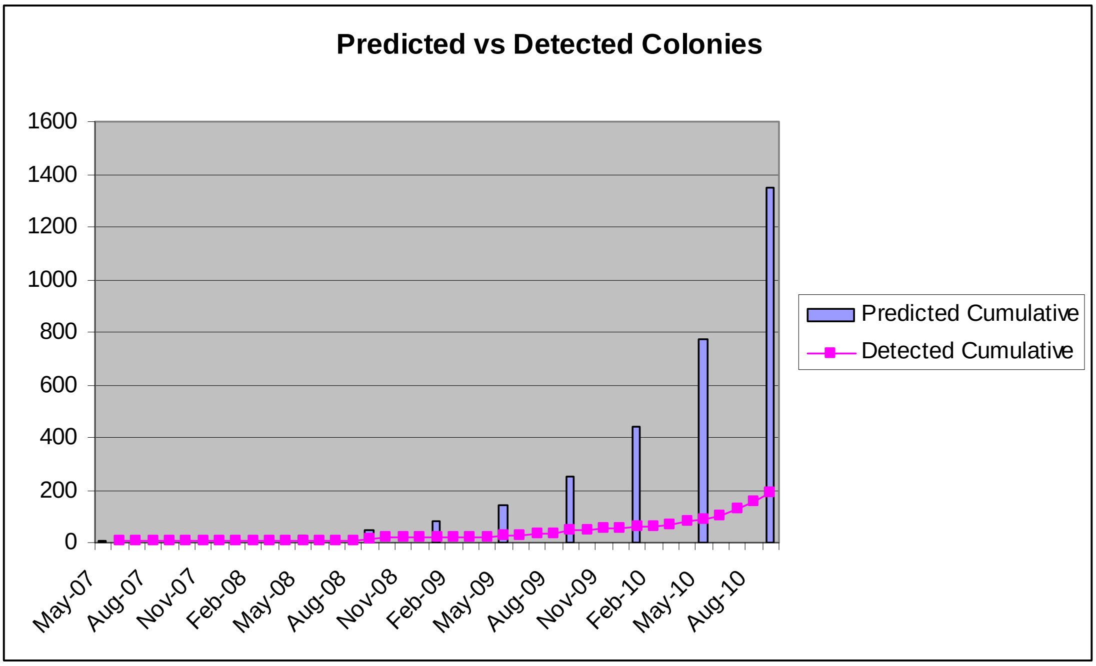


Fig. 4. Detections vs possible actual colony numbers.

The model shown in Fig. 4 is admittedly a pessimistic one; but even if the “true” number of colonies is greatly reduced – to, say 800 colonies – the implication remains that a huge number of colonies are still undetected and still reproducing.

	Detected	Actual	Surveillance sensitivity
Worst case	250	1300	± 20%
Best case	250	800	± 30%

The table above shows a calculation of surveillance sensitivity (what proportion of colonies are being detected by surveillance). It shows that present detection methods are only finding between 20% and 30% of colonies.

From an epidemiological viewpoint, this represents an impossible situation. A surveillance system that is not able detect in excess of 90% of cases will not be able to support an eradication effort. As a comparison, the best available diagnostic test for Johne’s disease in livestock only unearths about 40% of cases. After many years of effort, Johne’s disease has proved ineradicable.

Conclusion

The likelihood that hundreds of undetected hives continue to exist and multiply, combined with a surveillance system that is only able to detect at the most about 30% of these, means that Asian honeybees will continue to spread undetected in Queensland. The incursion is not seen as eradicable.

Australian Government

Rural Industries Research and Development Corporation

Future Surveillance Needs for Honeybee Biosecurity

by Simon Barry, David Cook, Rob Duthie, David Clifford, Denis Anderson

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Foreword

The Australian honeybee industry produces honey and other bee products for domestic consumption and export, through apiculture of *Apis mellifera*. The industry has an estimated GVP of A$80 million. In addition, the annual benefit of apiculture to general agriculture through plant pollination in Australia is estimated to range from A$4 to 6 billion.

Because of the significant value of this industry there is a need for effective biosecurity. A component of this is the use of surveillance. This report considers a risk-based framework for exploring the costs and benefits of surveillance for exotic honeybee pests and diseases.

The report has developed a risk-based framework for considering the cost benefit of surveillance for pests both now and in the future. This will be of use to both industry and decision makers. The study also developed a number of tools to assist in this process and has assessed the high-risk pests that currently pose a threat to the Australian industry.

This project is part of the Pollination Program – a jointly funded partnership with the Rural Industries Research and Development Corporation (RIRDC), Horticulture Australia Limited (HAL) and the Australian Government Department of Agriculture, Fisheries and Forestry. The Pollination Program is managed by RIRDC and aims to secure the pollination of Australia's horticultural and agricultural crops into the future on a sustainable and profitable basis. Research and development in this program is conducted to raise awareness that will help protect pollination in Australia.

RIRDC funds for the program are provided by the Honeybee Research and Development Program, with industry levies matched by funds provided by the Australian Government. Funding from HAL for the program is from the apple and pear, almond, avocado, cherry, vegetable and summerfruit levies and voluntary contributions from the dried prune and melon industries, with matched funds from the Australian Government.

This report is an addition to RIRDC's diverse range of over 2000 research publications which can be viewed and freely downloaded from our website www.rirdc.gov.au.. Information on the Pollination Program is available online at www.rirdc.gov.au

Most of RIRDC's publications are available for viewing, free downloading or purchasing online at www.rirdc.gov.au. Purchases can also be made by phoning 1300 634 313.

Tony Byrne
Acting Managing Director
Rural Industries Research and Development Corporation

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The authors acknowledge the participants in the project workshop who provided their time and considerable expertise and experience to greatly improve the outcomes of the study. These participants are listed in the Appendices. We thank Iain East of DAFF for provision of unpublished reports. The background information presented in the introduction to Chapter 1 is directly sourced from these. An unpublished study produced by Biosecurity Australia was used as a source document in preparing the risk analysis presented in Chapter 2.

We thank Dave Alden, Iain East and Kim James for detailed comments that have significantly improved this report.

We thank Catherine Leather and Karen Barndt for assistance in organising and running the workshop and Amy Nason for assistance in preparing the final report. We thank Dave Alden and David Dall of RIRDC for project management.

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Executive Summary

What the report is about?

This report describes the development and use of a risk-based framework to assess future surveillance needs for honeybee pests that are exotic to Australia.

A risk-based framework considers the likelihood of occurrence of pest and disease incursions as well as the costs and benefits of their early detection. It is designed to provide a more transparent assessment of the costs and benefits of an early detection system. This can feed into decision making for the sector, for example, when justifying a particular early detection system or for identifying ways by which an early detection system can be improved.

Who is the report targeted at?

The report is targeted at decision-makers in the State and Commonwealth Governments as well as the Australian beekeeping industry, apiarists and horticulture industries that depend on bees for pollination.

Background

The Australian honeybee industry produces honey and other bee products for domestic consumption and export, through apiculture using the European honeybee, *Apis mellifera*. The industry has an estimated GVP of A$80 million. In addition, the annual benefit of the apiculture industry to general agriculture through plant pollination is estimated to range from $4 to 6 billion. The 5-year average for the annual gross value of production of 25 horticulture industries dependent upon pollination by *A. mellifera* is $3.9 billion. Thus, even a 10% reduction in production as a result of a pest or disease incursion would result in losses exceeding $350 million per annum.

There are a number of significant threats to Australian honeybees that could impact on these industries. Surveillance systems are one component of a biosecurity system that can protect against these threats.

Aims/objectives

The aim of the research was to produce a risk-based framework for considering the costs and benefits of surveillance systems for honeybee pests and diseases.

Methods used

The project relied on the expertise of a core team and a reference group of individuals.

The core team brought together individuals with skills in economics, modelling, risk assessment and bee pathology and biology.

The reference group consisted of Commonwealth, State and Industry representatives with relevant experience with the honeybee or horticulture industries. The group provided feedback and endorsement on all aspects of the risk-based framework and assumptions that underpinned its development. The group also came together for a one-day workshop in Canberra to provide input into the project, and this report synthesises the group's views with those of the core team.

To develop the risk-based framework it was first necessary to carry out some preliminary analyses and then to integrate the results of those analyses to form a risk-based framework. The first preliminary analysis was to identify exotic pests or diseases of importance to Australian honeybees and then subject those pests and diseases to a standard ‘pathway analysis’. The pathway analysis, supported by expert opinion from the workshop, identified the same entry pathway (seaports) for each identified pest of importance. This significantly narrowed the potential surveillance possibilities for the pests and, as existing surveillance was already in place at seaports for detecting these pests (the National Port Surveillance Program - NPSP); all further analyses were focussed at determining the costs and benefits of that surveillance.

To determine the costs and benefits of the NPSP our analyses focussed on the use of sentinel hives at seaports to detect only exotic bee mites, as evidence indicated that the use of sentinel hives at seaports for the early detection of the only other identified exotic pest of importance (the Asian honeybee, *Apis cerana*) was inadequate.

An economic analysis of the impact of exotic bee mites and potential cost-savings from using surveillance at seaports for their early detection was carried out together with a simulated analysis of the potential spread and likelihood of detection of these mites in sentinel hives at seaports.

Values obtained from these three analyses (pathway, economic and spread) were then integrated to form a risk-based framework under which costs and benefits of the current use of sentinel hives in the NPSP could be assessed.

Exotic pests and diseases of most importance to Australian honeybees, the Australian beekeeping industry and other industries that depend on honeybees for pollination were identified by subjecting pests and diseases that have been prioritised by Plant Health Australia for national cost-sharing arrangements in the event of incursions to the following set of 4 criteria:

- Was the pest on an identified entry pathway?
- Was there a diagnostic test/trap available for early detection of the pest?
- Could the pest be eradicated/managed following its detection?
- Would the incursion/establishment of the pest cause a significant impact?

With the candidate pests identified, a pathway analysis estimated their likely arrival and most likely route of entry into Australia.

A bioeconomic model was used to simulate the potential damage of exotic bee mites and the likely return on investment by using surveillance to detect them. An analysis of a simulated spread of the mites provided information on their potential rates of spread away from the port environment before they were likely to be detected in sentinel hives.

Information from the three analyses (pathway, economic and spread) was integrated into a risk-based framework under which the costs and benefits of using sentinel hives in the current NPSP were assessed.

Results/key findings

The following exotic honeybee pests were identified as being most important to Australian honeybees:

1. Varroa destructor (parasitic mite);
2. Varroa jacobsoni (parasitic mite);
3. Tropilaelaps clareae and T. mercedesae (parasitic mites);

4. Apis cerana (Asian honeybee).

The pathway analysis showed that the likelihood of entry of *A. mellifera* or *A. cerana* as unassisted swarms was '**Extremely Low**' and it was not considered further. The analysis showed that each pest was most likely to enter Australia on (in the case of mites) or as assisted swarms of bees on an international sea vessel. The overall probability of entry of:

- *V. destructor* associated with *A. cerana* by assisted entry was '**Low**";
- *V. destructor* associated with *A. mellifera* by assisted entry was '**High**';
- *V. jacobsoni* associated with *A. cerana* by assisted entry was '**High**';
- *V. jacobsoni* associated with *A. mellifera* by assisted entry was '**Low**';
- *Tropilaelaps* spp. associated with *A. mellifera* or *A. dorsata* (the Asian native bee host) by assisted entry was '**Very Low**'.

As the pathway analysis showed that each pest was most likely to enter Australia on an international sea vessel, workshop participants agreed unanimously that the use of sentinel hives at seaports was the method most likely to detect exotic mites quickly should they arrive in assisted bee swarms on international sea vessels. However, the use of sentinel hives at seaports was deemed unsuitable for the early detection of *A. cerana* and this is also borne-out by the fact that sentinel hives failed to detect the current incursion of that bee at Cairns. There was also much scepticism among workshop participants as to the effectiveness of 'log-hives' or 'bait-hives' for the early detection of *A. cerana*, as they also failed to detect the Cairns incursion. The general consensus was that more studies were needed to determine the role that these hives may play in honeybee biosecurity. Hence, log and bait hives were not considered further in this project and the remainder of the risk-based analysis focussed solely at determining the costs, benefits and areas of improvement for port surveillance as currently exists under the NSHP.

A bioeconomic model predicted that, without surveillance, the average damage cost to Australian plant industries as a result of an exotic bee mite incursion would be about $72 million over the next 30 years. The spread simulation showed that sentinel hives located at seaports were effective in the early detection of exotic bee mites, with one simulation showing that mites could spread only about 6km away from a seaport before being detected in sentinel hives located at the seaport.

Values obtained from the pathway, economic and spread analyses were integrated to form a risk-based framework. This framework consisted of two models, one to determine a probability of entry establishment and spread of exotic mites, and a second, an economic model, which takes values from the former model to calculate expected returns on the surveillance effort. The probability model of entry, establishment and spread of exotic mites can be summarized as:

$$h = p \times g \times (1 - e) + p \times (1 - g)$$

Where:

h = the expected probability of entry, establishment and spread after we apply surveillance

p = the expected probability of entry, establishment and spread without surveillance

g = the proportion of the threat (i.e. trade from risk regions) that is covered by the surveillance and;

e = efficiency of surveillance system (see details in Chapter 5).

The values *p* and *h* from this model were then used in the following economic model to calculate the expected return on the surveillance effort as an annual cost:

$$\mathrm{PV}(\mathrm{ED_n}) = \sum_{t=0}^{n} (1+\alpha)^{-t} . \sum_{j=1}^{s_t} p.d.A.N \, .$$

This model shows production loss per unit of area (d), spread area (A), population density (N) and the numbers of satellite sites in each time period (St) are with the probability of entry and establishment (p) in an expression of probability-weighted, or expected damage over time. Given a discount rate α, the present value of expected damage after n time periods can be calculated as PV(EDn) (see Cook et al. 2007):

An example of this working framework can be seen when determining cost savings in the use of sentinel hives to detect and respond to incursions of *V. destructor*. The pathway analysis determined that the risk of this is high so p=.85 based on the typical definition of high used. If we assume that we cover 95% of the risk (i.e. trade) then g=0.95. If the probability that the surveillance system at a port detects an incursion early enough for a successful response is 50% (i.e. e=.5) we can calculate the expected probability of entry, establishment and spread:

$$h = 0.85 \times (1-0.5) \times 0.95 + 0.85 \times (1-0.95) = 0.45 \, .$$

From the bioeconomic model the reduction of p from .85 (high) to 0.45 is associated with a reduction in expected cost from $47.1 million per annum to $43.2 million per annum.

Conclusions

This study used a risk-based analysis to assess exotic threats to Australian honeybees. While this is the standard approach applied by Biosecurity Australia to other exotic threats to Australian agriculture, the reliance here on qualitative descriptors for the exotic bee pests means that there is potential ambiguity in the outcomes of the analysis. Thus it is important that users consider carefully the indicative probability ranges to ensure the interpretability of the results of any future analysis.

The economic analysis used here to develop the risk-based framework could also be further developed in a number of ways, particularly in terms of the way it could be communicated to the bee surveillance community and used in risk mitigation strategy formulation. Given the significant pollination (i.e. private) benefits, there may be a case for revising the model to improve its explanatory power. A spatially explicit modelling approach may be more appropriate given the large geographic spread of honeybee surveillance beneficiaries.

This analysis showed that the use of sentinel hives to detect exotic bee mites (*Varroa* and *Tropilaelaps*) has potential to deliver positive cost-effective outcomes. However, their use as a surveillance method for those mites is underpinned by a lack of knowledge as to how sensitive they are at actually detecting the mites. The risk-based framework developed here can now be used in future studies to determine how the NSHP can be improved using different numbers of sentinel hives at different numbers of ports.

There was unanimous agreement at the project workshop that more thought and experimentation was needed to optimise the current NSHP. This could include training and research in countries with exotic mites to determine the sensitivity of using sentinel hives and for examining the rates of spread of bee mites. In addition, genetic techniques could be developed to streamline pest identification.

While there are clear benefits from using sentinel hives for the early detection of exotic bee mites, the current surveillance for the early detection of Asian honeybees (*A. cerana*) is ineffective and needs to be re-examined.

Recommendations

- That the risk-based framework developed here be adopted as the mechanism for determining future costs and benefits of improved surveillance for honeybee pests and diseases.
- That the current National Sentinel Hive Program be maintained and improved for the early detection of exotic bee mites using information provided in this report.
- That the active management of honeybees within port areas, as already occurs in some locations, be strongly encouraged.
- That targeted studies be funded to obtain clear empirical data of the efficiency of sentinel hives to detect exotic bee mites. Experiments should be performed outside Australia to determine the sensitivity of sentinel hives to detect low numbers of bee mites.
- That surveillance for the early detection of A. cerana be re-examined urgently with the aim of developing a new surveillance system that can detect low numbers of bees at remote locations.
- That AQIS continue to target bees as serious threats to the Australian honeybee industry and other industries that depend on honeybees for pollination and that port operations be strengthened to ensure a well educated and proactive work force to safeguard biosecurity for bee pests and diseases.

1. Introduction

General introduction[1]

The Australian honeybee industry produces honey and other bee products for domestic consumption and export, through apiculture using the European honeybee, *Apis mellifera*. The industry has an estimated GVP of A$80 million (Standing Committee on Primary Industry and Resources, 2007). In addition, the annual benefit of the apiculture industry to general agriculture through plant pollination is estimated to range from $4 to 6 billion (Standing Committee on Primary Industry and Resources 2007). The 5-year average for the annual gross value of production of 25 horticulture industries dependent upon pollination by *A. mellifera* is $3.9 billion. Thus, even a 10% reduction in production as a result of a pest or disease incursion would result in losses exceeding $350 million per annum.

Australia is free of several important disease-causing honeybee mites and other pests of honeybees. Exotic mites include the varroa mite (*Varroa destructor* and *V. jacobsoni*), Tropilaelaps mite (*Tropilaelaps mercedesae* and *T. clareae)* and tracheal mite (*Acarapis woodi*). Other pests of honeybees (through natural competition) include several species of exotic bees including the Asian cavity-nesting honeybee (*Apis cerana*), giant Asian honeybee (*Apis dorsata*) and Africanised honeybees (*Apis mellifera scutellata* and *A. m. capensis*).

If varroa mite were to establish in Australia its impact has been predicted to be devastating to the Australian apiculture industry (CIE 2005). However, the impact would not be limited to the apiculture industry as many horticultural, seed grain and pastoral industries would also be adversely affected due to reduced pollination of their plants (Cook *et al.* 2007).

The economic impact of *V. destructor* in North America following its establishment in the 1980's is estimated to range from US$0.6 to 14.6 billion (Robinson *et al.* 1989; Muth and Thurman 1995; Morse and Calderone 2000). In Australia, the pollination benefits that would be lost following Varroa mite introduction are estimated to be A$27.5 million for a group of 25 horticultural and seed grain industries (Cook *et al.* 2007).

The risk to Australia of exotic bee species entering via cargo movements has been highlighted by several detections of exotic bees in ships at Australian seaports in recent times (Boland 2005). In addition, exotic bee introductions may also introduce *Varroa* or other exotic disease-causing mites. *Varroa destructor* is now endemic in much of the world, including areas of New Zealand, increasing the possibility of its introduction to Australia.

Biosecurity is a continuum with elements operating pre-border, at the border level and beyond the quarantine border (post-border). A possible component of a biosecurity system is the use of surveillance techniques. These techniques are deployed post-border to attempt to detect incursions so that management actions can be implemented.

This project was commissioned to assess future surveillance needs for exotic pests and diseases of honeybees to protect the Australian honeybee and horticulture industries. There are several existing surveillance programs targeting honeybee pests and diseases. The National Sentinel Hive Program is the major program targeted at new pests.

[1] Much of the information in this introduction is sourced from unpublished material supplied by Dr Iain East, Australian Government Department of Agriculture, Fisheries and Forestry.

The National Sentinel Hive Program (NSHP) was established in 2000 to enhance early detection of incursions of varroa mite, Tropilaelaps mite, tracheal mite and Asian honeybees. Early detection of these pests is expected to improve the chance that incursions will be eradicable, and possibly, that the eradication program will be smaller and less costly. This program operates by situating sentinel hives near seaports identified as a 'high risk' of an incursion. The program is the result of consultation between Biosecurity Australia (BA), State and Federal Government Departments and Australian Honey Bee Industry Council (AHBIC) and the beekeeping industry.

Objectives

The aim of the research was to produce a risk-based framework for considering the costs and benefits of surveillance systems for honeybee pests and diseases.

A risk-based framework considers the likelihood of occurrence of pest and disease incursions as well as the costs and benefits of their early detection. It is designed to provide a more transparent assessment of the costs and benefits of an early detection system. This can feed into decision making for the sector, for example, when justifying a particular early detection system or for identifying ways by which an early detection system can be improved.

Methodology

The project relied on the expertise of a core team and a reference group of individuals.

The core team brought together individuals with skills in economics, modelling, risk assessment and bee pathology and biology.

The reference group consisted of Commonwealth, State and Industry representatives with relevant experience with the honeybee or horticulture industries. The group provided feedback and endorsement on all aspects of the risk-based framework and assumptions that underpinned its development. The group also came together for a one-day workshop in Canberra to provide input into the project, and this report synthesises the group's views with those of the core team.

For surveillance to be effective a number of issues need to be taken into account. First the pest or pathogen must exist on an importation pathway; otherwise the surveillance effort is wasted. Second, the pest must be detectable by the surveillance system in a timely manner so that management actions can be successfully applied; otherwise it provides no useful management information. Third, there must be a management action that can be applied. Fourth, the impact of the pest must be large enough that the expenditure on the surveillance scheme is justified.

The consideration of all possible pests and production systems within the honeybee and horticulture industries is a complex task. There are a large number of potential pests and surveillance covers a range of activities from individual inspection of a grower's own hives to potential regional, state and national programs. To consider the effectiveness of all these scenarios in a detailed manner is clearly beyond the scope of this project. Instead, an initial expert-based assessment was performed to target further analysis. This assessment focussed on those pests and diseases that have been prioritised by Plant Health Australia for national cost-sharing arrangements in the event of incursions.

For these pests we considered a pathway assessment to determine that they were on a pathway and to determine a level of threat. This pathway analysis, supported by expert opinion from the workshop, identified the same entry pathway for each identified pest of importance. This significantly narrowed potential surveillance possibilities to the extent that all further work in the project was focussed on determining the costs and benefits of using sentinel hives at sea ports to detect exotic bee mites (see below).

Finally, we have provided a framework to bring this information together to inform decision-making.

Scope of Project

The aim of the project was to develop a risk-based framework for the assessment of honeybee pest and disease surveillance options. The framework was then to be applied to the future threats to the industry.

Bee surveillance within Australia involves a number of programs including vessel declarations and cargo inspections as well as the National Sentinel Hive Program and state based trap hive programs. These programs are described in more detail in Chapter 2 of this report. This project focuses on the development of an assessment method that is applicable to the National Sentinel Hive Program and other trapping programs. The use of vessel declarations and cargo inspection are generic technologies that are applicable to a wide range of insect and non-insect species and indeed even to undesirable non-biological imports. The value of these programs therefore extends well beyond their role in bee surveillance and they are not considered further when constructing the risk based framework.

The core reference teams discussed the potential coverage of any national surveillance program. It was agreed that the focus should be on pests prioritised for national cost-sharing arrangements. Each pest was assessed in relation to whether:

- It was on an identified pathway,
- There was a diagnostic test/trap available for its detection,
- Eradication/management be feasible if it was detected, and
- The expected impacts of its incursion/establishment would be significant.

These criteria were used as a primary filter to assess whether surveillance would represent a feasible management strategy.

Based on these criteria, the following pests were identified as being worthy of further analysis:

- *Varroa destructor*
- *Varroa jacobsoni*
- *Tropilaelaps sp (T. mercedesae and T. clareae)*
- *Apis cerana*

A number of other pests such as tracheal mites and Africanized bees were also discussed, but were not considered further because of practical difficulties in their detection.

To assess the identified pests we developed a pathway analysis using the standard protocols used by Biosecurity Australia to assess the likelihood and mechanism of their introduction to Australia. This is described in Chapter 2. That pathway analysis, supported by expert opinion from the workshop, identified the same entry pathway for each pest (entry at seaports on international vessels). This significantly narrowed the potential surveillance possibilities and, as existing surveillance was already in place for the early detection of these pests, all further analysis here was focussed on determining the costs and benefits and possible areas of improvement of that surveillance. In particular, we focussed on the use of sentinel hives at seaports as they were at the heart of that surveillance. There was unanimous agreement among the workshop participants that the use of sentinel hives at seaports was the most likely method to detect exotic bee mites quickly but that this method was not suitable for the early detection of Asian honeybees. This was also supported by the fact that sentinel hives at Cairns had failed to detect the current incursion there of *A. cerana*. Further, there was much scepticism among workshop participants as to the effectiveness of 'log-hives' or 'bait-hives' for the early detection of *A. cerana*. Hence, all further analyses were directed at determining the costs, benefits and areas of improvement of sentinel hives at seaports for only the early detection of exotic bee mites.

The core of the approach was an economic analysis, which considers the cost/benefit of particular options, as outlined in Chapter 3. A key determinant of the efficiency of a surveillance system for exotic mites is whether an incursion might be detected sufficiently quickly to allow successful management actions to occur. To assess this possibility we have developed a spatial modelling system and synthesised knowledge of honeybee and mite behaviour to explore the potential spread of exotic mites and the likelihood of their detection in sentinel hives. This is described in Chapter 4. These efforts are brought together in Chapter 5, which considers the implications of the analyses for honeybee surveillance in Australia. Chapter 6 presents analysis of the National Sentinel Hive Program.

2. Pathway Analysis for the Entry of Exotic Bees and Exotic Bee Pests into Australia

Summary

A pathway analysis examining the likelihood of entry, establishment and spread of the Varroa mites (*Varroa destructor* and *Varroa jacobsoni*) and Tropilaelaps mites (*Tropilaelaps spp.*) under existing Australian quarantine, surveillance and awareness arrangements was conducted using a qualitative risk assessment methodology.   As a by-product, this analysis also considered the probability of entry of *Apis cerana* and *Apis dorsata*. This analysis can be used as the basis for assessing threats any new pests of honeybees that may arise in the future. The technique was applied to the current pests determined to be detectable by surveillance and that represent a significant threat to the honeybee population in Australia.

It was determined that:

- The likelihood of entry of Varroa spp. or Tropilaelaps spp. with European honeybees (*A. mellifera*) or Asian honeybees (*A. cerana*) as unassisted swarms is extremely low; accordingly this possibility was not considered further and was not considered further;

- Seaports and associated vessels and cargo are the most likely assisted entry points for exotic bees and exotic honeybee pests;

- There is a low risk of assisted entry, establishment and spread of *Varroa destructor* associated with *Apis cerana*;

- There is a high risk of assisted entry, establishment and spread of *Varroa jacobsoni* associated with *Apis cerana*;

- There is a low risk of assisted entry, establishment and spread of *Varroa jacobsoni* associated with *Apis mellifera*;

- There is a high risk of entry, establishment and spread of *Varroa destructor* with *Apis mellifera*[2]; and

- There is a very low risk of assisted entry, establishment and spread of *Tropilaelaps spp.* with *Apis mellifera* or *Apis dorsata*.

- There is a high probability of entry of *Apis cerana*, and

- There is a low probability of entry of *Apis dorsata*.

Importantly, the assessment reported here considered the likelihoods of entry, establishment and spread under current quarantine, surveillance and awareness requirements. If the relevant current quarantine, surveillance and awareness requirements were to change the risk associated with each pathway might also change.

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[2] There is currently a prohibition on the importation of all live bees into Australia. This measure reduces the risk of introduction but it may also increase the temptation to introduce new genetic stock illegally over time. This may increase the risk of introduction via this pathway over time.

Introduction

Australia enjoys freedom from a wide range of exotic bees and their associated pests and diseases. There is currently a range of awareness, surveillance and quarantine measures in place across the biosecurity continuum (pre-border, border and post-border) to maintain this freedom. Off-shore surveys for exotic pests and diseases, extensive screening of mail using x-ray and detector dogs, stringent air and seaport quarantine awareness, surveillance, inspection and reporting requirements, and bans on the importation of live honeybees and used bee keeping materials all contribute to the maintenance of the nations favourable quarantine status.

However, the introduction of Varroa mite (*Varroa destructor*) into Hawaii (in 2007) and New Zealand (in 2000), and the recent detection of a strain of *Varroa jacobsoni* that is pathogenic to *A. mellifera* in Papua New Guinea have heightened concerns of an incursion of these exotic mites and other bee pests and diseases into Australia.

To help address these concerns and to determine options for future honeybee biosecurity arrangements, pathway analysis for the introduction of exotic bees and their associated pests and diseases has been conducted.

Pathway analysis methodology

This pathway analysis was conducted using a qualitative risk assessment approach. This methodology is in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for Pest Risk Analysis* (FAO 2007) and ISPM 11: *Pest Risk Analysis for Quarantine Pests, including analysis of environmental risks and living modified organisms* (FAO 2004). The likelihood that an event will occur was evaluated and reported qualitatively, using descriptors for the likelihood of entry, establishment and spread of the honeybees as vectors for the exotic mite species of concern. Appendix 1 provides a brief outline of methodology used.

The methodology in this assessment can be used as the basis for the calculation of the probability of entry, establishment and spread of any new pests. It is a general methodology consistent with international standards.

Pathways considered

There are several exotic bee species and associated exotic mites that have been identified as risks to Australian industries. Table 1 provides a list of the exotic bees and their associated exotic pests that were considered in the preliminary scoping phase of this pathway analysis.

However, based on the initial assessment by the core team it was determined that this pathway analysis would focus on the two species of Varroa mites (*V. destructor* and *V. jacobsoni*) and *Tropilaelaps* spp. Tracheal mites where not considered because of the practical difficulties in detection. The probability of entry of *A. cerana* and *A. dorsata* was picked up as a by-product of the analysis. The two Varroa species were considered to pose the greatest potential economic impact to the Australian honeybee industry, and *Tropilaelaps* spp. was seen as a potentially serious emerging threat to the honeybee industry. It should be noted that whilst this pathway analysis focused on these three groups of mites, it is considered that the analysis could be extrapolated equally to other exotic bees, pests and diseases.

Table 1 Exotic bees and associated exotic mites considered in the preliminary scoping phase of the pathway analysis

Bee species	Associated exotic mite
Apis mellifera	*Varroa destructor*
	Varroa jacobsoni
	Tropilaelaps spp.
	Acarapis woodi (honeybee tracheal mite)*
Apis cerana	*Varroa destructor*
	Varroa jacobsoni
Apis dorsata (Giant honeybee)	*Tropilaelaps* spp.
Apis mellifera scutellata and *Apis mellifera capensis* (African or Africanised)*	

* Not considered further in this pathway analysis

Scope

This pathway analysis considered the likelihood of entry, establishment and spread of *V. destructor*, *V. jacobsoni* and *Tropilaelaps* spp. associated with *A. cerana* and *A. mellifera* under existing Australian quarantine, surveillance and awareness arrangements. It also considered the likelihood of entry, establishment and spread of *Apis cerana* and *A dorsata*.

The entry of exotic bees and their associated mites into Australia was considered for both assisted and unassisted transport modes. Unassisted transport was considered to be by swarming, or by swarms or individual bees floating in hollow logs or other debris. The likelihood of this pathway was considered to be extremely low, but a brief analysis was presented for consistency. Assisted transport was considered to be the entry of hives, swarms or individual bees into Australian seaports, airports or mail centres by means other than swarming or floating. Assisted entry was considered to have a much greater likelihood and detailed analysis was provided.

Existing surveillance, awareness and quarantine programs and policy [3]

This pathway analysis was conducted with consideration given to Australia's current quarantine, surveillance and awareness arrangements. The current requirements of relevance are outlined below.

The National Sentinel Hive Program (NSHP)

The National Sentinel Hive Program (NSHP) was established in 2000 to assist in the early detection of honeybee parasites (most notably Varroa spp.) and exotic bees at or around seaports. The NSHP maintains between one and six beehives at 26 different ports throughout Australia. The program also maintains pheromone-baited log traps for Asian honeybees in Darwin, Gove, Cairns and Brisbane.

Throughout its eight years of operation, the NSHP has not detected any incursions. Importantly, as a result of the 2007 incursion of the Asian honeybee in Cairns at least seven colonies of *A. cerana* were established in the Cairns port area, and despite their proximity to sentinel hives the sentinel hives did not detect the incursion.

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[3] Information on Programs compiled by Iain East.

Bait hives at ports in Tasmania, South Australia and Victoria

The Australian Quarantine and Inspection Service (AQIS) assists the Department of Primary Industries, Victoria and the Department of Primary Industries and Water, Tasmania to monitor bait hives located within ports in those states. The South Australian Primary Industries and Resources agency independently operates a similar program in that state's ports.

Tasmania maintains between one and three bait hives at each of seven ports in the state. One swarm was captured at the Port of Burnie in December 2006. Victoria maintains five bait hives at the port of Melbourne and further bait hives at Geelong and Portland. Two swarms have been trapped at Melbourne and at least one in Portland. None of the swarms had exotic pests or diseases. South Australia maintains approximately 40 bait hives at ports and other high-risk locations such as container storage areas. In the past 18 months, ten swarms have been detected but all were A. mellifera and carried no parasitic mites.

Queensland apiary survey

During 2007, 43 beekeepers in Queensland participated in a producer survey examining hives for external parasites. This survey used the standard Bayvarol strip and sticky mat technique. No exotic mites were found.

NSW 'sugar shake' program

Sugar shaking bees is a method used to detect external parasites, such as *Varroa spp,* and *Tropilaelaps spp*. The sugar-shake technique relies on the separation of *Varroa spp*. from the adult bee in the presence of fine sugar particles. The legs of *Varroa spp*. mites have sticky pads that help them hold onto the honeybees and it is believed that fine sugar particles break down that bond, causing dislodgment. The sugar covering the honeybees also stimulates grooming behaviour, assisting to dislodge mites. The sugar–parasite mix is then separated from the honeybees and inspected for any mites. In 2007-08, the NSW program surveyed hives at 43 locations in NSW, two in Victoria and one in Queensland, and found no parasitic mites.

Victorian 'sugar shake' program

Victoria has recently introduced a sugar-shake program for industry surveillance, and it is currently focussed on members of the amateur beekeeping clubs that operate in the greater Melbourne area.

Health Certification for interstate movement

Within Australia interstate movement of honeybees requires health certification of hives by a government inspector or some other authorised person prior to their movement. New South Wales currently has 17 regulatory officers authorised to inspect beehives. However, dependent upon the apiarist and their hives' health history, certificates may be issued without physical inspection of hives.

Vessel and cargo inspections conducted by AQIS

As part of AQIS' international vessel clearance process, vessel masters en route to Australia are required to report any detection of honeybees to AQIS before arriving at an Australian port. Before or upon arrival, AQIS responds to any reports and instructs that any bees on board be destroyed.

Border inspections by AQIS also include the process of cargo inspection after arrival of a vessel in Australia. AQIS staff also undertakes wharf surveillance as part of their ongoing duties, and work closely with port workers to ensure that sightings of honeybees are reported to AQIS and state authorities. AQIS responds as necessary to reports of insect sightings.

Offshore surveillance conducted by NAQS

The AQIS Northern Australia Quarantine Strategy (NAQS) Program focuses on pests and diseases with the potential to enter Australia from Timor Leste, Indonesia or Papua New Guinea. This includes natural or non-conventional pathways such as wind currents, migratory animals, traditional vessel movements and illegal fishing activity. *Apis dorsata* (Giant Asian Bee), *Apis florea* (Dwarf honeybee) and *A. cerana* and the parasites *Varroa spp., Tropilaelaps spp.* and *Acarapis woodi* (tracheal mite) are all targeted by the NAQS program in their surveillance activities.

A stocktake of previous exotic bee detections and incursions

Numerous detections of exotic bees have been documented over the past 30 years. Table 2 provides details of the majority of these detections. The most serious incursion would appear to be the discovery of numerous swarms of *A. cerana* in the Cairns port area and surrounds from 2007 to 2009. Fortunately no exotic mites have been found to be associated with this exotic bee incursion.

Whilst the historical data does not provide extensive detail in several cases, analysis clearly indicates that a majority of detections or incursions originated from vessels and or cargo in the vicinity of seaports. Occasionally exotic bees have been detected at airports and mail centres in airfreight and personal possessions. However, the likelihood of an incursion of exotic bees and possibly exotic mites via an airport or mail centre is considered to be extremely low under existing quarantine, surveillance and monitoring arrangements, and the data presented in table 2 supports this assumption.

Table 2 A list of incursions and potential incursions involving honeybee pests

Date	Agent	Place	Comments
Early 1970s	Apis dorsata	Fremantle	From Java, Indonesia. No details available.
February 1994	Apis mellifera scutellata	Fremantle	A nest of live bees was found on a container and destroyed.
1992	Bombus terrestris ssp audax	Tasmania	Bumblebees accidently introduced into Tasmania possibly from NZ.
April 1995	Apis cerana	Near Brisbane	Machinery via sea cargo from PNG.
June 1996	Apis cerana	South Australia	No further details
February 1997	Apis mellifera scutellata	Fremantle	Abandoned nest only. Originated from Durban in South Africa.
December 1997	Bumble bee (Bombus Vosnesenski)	Buderim, Qld	Not diagnosed till May 1999. Mites were found – identified as Kunzenia sp. which are basically scavengers in bumble bee nests, not significant for Apis spp..
June 1998	Apis cerana	Darwin	Nest discovered by a local beekeeper. Eradication program instituted and intensive surveillance. DNA test showed the honeybees were Java type. No mites seen on inspection.
July 1999	Apis dorsata	Sydney	Airfreight from Penang Malaysia - computer motherboards. Examination showed no mites.
September 1999	Apis cerana		Asian honeybees were detected on a ship (ex Singapore, Lae and Port Moresby) berthed in Brisbane. A swarm of approximately 50-100 bees left the ship but follow up monitoring revealed nothing.
December 1999	Apis cerana	Brisbane	Introduced with heavy earth moving equipment from Lae, PNG. Hive of 5,000 bees destroyed. DNA test showed the honeybees were Java type. Varroa jacobsoni found.
January 2002	Apis cerana	Melbourne	Hive (well established with 4 healthy combs and approx. 1000 healthy individuals) on under surface of a shipping container from Lae, New Guinea. Destroyed. Inspection revealed Varroa jacobsoni.
December 2002	Apis cerana	Brisbane	One bee found on ship from PNG. Follow-up surveillance in Hamilton area revealed nothing.
February 2003	Apis dorsata	Vessel off north Australia	Oil tanker from Singapore. A "quite large swarm" found by crew and (inexpertly) destroyed before arrival. Only dead bees found. No mites seen on inspection.
February 2003	Apis dorsata	Vessel off north Australia	Vessel from Indonesia. Seven dead and one dying bee found. No evidence of swarm found despite repeated checks. No mites found on inspection.
May 2004	Apis cerana	Cairns	Vessel from PNG. Swarm of Apis cerana found in hold on arrival in port. Bees destroyed. Spread considered unlikely. No mites found on inspection.

Date	Agent	Place	Comments
Nov 2004	Apis cerana	Brisbane	Vessel from PNG. Nest of Apis cerana found under a container in port. Bees destroyed. Spread considered unlikely. Varroa jacobsoni found on inspection. Surveillance for Apis cerana put in place within 6 km radius for 12 months.
April 2005	Apis cerana Java	Brisbane	Cargo vessel (Cape Delfaro) from Lae, PNG. V. jacobsoni and V. underwoodi detected.
May 2007	Apis cerana	Cairns port area	Seven swarms found and destroyed. Subsequent swarms have been found and destroyed in 2008. Further detections have been made through 2009..

Incursion information sourced from Boland (2005). A review of the National Sentinel Hive Program. Biosecurity Australia sourced at www.daff.gov.au/__data/assets/pdf_file/0011/689564/sentinel-hive-review-jun05.pdf

Unassisted pathways for the introduction of *Varroa spp*. and *Tropilaelaps spp*. into Australia

Probability of entry by swarming or with flotsam

Factors considered to be of importance include the following:

- *Apis cerana* is present throughout Asia including the southern coast of the island of New Guinea adjacent to the Torres Strait. *Apis mellifera* is distributed throughout the world. The closest non-endemic populations of *A. mellifera* are in New Zealand, Port Moresby (PNG) and Timika (West Papua).

- *Apis cerana* has a high rate of reproductive swarming (6–12 times per year) as compared to *A. mellifera* (1-2 swarms per year). However, the distance of normal reproductive swarming of both species is less than 10 km.

- *Apis spp*. swarms normally travel only relatively short distances over open water. There has been no observed unassisted spread of *A. cerana* from the northern Torres Straits islands to the southern Torres Straits islands or to northern Australia, despite *A. cerana* being present in the northern Torres Straits islands since 1993. It is unlikely that *Apis spp*. could reach the Australian mainland due to swarming behaviour.

- *Apis cerana* inhabits the tropical coastal areas of PNG and favours hives in hollow logs. *Apis mellifera* may also favour hollow logs in some instances. It is theoretically possible that a viable hive could survive in a fallen log or other debris that is washed as flotsam from the coast of PNG or Western Papua to the northern Australian coast. However, survival is considered unlikely due to the distance to be travelled over open ocean and the extended travel time without food or water.

Conclusion

On the basis of these considerations it was concluded that the likelihood of entry of *A. mellifera* or *A. cerana* as unassisted swarms is considered to be Extremely Low; accordingly it was not considered further in this analysis.

Assisted pathways for the introduction of *Varroa spp*. and *Tropilaelaps spp*. into Australia

Pathway 1 – Apis cerana with Varroa destructor

Varroa destructor is a relatively benign external parasite of brood and adults of *A. cerana*. There are several *V. destructor* genotypes that naturally infest different populations of *A. cerana* on mainland Asia, including the Japan, Korea, China, Vietnam, Nepal and Sri Lanka genotypes. Only the Korea and Japan genotypes of *V. destructor* are known to be pathogenic to *A. mellifera*.

Pathway 2 – Apis cerana with Varroa jacobsoni

Varroa jacobsoni is a complex of several genotypes that naturally infest different populations of *A. cerana* in the southern mainland Asia–Malaysian–Indonesian region. Included are the Java, Sumatra, Malaysia, Borneo, Bali, Lombok, Sumbawa, Flores, and Ambon genotypes.

Pathway 3 – Apis mellifera with Varroa jacobsoni

In 2008, surveys in PNG detected the widespread presence of a strain of *V. jacobsoni* that is pathogenic to *A. mellifera*. Further research is required to confirm whether this strain can reproduce on both *A. mellifera* and *A. cerana,* but this discovery potentially constitutes a new and significant risk pathway for the Australian honeybee industry. For the purposes of this pathway analysis it was assumed that the PNG strain of *V. jacobsoni* can reproduce on both *A. mellifera* and *A. cerana.*

Pathway 4 – Apis mellifera with Varroa destructor

Varroa destructor infests *A. mellifera* causing severe damage to colonies; the pest is now distributed throughout most beekeeping areas of the world other than Australia. The mite feeds on internal body fluids of larvae, pupae and adult worker bees, and transmits or activates several viral diseases.

Pathway 5 – Apis mellifera or A. dorsata with Tropilaelaps spp.

Mites in the genus *Tropilaelaps* were originally described as external parasites of the brood of *Apis dorsata* (Giant honeybee). However, a host switch occurred onto the brood of *A. mellifera* where infestations can rapidly lead to colony death. *Tropilaelap*s is now considered to be a serious threat to *A. mellifera* wherever it is present.

Pathway 6 – Additional vectors of *Varroa spp*.

Varroa spp. can attach themselves to other flower-visiting insects such as bumble bees (*Bombus* spp.), hoverflies (*Syrphidae*), some species of honeybeetles (*Scarabaeidae)* and wasps (*Vespidae*). The association with *Bombus* spp. is an important consideration in any future introduction of the bumble bee as a pollinator. However, it is considered that current quarantine requirements for exotic species of these insect groups and associated commodities will adequately manage any risk associated with the introduction of *Varroa spp*. via these pathways. No further consideration of these additional vectors of *Varroa spp*. is therefore provided.

Pest information

Varroa destructor

There are more than 25 different genotypes of *Varroa* spp. on *A. cerana*. The various genotypes of *V. destructor* are found on *A. cerana* throughout mainland Asia, but only the Korea and Japan genotypes have become pests of *A. mellifera*. The Korea genotype is the most common on *A. mellifera* and is found in the United Kingdom, Europe, Russia, the Middle East, Africa, Asia, Canada, North and South America, and New Zealand. The Japan genotype is found on *A. mellifera* in Japan, Thailand, North and South America, and Canada.

The Korea and Japan *V. destructor* genotypes have spread rapidly through both managed and feral honeybee colonies worldwide. In many cases human distribution of infested bees has been a key factor in the spread of the mites. In 2000, *V. destructor* was detected on the North Island of New Zealand and it had spread to the South Island by 2006. The mite was also detected on the Hawaiian Islands in 2007, and is now present in all major beekeeping regions of the world except for Australia. Table 4 provides approximate dates of introduction and spread of *V. destructor* around the world.

If *V. destructor* were to become established in Australia, international experience would suggest that apiarists would experience loss of productive colonies and the need to adopt costly control measures. Feral bee populations would also be severely reduced. A reduction in the pollination capability would also affect the viability of many horticultural and agricultural industries and have an impact on the national economy.

Table 3 Approximate dates of introduction and spread of Varroa destructor around the world

Date of introduction	Country	Date of introduction	Country
Early 1960’s	Japan and the USSR	1987	Portugal
1960’s – 1970’s	Eastern Europe	1987	USA
1971	Brazil	1989	Canada
Late 1970’s	South America	1992	England
1982	France	2000	New Zealand (North Island)
1984	Switzerland, Spain and Italy	2006	New Zealand (South Island)
		2007	Hawaii

Varroa jacobsoni

Varroa jacobsoni is defined as consisting of genotypes that naturally infest different populations of *A. cerana* in the southern mainland Asia–Malaysian–Indonesian region. Included are the Java, Sumatra, Malaysia, Borneo, Bali, Lombok, Sumbawa, Flores, and Ambon genotypes.

Varroa jacobsoni has until recently only been known as a relatively benign external parasite of *A. cerana*. However, surveys in PNG in 2008 detected the widespread presence of a strain of the mite pathogenic to *A. mellifera*. Further research is required to confirm whether this strain can reproduce on both *A. mellifera* and *A. cerana* but this discovery potentially establishes a new and significant risk pathway for the Australian honeybee industry. For the purposes of this pathway analysis it was assumed that the PNG strain of *V. jacobsoni* will reproduce on both *A. mellifera* and *A. cerana.*

Varroa jacobsoni is considered to be widely dispersed throughout Asia but is not present in Australia. If *V. jacobsoni* were to become established in Australia, international experience would suggest that apiarists would experience loss of productive colonies and need to adopt costly control measures. Feral bee populations would also be severely affected. A reduction in the pollination capability would also affect the viability of many horticultural and agricultural industries and have an impact on the national economy.

Tropilaelaps spp.

Mites in the genus *Tropilaelaps* are external parasites of the brood of honeybees (*Apis* spp.). Different *Tropilaelaps* subspecies were originally described from *Apis dorsata* (Giant honeybee), but a host switch occurred to *A. mellifera,* where infestations can rapidly lead to colony death. There are four species documented in the literature and two (*Tropilaelaps clareae* and *Tropilaelaps mercedesae*) are considered harmful to *A. mellifera*.

Tropilaelaps spp. are thought to be distributed throughout Asia, including Indonesia and the western half of New Guinea (Papua). *Tropilaelaps* spp. are not present in Australia, Europe or New Zealand. If *Tropilaelaps* spp. were to become established in Australia, international experience would suggest that apiarists would experience loss of productive colonies and need to adopt costly control measures. Feral bee populations would also be severely affected. A reduction in the pollination capability would also affect the viability of many horticultural and agricultural industries and have an impact on the national economy.

Risk assessments for the identified pathways

Varroa destructor, V. jacobsoni and Tropilaelaps spp. are not present in Australia and have the potential for entry, establishment, spread and delivery of economic consequences in Australia, and thus meet the criteria for a quarantine pest.

The risk assessments in this section focus on assisted pathways identified for the mite species associated with A. cerana, A. mellifera and A. dorsata. The probability of entry has been considered individually for each identified pathway as these pathways each have a significant effect on the overall assessments. The probability of entry has been considered as the probability of importation (the likelihood that the honeybees and mites are transported to the quarantine barrier alive) combined with the probability of distribution (the likelihood that bees and mites will cross the quarantine barrier alive).

However, the combined probability of establishment (the likelihood that the mites will find suitable resources to survive and reproduce post-barrier) and spread (the likelihood that the mites will move from the original incursion site/s) have been assessed only once for the pathways considered here. This is because the probability of establishment and spread is influenced by many relatively constant factors such as the efficacy of current awareness, surveillance and quarantine requirements, the suitability of the environment, and the biology of the bees and the mites themselves. The majority of these variables are not considered to vary significantly between pathways.

Pathway 1- Apis cerana with Varroa destructor

Probability of importation

- *Varroa destructor* is a relatively benign external parasite of *A. cerana*.

- The Korea and Japan genotype only infests *A. mellifera* and is only found on *A. cerana* in mainland Asia.

- *A. cerana* is present throughout Asia including the southern coast of the island of New Guinea, the Solomon Islands and some of the northern Torres Straits islands. However, it is unlikely to be infested with the Korea and Japan strains of *V. destructor* within PNG or the northern Torres Strait Islands.

- Smuggling of *A. cerana* is unlikely to occur as it is considered an inferior species for honey production, and there is no demand for its genetics.

- Commercial aircraft travel at high altitudes greatly reducing the likelihood of bee survival in the cargo or luggage areas. There would also be a high probability of discovery of a viable hive or swarm during loading and unloading of cargo.

- AQIS interception records (Table 2) show that there has been one and possibly several other detections of individual exotic bees with air cargo. However, records do not indicate if the specimens were alive or dead.

- Large ocean-going vessels tend to have a large variety of cryptic habitats for bee swarms, which would decrease the likelihood of detection. Colonies may survive for a significant time, particularly if there is a comb associated with the honeybees.

- Incursion and interception records (Table 2) indicate that *A. cerana* has been detected on freighters and their cargo several times over the years. *Varroa* spp. mites have also been detected on *A. cerana* specimens that have been intercepted on several occasions.

Conclusion

The likelihood of importation of *V. destructor* with *A. cerana* by assisted entry is **Low.**

Probability of distribution

- It is likely that swarms of bees would be detected in or on small aircraft upon arrival and it is unlikely that swarms of sufficient size to establish would survive commercial flights. Therefore distribution from airports is considered unlikely.

- Incursion and interception records (Table 2) clearly indicate that sea ports for commercial vessels and cargo represent the highest risk of importation and distribution for exotic bees and mites.

- AQIS have clearly defined international vessel and cargo clearance procedures and requirements and have responded to several suspected exotic bee detections upon cargo ships and in seaport areas (Table 2).

- The majority of commercial ports have been monitored using the National Sentinel Hive Program since 2000. Some ports also have bait hives and the ports of Darwin, Gove, Cairns and Brisbane maintain pheromone-baited log traps for Asian honeybee. However, the National Sentinel Hive Program has not detected any incursions, including the 2007 incursion of *A. cerana* in Cairns.

  - *A. cerana* has a high rate of reproductive swarming (6–12 times per year) and is likely to swarm from an original arrival point relatively rapidly (dependent upon the availability of food and shelter).

- An incursion of *A. cerana* will have contact with the hives of local bee populations (feral or managed *A. mellifera*, or native bees) where they exist. *Varroa destructor* may be transmitted to native populations if present on *A. cerana*.

Conclusion

The likelihood of distribution of *V. destructor* associated with *A. cerana* is **High.**

Pathway 2- Apis cerana with Varroa jacobsoni

Probability of importation

- *Varroa jacobsoni* is a relatively benign external parasite of *A. cerana*.

- *A. cerana* is present throughout Asia including the southern coast of the island of New Guinea, the Solomon Islands and some of the northern Torres Straits islands.

- A pathogenic strain of *V. jacobsoni* has been found on *A. mellifera* in PNG. Whilst yet to be scientifically proven, it has been assumed that this strain can reproduce on both *A. mellifera* and *A. cerana.*

- Smuggling of *A. cerana* is unlikely to occur as it is considered an inferior species for honey production, and there is no demand for its genetics.

- Light planes travel regularly between the islands of New Guinea and northern Australia. Light planes travel at relatively low altitudes increasing the likelihood of survival of bees. However, it is a very likely that a hive would be quickly detected in the small spaces within the aircraft.

- Commercial aircraft travel at higher altitudes greatly reducing the likelihood of honeybee survival in the cargo or luggage areas. There would also be a high probability of discovery of a viable hive or swarm during loading and unloading of cargo.

- AQIS interception records (Table 2) show that there has been one and possibly several other detections of individual exotic bees with air cargo. However, records do not indicate if the specimens were alive or dead.

- The small boat inter-island traffic between the islands in Torres Strait and these islands and the mainlands of PNG and Australia provide a means for the transfer of live bees and *V. jacobsoni*. However, any hive or swarm on a small boat will almost certainly be detected.

- Large ocean-going vessels tend to have a large variety of cryptic habitats for bee swarms, which would decrease the likelihood of detection. Colonies may survive for a significant time, particularly if there is a comb associated with the bees.

- Incursion and interception records (Table 2) indicate that *A. cerana* has been detected on freighters and their cargo several times over the years. *Varroa* spp. mites have also been detected on *A. cerana* specimens that have been intercepted on several occasions.

Conclusion

The likelihood of importation of *V. jacobsoni* with *A. cerana* by assisted entry is **High.**

Probability of distribution

- It is likely that swarms of honeybees would be detected in or on small aircraft upon arrival and it is unlikely that swarms of sufficient size to establish would survive commercial flights. Therefore distribution from airports is considered unlikely.

- Incursion and interception records (Table 2) clearly indicate that sea ports for commercial vessels and cargo represent the highest risk of importation and distribution for exotic bees and mites.

- AQIS have clearly defined international vessel and cargo clearance procedures and requirements and have responded to several suspected exotic bee detections upon cargo ships and in seaport areas (Table 2).

- The majority of commercial ports have been monitored using the National Sentinel Hive Program since 2000. Some ports also have bait hives and the ports of Darwin, Gove, Cairns and Brisbane maintain pheromone-baited log traps for Asian honeybee. However, the National Sentinel Hive Program has not detected any incursions, including the 2007 incursion of *A. cerana* in Cairns.

- *A. cerana* has a high rate of reproductive swarming (6–12 times per year) and is likely to swarm from an original arrival point relatively rapidly (dependent upon the availability of food and shelter).

- An incursion of *A. cerana* will have contact with the hives of local bee populations (feral or managed *A. mellifera*, or native bees) where they exist. *V. jacobsoni* may be transmitted to native populations if present on *A. cerana*.

Conclusion

The likelihood of distribution of *Varroa jacobsoni* associated with *A. cerana* is **High.**

Pathway 3 – Apis mellifera with Varroa jacobsoni

Probability of importation

- Recent surveillance in PNG has revealed that a strain of *V. jacobsoni* pathogenic to *A. mellifera* is widespread on the mainland. Further research is required to confirm if this strain can reproduce on both *A. mellifera* and *A. cerana* but this discovery poses a new and significant risk pathway for the Australian honeybee industry. For the purposes of this pathway analysis it was assumed that the PNG strain of *V. jacobsoni* can reproduce on both *A. mellifera* and *A. cerana.*

- The closest *A. mellifera* hives within *V. jacobsoni* distribution are thought to be at Port Moresby in PNG and at Timika in Papua. However, there is not a significant apiary industry or sufficient numbers of feral *A. mellifera* in these areas to suggest that feral *A. mellifera* are likely to swarm onto seagoing vessels or cargo.

- Due to the undeveloped nature of the apiary industry in these areas and relatively few feral hives, assisted entry of *A. mellifera* with *V. jacobsoni* from these areas is considered unlikely.

- The legal and illegal movement of queen bees has assisted the dispersal of *Varroa* spp. internationally. However, due to the underdeveloped nature of the *A. mellifera* apiary industry in PNG and Papua it is unlikely that genetic material, potentially infested with *V. Jacobsoni,* would be smuggled from these areas.

Conclusion

The likelihood of importation of *V. jacobsoni* with *A. mellifera* by assisted entry is **Low.**

Probability of distribution

- It is likely that swarms of bees would be detected in or on small aircraft upon arrival and it is unlikely that swarms of sufficient size to establish would survive commercial flights. Therefore distribution from airports is considered unlikely.
- Incursion and interception records (Table 2) clearly indicate that ports for commercial vessels and cargo represent the highest risk of entry for exotic bees and mites.
- AQIS have clearly defined international vessel and cargo clearance procedures and requirements and have responded to several suspected exotic bee detections upon cargo ships and in seaport areas (Table 2).
- The majority of commercial ports have been monitored using the National Sentinel Hive Program since 2000. Some ports also have bait hives and the ports of Darwin, Gove, Cairns and Brisbane maintain pheromone-baited log traps for Asian honeybee. However, the National Sentinel Hive Program has not detected any incursions, including the 2007 incursion of *A. cerana* in Cairns.
- Bait hives at some ports have detected *A. mellifera* but it is difficult to determine if they are exotic or not, and the likelihood of distribution is considerable.

Conclusion

The likelihood of distribution of *Varroa jacobsoni* associated with *A. mellifera* is **High.**

Pathway 4 – Apis mellifera with Varroa destructor

Probability of importation

- *Varroa destructor* has spread rapidly throughout the world (table 4) and is now present in all areas of the world as an external parasite of *A. mellifera*, except for Australia.
- Recent incursions of *V. destructor* have occurred in New Zealand in 2000 and Hawaii in 2007.
- The mode of entry of *V. destructor* into New Zealand remains unclear but the cluster of detections around southern Auckland and the associated port area would suggest an undetected swarm infested with *V. destructor* associated with a container or large vessel.
- The mode of entry of *V. destructor* into Hawaii remains unclear but once again the cluster of detections would suggest an undetected swarm infested with *V. destructor* associated with a container or large vessel.
- The spread of *V. destructor* between countries and continents has also been assisted by the introduction of infested hives, infested queen bees and infested beekeeping material.
- The importation of live bees and used beekeeping material is not permitted into Australia.
- The ban on the importation of queen bees into Australia may increase the likelihood of smuggling. However, the risks associated with the introduction of *V. destructor* are well

known to the beekeeping community and smuggling is considered to currently be a relatively low risk.

Conclusion

The likelihood of importation of *V. destructor* with *A. mellifera* by assisted entry is High.

Probability of distribution

- It is most likely that *A. mellifera* could enter either on imported cargo or as a swarm from a cargo vessel (Table 2).
- It is likely that swarms of bees would be detected in or on small aircraft upon arrival and it is unlikely that swarms of sufficient size to establish would survive commercial flights. Therefore distribution from airports is considered unlikely.
- Incursion and interception records (Table 2) clearly indicate that ports for commercial vessels and cargo represent the highest risk of entry for exotic bees and mites.
- AQIS have clearly defined international vessel and cargo clearance procedures and requirements and have responded to several suspected exotic bee detections upon cargo ships and in seaport areas (Table 2).
- The majority of commercial ports have been monitored using the National Sentinel Hive Program since 2000. Some ports also have bait hives and the ports of Darwin, Gove, Cairns and Brisbane maintain pheromone-baited log traps for Asian honeybee. However, the National Sentinel Hive Program has not detected any incursions, including the 2007 incursion of *A. cerana* in Cairns.
- Bait hives at some ports have detected *A. mellifera* but it is difficult to determine if they are exotic or not, and the likelihood of distribution is considerable.

Conclusion

The likelihood of distribution of *V. destructor* with *A. mellifera* is **High.**

Pathway 5 – Apis mellifera or A. dorsata with Tropilaelaps spp.

Probability of importation

- There are four *Tropilaelaps* species. Two of the species (*Tropilaelaps clareae* and *Tropilaelaps mercedesae*) have spread from their original host, the giant honeybee (*Apis dorsata*), to *A. mellifera.*
- *Tropilaelaps clareae* is found in the Philippines (except Palawan Island) and Sulawesi. *Tropilaelaps mercedesae* is found throughout mainland Asia, Indonesia and New Guinea.
- *Tropilaelaps* spp. are external parasites of bee brood only and cannot survive more than seven days away from bee brood.
- *Tropilaelaps* spp. do not parasitise adult bees but can attach and transfer between adult bees.
- *Tropilaelaps* spp. may be imported on adult *A. dorsata* and *A. dorsata* have been detected by AQIS at the barrier on several occasions (Table 2). However, it appears that no *Tropilaelaps* spp. mites have been detected on intercepted adult specimens.

- The short survival time of *Tropilaelaps* spp. away from brood would suggest that establishment on exotic adult bees is unlikely.

- The importation of any *Apis* spp. brood into Australia is currently prohibited.

Conclusion

The likelihood of importation of *Tropilaelaps* spp. with *A. mellifera* or *A. dorsata* by assisted entry is Low.

Probability of distribution

- It is most likely that *A. mellifera* or *A. dorsata* could enter either on imported cargo or as a swarm from a cargo vessel.

- It is likely that swarms of bees would be detected in or on small aircraft upon arrival and it is unlikely that swarms of sufficient size to establish would survive commercial flights. Therefore distribution from airports is considered unlikely.

- Incursion and interception records (Table 2) clearly indicate that ports for commercial vessels and cargo represent the highest risk of entry for exotic bees and mites.

- AQIS have clearly defined international vessel and cargo clearance procedures and requirements and have responded to several suspected exotic bee detections upon cargo ships and in seaport areas (Table 2).

- The majority of commercial ports have been monitored using the National Sentinel Hive Program since 2000. Some ports also have bait hives and the ports of Darwin, Gove, Cairns and Brisbane maintain pheromone-baited log traps for Asian honeybee. However, the National Sentinel Hive Program has not detected any incursions, including the 2007 incursion of *A. cerana* in Cairns.

- Bait hives at some ports have detected *A. mellifera* but it is difficult to determine if they are exotic or not and the likelihood of distribution is considerable.

- It would only be likely that exotic bees cross the quarantine barrier carrying *Tropilaelaps* spp. if there is a relatively short transit time of several days or an active hive with infested brood has been transported to an Australian sea or airport.

Conclusion

The likelihood of distribution of *Tropilaelaps* spp. with *A. mellifera* or *A. dorsata* is **Low.**

Overall probability of entry

The probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix of rules for combining descriptive likelihoods (Appendix 1). The overall probabilities of entry for the five pathways being assessed in this PRA are set out in Table 4.

Table 4 Overall probability of entry of Varroa destructor, V. jacobsoni and Tropilaelaps spp for the pathways under consideration

Pathway	Probability of importation	Probability of distribution	Overall probability of entry

Pathway 1- *A. cerana* with *V. destructor*	Low	High	Low
Pathway 2- *A. cerana* with *V. jacobsoni*	High	High	High
Pathway 3 – *A. mellifera* with *V. jacobsoni*	Low	High	Low
Pathway 4 – *A. mellifera* with *V. destructor*	High	High	High
Pathway 5 – *A. mellifera* or *A. dorsata* with *Tropilaelaps spp.*	Low	Low	Very low

Probability of establishment and spread of *Varroa spp*. and *Tropilaelaps spp*.

- Australian climatic conditions and resource availability would favour the establishment and spread of exotic bee species and exotic mites.
- The majority of commercial ports have been monitored using the National Sentinel Hive Program since 2000. Some ports also have bait hives and the ports of Darwin, Gove, Cairns and Brisbane maintain pheromone-baited log traps for Asian honeybee. However, the National Sentinel Hive Program has not detected any incursions, including the 2007 incursion of *A. cerana* in Cairns.
- Bait hives at ports have detected *A. mellifera*. However, once past the quarantine barrier it would be difficult to distinguish exotic from domestic or feral *A. mellifera*.
- Interaction between exotic and endemic *A. mellifera* would occur. The level and extent of interaction would be dependent upon the number of domestic hives and feral *A. mellifera* within flight distance of the exotic incursion.
- *Apis cerana* will also interact with endemic bee populations through swarming and robbing behaviour.
- It is likely that transfer of *Varroa spp*. or *Tropilaelaps spp*. could occur during these interactions.
- If domestic hives or feral populations become infested with *Varroa spp*. it may be twelve months or more before mite levels increase to detectable levels.
- *Tropilaelaps spp*. cannot survive without brood for more than seven days but the reproductive cycle is more rapid than *Varroa spp.* If susceptible brood are found populations could establish rapidly.
- Human-assisted transfer of domestic *A. mellifera* infested with undetectable levels of *Varroa spp*. or *Tropilaelaps spp*. may occur before infestations are detected.

Conclusion

The likelihood of establishment and spread of *Varroa spp.* and *Tropilaelaps spp*. is **High.**

Overall likelihood of entry, establishment and spread

The probability of entry, establishment and spread is determined by combining the probability of entry, of establishment and spread using the matrix of rules for combining descriptive likelihood (Appendix 1).

The overall assessment of likelihood that *Varroa spp*. and *Tropilaelaps spp*. will enter Australia by the pathways discussed in this pathway analysis, be distributed in a viable state to susceptible hosts, establish in that area, and subsequently spread within Australia are set out in Table 5.

Table 5 Overall probability of entry, establishment and spread of Varroa spp. and Tropilaelaps spp. for the pathways under consideration

Pathway	Probability of entry	Probability of establishment and spread	Overall probability of entry, establishment and spread
Pathway 1- *A. cerana* with *Varroa destructor*	Low	High	Low[4]
Pathway 2- *A. cerana* with *Varroa jacobsoni*	High	High	High
Pathway 3 – *A. mellifera* with *V. jacobsoni*	Low	High	Low
Pathway 4 – *A. mellifera* with *V. destructor*	High	High	High
Pathway 5 – *A. mellifera* or *A. dorsata* with *Tropilaelaps* spp.	Very low	High	Very low[5]

[4] The probability of entry of *A. cerana* **without** any associated exotic pests or diseases is considered to be high (this likelihood is supported by the recent Cairns incursion and subsequent eradication campaign).
[5] It should be noted that the probability of entry of *A. dorsata* **without** any associated exotic pests or diseases is considered to be low (this is supported by the infrequent border detections and no recorded post barrier incursions of this species).

Pathway analysis conclusion

The pathway analysis has indicated that:

- there is a low risk of entry, establishment and spread of *Varroa destructor* associated with *Apis cerana*;
- there is a high risk of entry, establishment and spread of *Varroa jacobsoni* associated with *Apis cerana*;
- there is a low risk of entry, establishment and spread of *Varroa jacobsoni* associated with *Apis mellifera*;
- there is a high risk of entry, establishment and spread of *Varroa destructor* with *Apis mellifera*; and
- there is a very low risk of entry, establishment and spread of *Tropilaelaps spp*. with *Apis mellifera* or *Apis dorsata*.

The pathway analysis for *Varroa destructor*, *Varroa jacobsoni* and *Tropilaelaps spp*. has considered scientific information and other relevant literature. The pathway analysis has also considered the relevant current quarantine[6], surveillance and awareness requirements. It is important to note that if the relevant current quarantine, surveillance and awareness requirements should change the risk associated with each pathway may also change.

[6] There is currently a prohibition on the importation of all live bees into Australia. This measure greatly reduces the risk of introduction but it may also increase the temptation to introduce new genetic stock illegally over time. This may increase the risk of introduction via this pathway over time.

3. Predictive Economic Modelling

Introduction

The analysis in this chapter formed a core component of the risk-based assessment framework. For reasons given earlier in this report, the analysis focussed on an incursion of the exotic bee mite *Varroa destructor*. However, the economic model and methodology presented here also provides a framework for the future analysis of other pest species of interest.

Background to the evaluation of pollination services

Australia is particularly vulnerable to the impact of invasive species that affect the European honeybee due to the absence of other native pollinators capable of delivering the same pollination benefits. There are several studies that place a value on pollination services for different regions of the world. Gill (1989a) provided an overview of the methodologies used in some of these valuations, with particular reference to the North American experience.

Varroa destructor is thought to have been introduced into the U.S. in the mid-1980s by way of illegal commercial bee movements from Europe and South America (Guzman *et al.* 1997) and has subsequently led to severe losses of both feral and commercial *Apis mellifera* colonies (Watanabe 1994). The extent of the resultant economic impact is not clear. Robinson *et al.* (1989) placed a value of U.S.$9.3 billion on pollination services to crops across the whole of North America. Morse and Calderone (2000) revised this value upwards to around U.S.$14.6 billion. These estimates are thought to be exaggerated, and were more conservatively estimated at around $600 million by Muth and Thurman (1995).

Given the significant proportion of the community potentially affected by a decrease in pollination services it is surprising there have not been more economic analyses undertaken of pollination markets, particularly in the U.S. where a government-provided price support scheme operated until 1996. Ostensibly, the reasoning for this support scheme was to correct a market failure caused by private providers of pollination services being unable to capture all the benefits attributable to their operations. The existence of positive externalities generally leads to a level of service provision below a socially desirable level. Analyses concerning the existence and internalisation (or lack thereof) of these externalities include Cheung (1973), Johnson (1973) and Burgett et al. (2004). Olmstead and Wooten (1987) might also be added to this list, but their research focused on a specific pollination market, that of the Californian alfalfa market of the 1940s and 1950s. Although government intervention in the U.S. pollination market acknowledged the existence of externalities, it is interesting to note that the decision was taken to support the price of honey rather than to subsidise the provision of pollination services.

Research into the pollination benefits enjoyed by Australia's plant industries is also scarce. In conducting an investigation into the feasibility of employing biological control agents to reduce the abundance of the noxious weed Patterson's Curse (Echium plantagineum), the Industries Assistance Commission (1985) put forward a value of just under $160 million for pollination benefits. This study was based on a pollination index ranking reliance on pollination of certain crops, but contained an upward bias due to excessive attribution rates to A. mellifera as opposed to other pollinators. Although not attempting a valuation exercise, Cunningham et al. (2002) contains a similar index which we have revised and used as the basis for assumptions later in the impact simulation modelling to follow. Cook et al. (2007) used this index combined with a bioeconomic model to simulate the likely impact on 25 Australian plant industries if the *V. destructor* mite were the become established. They estimated losses of between $20 million and $50 million per year could result.

Perhaps the most cited Australian study is Gill (1989b), who used a closed-market partial equilibrium model to examine the loss of producer and consumer surplus brought about by a negative supply shock (induced by an incident like *V. destructor* establishment and spread). The results indicated that production benefits of between $0.6 billion and $1.2 billion were attributable to pollination services provided by both commercial and feral honeybee pollinators. These results were repeated in Gibbs and Muirhead (1998). Using a methodology derived from Gill (1989b), Gordon and Davis (2003) then put forward a value of pollination service in Australia of $1.7 billion.

Each of these estimates contains an upward bias due to the assumed closed economy in the absence of pollinators, but more importantly (with the exception of Cook et al. (2007)) through their lack of a transitional period between the 'with' and 'without' pollinator states. Nonetheless, they indicate a substantial private benefit is generated by maintaining pollination services, and hence by maintaining the country's area freedom from pests and diseases capable of decreasing the level of crop pollination. This is reinforced by invasion response cost sharing arrangements between Federal and State governments and livestock industries set out in Animal Health Australia (2002), known as the Emergency Animal Disease Response Agreement (EADRA).

The model on which the EADRA is based is described in Centre for International Economics (1998). It involves 'high-profile' diseases being placed in one of four cost sharing categories relating to their significance in terms of potential damage to public resources and private industries. The categories relate to species with little or no impact on the community beyond agricultural industries (or low public cost) to those with high environmental/social costs. If a species categorised under the agreement is detected in Australia, the category chosen dictates an appropriate split of eradication funding between government and private industry. Eradication is conditional on a benefit cost analysis being completed, which indicates that a net social gain will result from a successful campaign.

Currently the EADRA lists the *V. destructor, Tropilaelaps* and Tracheal mites as category 2 species, meaning that funding arrangements for any future eradication campaigns mounted against them will be funded 80% by government and 20% by the honeybee keeping industry (i.e. 80/20). *V. jacobsoni* is listed as a category 4 species in the same agreement (i.e. 20/80), but this is likely to change given the recent detection of a new form of *V. jacobsoni* that is pathogenic to *A. mellifera* in Papua New Guinea. For each of these pests, the apiculture industry is obliged to pay all of the private costs of any future eradication campaign. A similar agreement applying to priority plant pests and diseases, the Emergency Plant Pest Response Deed (EPPRD) detailed in Plant Health Australia (2005) and Plant Health Australia (2001), does not currently include *V. destructor*. Pests of significance to the apiculture industry have typically been dealt with under the banner of livestock industries.

As past studies have shown, and as we will verify, these arrangements mean that other beneficiaries can receive a free ride on the eradication benefits provided by the apiculture industry when an incursion takes place. To some extent, apiculturists could recover a small proportion of these positive flow-ons through horizontal integration, but transaction costs are likely to be prohibitively high. Moreover, successful eradication would mean that pollination by wild *A. mellifera* would continue to make up a large proportion of market share.

In this analysis we are not concerned with the appropriateness of the 80 per cent government, 20 per cent private categorisation of honeybee pests under the EADRA. Our analysis is limited to the potential response benefits accruing to private agricultural industries.

Impact simulation modelling

We use the bioeconomic model developed in Cook et al. (2007) to estimate the likely benefits of surveillance measures over time. The model is adapted to simulate the possible effects of three bee mites, *V. destructor*, the recently discovered Varroa variant found in PNG and Tropilaelaps mites simultaneously. Three biological models were run concurrently and used to populate a common space to avoid double or triple counting. We note that there are actually two Tropilaelaps species of concern to Australia, (*T. clareae* and *T. koenigerum*), but we treat them as a single species for the purposes of this analysis. The objective of the model is to assess the significance of the threat posed by these three mite species to Australian agriculture by simulating total expected (or probability-weighted) damage over a specified period of time (30 years) with and without surveillance. The difference between these simulations effectively represents the benefits potentially produced through surveillance measures.

The use of random number generators to simulate chance or random events is common in risk analyses modelling natural systems with high parameter uncertainty and variability. This is the approach we adopt. Parameters are stated within an abstract model as probability distributions rather than point estimates, and a Monte Carlo algorithm used to sample from each of these distributions (Cook and Matheson 2008).

To summarize the Cook et al. (2007) model, production loss per unit of area (d), spread area (A), population density (N) and the numbers of satellite sites in each time period (St) are with the probability of entry and establishment (p) in an expression of probability-weighted, or expected damage over time. Given a discount rate α, the present value of expected damage after n time periods ($PV(ED_n)$) is (Cook et al. 2007):

$$\mathrm{PV}(\mathrm{ED}_n) = \sum_{t=0}^{n} (1+\alpha)^{-t} . \sum_{j=1}^{s_t} p.d.A.N \, . \tag{1}$$

Separate models were run simultaneously for each of the mite species simulating likely impacts of incursions over a 30-year period. The areas affected in each iteration were then summed for each time period and capped at the total crop area (given in Table 6).

Discounting is used because a dollar available for investment in the present is more valuable than a dollar that will not become available until a later period. The future dollar has an opportunity cost associated with it (i.e. investment opportunities we have had to forgo while we wait for it to become available for spending) (Cook et al. 2007). The expression in (1) provides a probability-weighted estimate of pest-induced revenue losses amongst plant industries in present value terms. It is a measure of expected damage taking into account uncertainty in the likelihood of arrival and establishment, severity of production effects, and change in abundance and distribution of honeybee pests over time.

Let us firstly look at the no surveillance case. Simulating potential losses to plant industries resulting from pollination declines is difficult. Cunningham et al. (2002) and Free (1993) provide estimates of the total proportion of regional yield gains attributable to pollination services, but the resultant yield change in the absence of feral *A. mellifera* is a matter for speculation. The process of defining the "supply shocks" indicated in Table 6 in response to a pest-induced feral *A. mellifera* decline is not dissimilar to those used in Gill (1989b). However, the magnitude of change is assumed smaller since other changes to management behaviours serve to soften the impact.

Table 6 Crop statistics, production cost increases and yield losses

Crop	Area (Ha)[a]	Annual Gross Value of Production (5-Year Average)[a]	Percentage of Total Pollination Services Delivered by Insects[b]	Additional Hives Required Per Hectare in the Absence of Feral Apis mellifera[c]	Percentage Yield Loss in the Absence of Feral Apis mellifera[c]
Almond	4,430	$ 41,759,605	100	2 - 5	10 - 30
Apple	13,260	$ 378,444,535	90	2	0 - 20
Apricot	1,085	$ 31,490,850	70	1 - 2	0 - 10
Avocado	4,000	$ 78,740,005	100	2	10 - 30
Blueberry	510	$ 26,823,780	100	1 - 2	10 - 30
Canola	1,909,730	$ 1,502,672,850	15	0	0 - 5
Cherry	1,270	$ 42,829,140	90	1 - 2	0 - 20
Cucumber	1,205	$ 16,530,650	100	1 - 2	0 - 20
Field Pea	422,675	$ 98,764,290	50	0	0 - 10
Lemon & Lime	1,785	$ 24,523,360	20	0.5	0 - 5
Lupin	1,347,180	$ 272,872,360	10	0	0 - 5
Macadamia Nut	14,000	$ 50,675,680	90	2 - 5	0 - 20
Mandarin	4,895	$ 86,286,200	30	0.5	0 - 5
Mango	2,650	$ 100,964,215	50	2	0 - 10
Nectarine	985	$ 114,537,870	60	1 - 2	0 - 10
Orange	30,560	$ 297,818,985	30	0.5	0 - 5
Peach	1,885	$ 84,923,755	60	1 - 2	0 - 10
Pear (Not Nashi)	3,025	$ 106,191,015	50	2	0 - 10
Plum	835	$ 44,197,390	70	1 - 2	0 - 10
Pumpkin	8,995	$ 59,762,785	90	1 - 2	0 - 20
Rockmelon	3,940	$ 104,172,020	100	1 - 2	0 - 20
Strawberry	905	$ 150,867,890	40	0	0 - 10
Sunflower	161,545	$ 50,798,325	100	2 - 5	10 - 30
Watermelon	4,950	$ 68,058,840	100	1 - 2	0 - 20
Zucchini	1,955	$ 32,249,965	100	1 - 2	0 - 20

[a] Australian Bureau of Statistics (2004).
[b] Based on pollinator reliance figures in Cunningham *et al.* (2002) and Free (1993).
[c] Based in part on Ministry of Agriculture and Forestry (2000).

Following Cook et al. (2007) we placed twenty five affected crops in one of four categories roughly proportional to pollinator reliance, as Table 6 indicates. A conservative approach has been adopted in that expected yield loss is much smaller than pollinator reliance (since commercial pollination services are assumed to offset losses). By assuming yield losses remain positive we imply that purchases of commercial pollinators will not be sufficient to avoid a decline in yield in the absence of feral *A. mellifera* hives. The number of hives required per hectare in the absence of feral *A. mellifera* for specific crops have not been estimated on the basis of feral hive equivalents in relevant land areas. For instance, the average density of feral hives may not necessarily be between one and five per hectare of sunflowers currently grown in Australia, but in order to receive sufficient pollination growers must pay for that number of hives. However, commercial pollination services are assumed to be an imperfect substitute for wild pollinators.

While an increased level of quantitative research has been witnessed across many disciplines in recent years, it is often not the case in the biological and natural resource management fields. A lack of basic data prevents the same level of quantification being achievable in analytical work compared to other fields such as engineering (Nunn 2001). This presents a major limitation when examining potential impacts of invasive species over time when one considers that entry and establishment probabilities tend to be highly sensitive (Cook et al. 2007; Cook and Matheson 2008).

As a substitute for rigorous quantitative risk analyses reporting the probability of species arrival, we have used the semi-quantitative categorisation system outlined in Biosecurity Australia (2001). This involves uniform (or rectangular) distributions being used to represent uncertainty in the probability of entry and establishment. The probability of each of the three bee mite species (*V. destructor, Varroa* (PNG variant) and Tropilaelaps) entering Australia is estimated as high. According to the Biosecurity Australia (2001) categorisation system, this can be represented by a uniform distribution with a minimum value of 0.7 and a maximum value of 1.0 (i.e. Uniform(0.7, 1.0)). The choice of risk category in this analysis is subjective. The probability of establishment conditional on entry already haven taken place is categorised as moderate, represented as Uniform (0.3, 0.7). Hence, the combined probability of entry and establishment is given by Uniform (0.2, 0.7).

The honeybee mite spread module of the model is largely unchanged from Cook et al. (2007), reflecting the view that the newly discovered Varroa (PNG variant) and the Tropilaelaps mites are likely to exhibit similar behaviour to *V. destructor*. The only exception is the assumed rate of spread of the Tropilaelaps mite, which is believed to be slightly higher than that of the other two mite species (Wilkins and Brown 2005). These and other species-specific assumptions underpinning the biological module of the model are provided in Table 7. The spread of honeybee mites (and consequent wild pollination decline) is assumed to follow a Verhulst-Pearl logistic function, as is the density of mite infestations within a given area of crop. Satellite infestations can also occur randomly in any given year via a logistic process dependent on the total area affected in the previous year. For a full description of these parameters and the complete model see Cook et al. (2007).

Table 7 Biological parameters

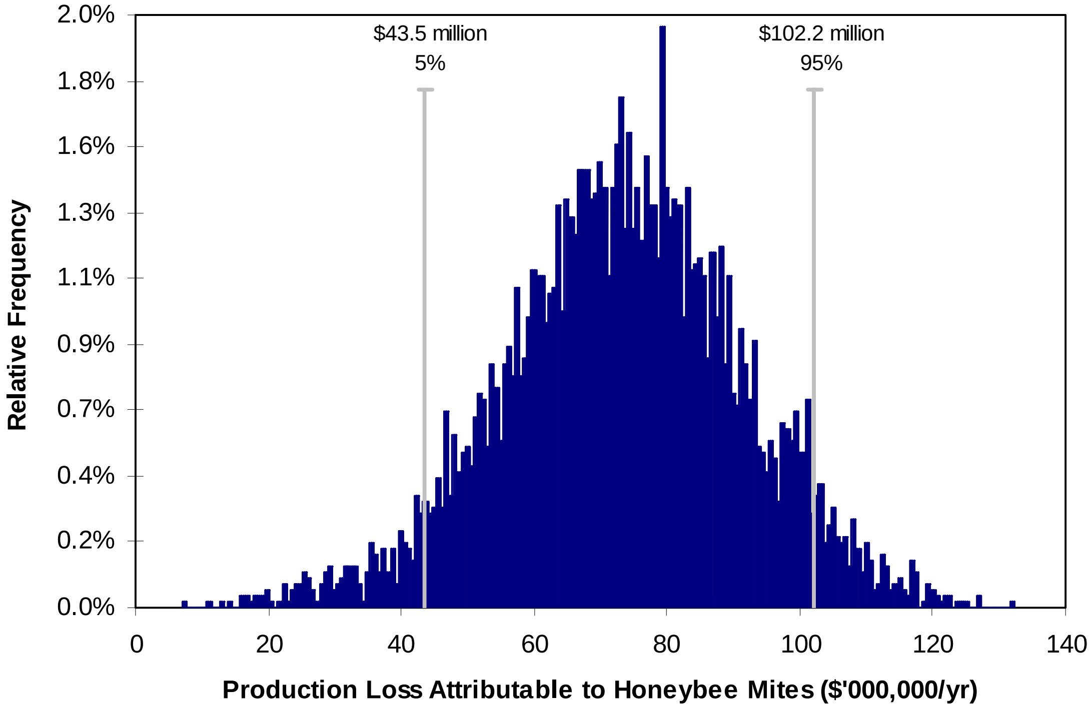
Parameter	Varroa destructora	Varroa (PNG Variant)a	Tropilaelapsa
Crop area (Ha) affected upon incursion	PERT(10,30,50) (Cook et al 2007) b	PERT(10,30,50)	PERT(10,30,50)
Maximum crop area (Ha) affected	UNIFORM(82000,100000) (Bourke & Harwood 2009) c	UNIFORM(82000,100000)	UNIFORM(82000,100000)
Population growth rate	PERT(0.20,0.35,0.50)	PERT(0.20,0.35,0.50)	PERT(0.50,0.60,0.70)
Population density upon incursion	PERT(5.0%,7.5%,10.0%)	PERT(5.0%,7.5%,10.0%)	PERT(5.0%,7.5%,10.0%)
Carrying capacity at maximum density of infestation	PERT(70%,85%,100%)	PERT(70%,85%,100%)	PERT(70%,85%,100%)
Maximum attainable no. satellite sites	PERT(30,40,50)	PERT(30,40,50)	PERT(30,40,50)
Minimum no. satellite sites	PERT(0,5,10)	PERT(0,5,10)	PERT(0,5,10)
Intrinsic rate of satellite generation	PERT(1.0×10-3,5.95×10-3,1.0×10-2)	PERT(1.0×10-3,5.95×10-3,1.0×10-2)	PERT(1.0×10-3,5.95×10-3,1.0×10-2)

[a] All parameter values are taken from Cook *et al.* (2007) unless otherwise stated.
[b] The term "PERT" is an acronym for the Program Evaluation and Review Technique, used to form a special case of the beta distribution using lower boundary (minimum), modal (most likely) and upper boundary (maximum) parameters (Vose 2000).
[c] The term "UNIFORM" refers to a rectangular distribution specified using a lower boundary (minimum) and an upper boundary (maximum).

We use 5,000 iterations of the model in which one value is randomly sampled across the range of each distribution. The advantage of using this approach is that it provides an indication of the complete set of possible damage scenarios. However, since we have assumed the complete independence of parameters, the tails of the expected damage distribution may be over-stated in the results. Nevertheless, for the purposes of this discussion we simply acknowledge this to be the case.

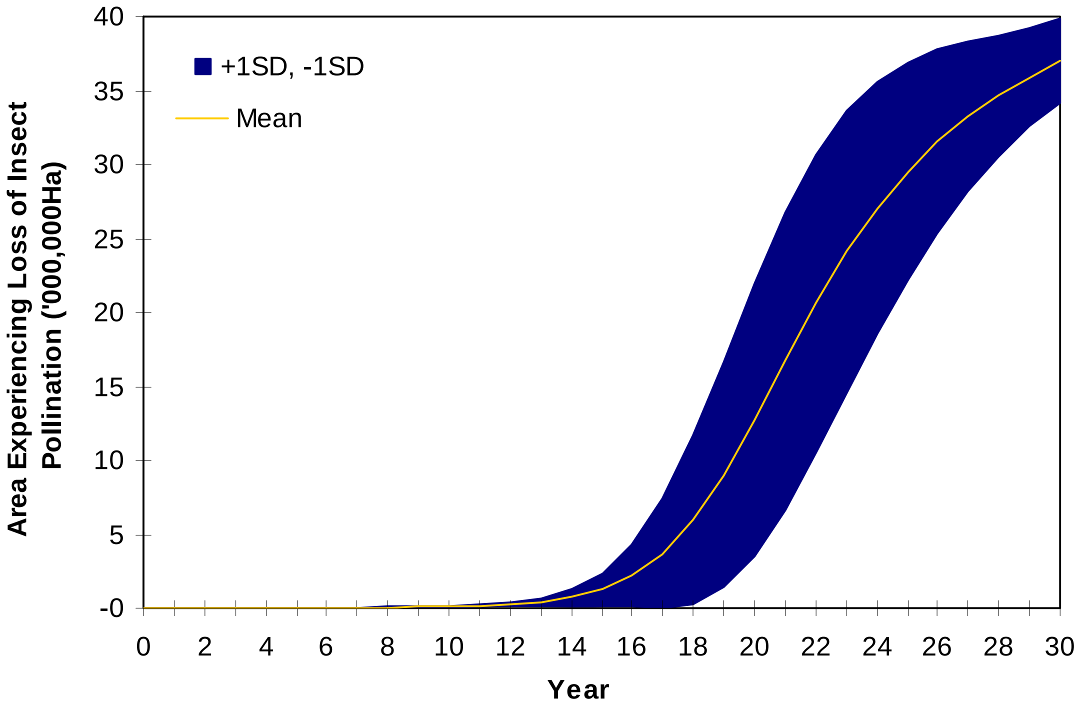
Taking the mean of the distribution of expected damage costs over a 30-year simulation (i.e. $PV(ED_n)/n$) without surveillance measures, we estimate that the average damage to Australian plant industries that could occur as a result of honeybee mite incursions over the next 30 years is $72.3 million per annum. This is equivalent to a loss of 2.5% of the annual combined GVP of all crops included in the model. Due to the uncertainty and variability of the parameter estimates used in the model our confidence intervals are broad. Results indicate a 90% likelihood of damages between $43.5 million (1.5% of GVP) and $102.2 million (3.5% of GVP) per annum. Figure 1 presents the relative frequency distribution for average annual damage over the 30-year period following establishment.

Figure 1 Average annual production damage that could result from honeybee mite incursions over 30 years



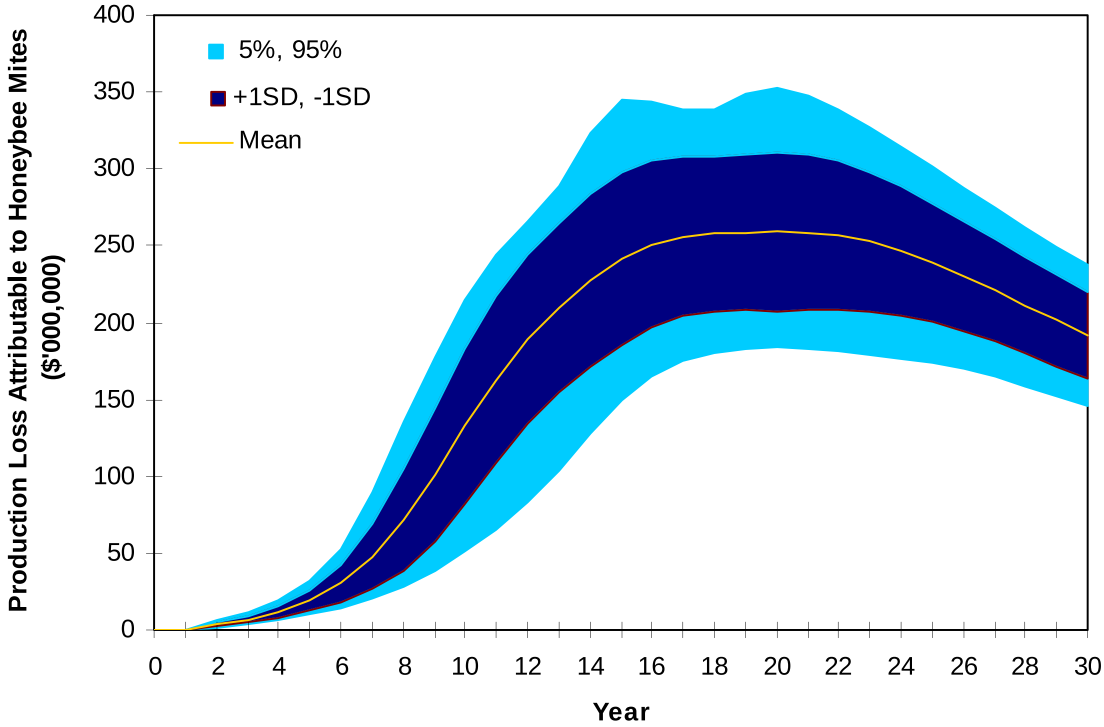
Our assumptions imply the spread of honeybee mites through wild European honeybee colonies will occur slowly at first before accelerating rapidly. Figure 2 plots the crop area affected by decreased bee pollination over time. This diagram suggests insect pollination services will remain largely unchanged until approximately year 15. This inflexion (or threshold) point in the area curve corresponds to a sudden rise in the predicted mite populations after an initial incubation period during which populations gain a foothold in the natural environment.

Figure 2 Estimated area affected by honeybee mites in Australia over time in the absence of surveillance



Translating the affected area data into economic losses in Figure 3, we see a broadly similar pattern to Figure 2 with the periods of highest impact expected to occur 15-25 years into the future. Thereafter, the effects of discounting erode damage estimates. Note also that this figure illustrates the uncertainty surrounding the predictive model. The values expressed in this figure are in current value terms (i.e. PV(ED_n) from expression (1)).

Figure 3 Estimated loss of Plant Industry production over time attributable to honeybee mite incursions

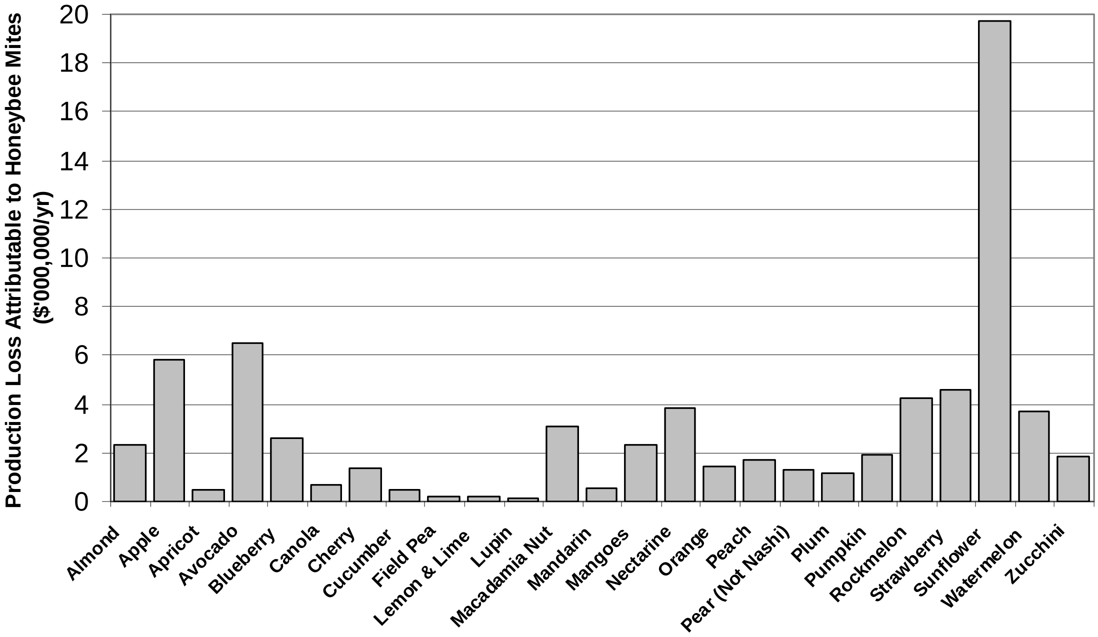


Because plant industries are not currently signatories to any cost sharing agreement relating to bee mites, the pollination benefits accruing to them following the successful removal of any future incursion represent a large positive externality[7]. While the public and apiculture industries would provide necessary funding for an eradication campaign against an incursion (under the EADRA) should it happen tomorrow, other private beneficiaries are not obliged to pay anything. Hence, economic justification of a future eradication campaign may prove difficult. The omission of such a large externality in benefit cost analyses places a strong negative bias on the calculated net benefits expected to result from the successful eradication of an outbreak.

As Figure 4 indicates, by far the largest benefits are enjoyed by the sunflower industry, followed by the avocado, apple and strawberry industries. Of the 25 crops used in the simulations, 18 derived notional benefits from bee mite freedom of over $1 million per year. Technical model limitations prevented the inclusion of other crops and pastures, but the implication is nevertheless clear.

[7] Recall that the EADRA lists the *V. destructor* and Tropilaelaps as category 2 species, and *V. jacobsoni* as a category 4 species. For each of these pests, the apiculture industry is obliged to meet all private costs of future eradication campaigns.

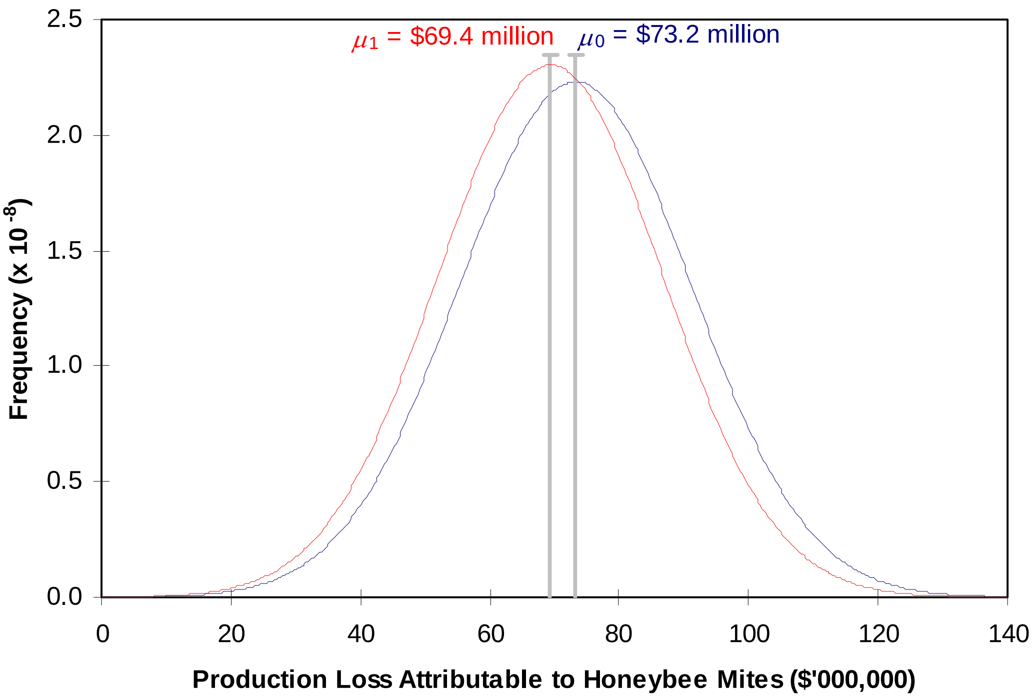
Figure 4 Estimated benefits to selected Australian plant industries of honeybee mite area freedom



Thus far, our analysis has presented a scenario in which there is no surveillance effort devoted to bee mite exclusion. In effect, it presents a worst-case scenario for Australian plant industries. It is important to now consider what the likely impact on our results would be if surveillance (regardless of the form it may take) were to successfully lower the probability of mite establishment. This would have the effect of lessening the expected loss of pollination services to crops over time. But, how large or small will the change be?

To answer this question, we considered a hypothetical situation in which surveillance measures are introduced that lower the probability of each mite species becoming established in Australia from moderate (under the Biosecurity Australia (2001) categorisation system) to low (represented by Uniform (0.05,0.30). This will shift the distribution of average damage (shown in Figure 5) to the left. The extent of this shift is shown in Figure 5. Here the distribution of expected damage under both the without surveillance (i.e. worst case) and the with surveillance scenarios are shown using distributions fitted with the @Risk software package. Both are Normal distributions specified with mean (μ) and standard deviation.

Figure 5 Hypothetical shift in the distribution of average production loss resulting from surveillance



The distribution of average yearly losses from bee mites without surveillance, shown in dark blue, has a mean of $73.2 million and standard deviation of $17.9 million (i.e. Normal (73236519, 17885207)). With surveillance measures in place which succeed in lowering the probability of mite establishment from Uniform (0.30,0.70) (moderate, Biosecurity Australia (2001)) to Uniform (0.05,0.30) (low) average damage, shown in red, is given by Normal (69371461, 17323952). By lowering the expected losses from bee mite incursions, surveillance is generating a benefit for plant industries (i.e. under a surveillance strategy plant industries can expect to suffer lower loss of pollination services as a result of mite incursions). Under our hypothetical assumptions the decrease in mean average production loss generated by surveillance is 5.3%, equivalent to $3.9 million per year.

Although highly uncertain, the predictive assessment can be used in a speculative benefit cost analysis framework to put the effects of surveillance into perspective. It is important for policy-makers to determine if surveillance effort is likely to produce a net benefit for society over time, and what the likely size of this net benefit (or cost) is. For instance, if the probability of honeybee mite establishment can be lowered to the extent indicated above (i.e. approximately by one third of the 'without surveillance' probability of establishment) with an investment of $750,000/yr, the ratio of benefits to costs is 5.2:1. However, if such a reduction is impossible without the investment of $2 million/yr, the benefit cost ration falls to 1.9:1. For our hypothetical reduction in the probability of establishment, $3.9 million effectively represents a point of 'break-even' investment where the ratio of benefits to costs is 1. For investments over this value the costs of surveillance provision are likely to outweigh the prevented bee mite damage over time.

We consider estimating the efficiency of surveillance in the next chapter and return to the question of integration in Chapter 5.

4. Efficiency of Sentinel Hives for the Early Detection of Exotic Bee Mites

Introduction

For reasons given earlier in this report (see Chapter 1) this Chapter explores a simulation model to examine the potential efficiency of targeted surveillance for the early detection of exotic bees mites (*Varroa* and *Tropilaelaps*). The simulation approach concentrates on considering sentinel hives for the early detection of mites as these are at the heart of the current National Sentinel Hive Program (NSHP). It was necessary to consider a simulation approach, as there is insufficient data to do otherwise.

Simulation models are not directly predictive. Rather, they let the user logically structure their assumptions and determine the implications of these on the question at hand. They allow synthesis of available information and beliefs. In using them, it is important to remember that they are abstractions of reality rather than reality itself. Any decision made from them needs to consider the simulation results as an input rather than letting the results directly determine the decision.

An important implication of this discussion is that the complexity of the simulation model needs to be in proportion with the available data and to model the key features of the system. Models that are too complex cannot be parameterised by empirical data and thus lose their connection to the real world. A model that cannot represent a key phenomenon of the system cannot adequately represent the full behaviour of the system, and therefore cannot explore the full range of system outcomes.

In undertaking the modelling for this study, significant knowledge gaps were recognised. In the absence of empirical data it is necessary to rely on expert opinion. In this case expert opinion was initially sought from Dr Denis Anderson using his extensive experience of bee mites and bee behaviour and his knowledge of the literature. These opinions were scrutinised and endorsed by attendees at the workshop. Even given this approach, significant uncertainty still remained.

Physical set up of the simulation

The first choices we made for this model were on the spatial and temporal scales of the simulation. We chose to model what might happen at the hectare scale, as this would allow consideration of honeybee dynamics without introducing undue complications. A hectare is equal to $100m^2$ or $0.01\ km^2$. We ran our simulation over a $36\ km^2$ area around a port on a monthly time-step. The area covered was enough to examine the dynamics of the invasion process. Several options were considered for the spatial scale including at the individual hive level (too dense) and the square kilometre scale (too sparse). In total we tracked what might happen in 3600 cells across our simulation region for the various experimental conditions explained below.

We further assumed that all actions occurred independently at each hectare – this includes ‘dying off’, detection (at sentinel hives), swarming and foraging. Assumptions related to each of these actions are discussed below. While this assumption may not fully hold in practice, it was thought that in the absence of other information it would still allow useful conclusions to be reached.

It was assumed that individual hectare areas would have in the order of three to five hives present at any particular time. This was based on expert judgement in environments with a range of suitable hive sites. This was taken as a worst case to bind the probability of detection. In a port environment, active management of the feral population would potentially reduce this number and increase the probability of detection in time to apply appropriate management.

‘Dying off’ and detection

The hives in any hectare area are likely to die off in winter months for various reasons including food shortage, inclement weather and hive destruction. We incorporated this into our model by assuming hives died off with probability Pdie which we set at 0.2. We experimented with different settings for this term and found little effect overall. A Pdie value of 0.3 is associated with colony collapse disorder.

Different methods of surveillance will have different success rates at detecting a pathogen if it is present in a given hectare. We modelled this as Pdetect, which was set to 0.05, 0.1, 0.2 and 0.5. The number and positions of the sentinel hives can be varied in the simulation to consider different effects if necessary in a particular application.

Swarming and Foraging

Hives in a given hectare will swarm during particular times of the year. The rate of swarming was set at several levels, and the number of swarms was assumed to follow a Poisson distribution with rate lambda. The values of lambda were 0.25, 0.5, 1 and 2, representing uncertainty about the true rate. In Table 8 below we show the probability of no swarms, one swarm, two swarms and more than two swarms occurring for particular values of lambda.

For example, for lambda equal to 0.25 there is a 78% chance that no swarming will occur in a particular month for any of the hives in a given hectare. If the value of lambda increases to 0.5 the chance of there being no swarm drops to 61%. If lambda goes to 1 or 2 the chance drops further to 37% and 14% respectively.

Table 8 Swarm probabilities for various values of the rate parameter lambda.

	Pr(0 swarms)	Pr(1 swarm)	Pr(2 swarms)	Pr(>2 swarms)
Lambda = 0.25	0.779	0.195	0.024	0.002
Lambda = 0.5	0.607	0.303	0.076	0.014
Lambda = 1	0.368	0.368	0.184	0.080
Lambda = 2	0.135	0.271	0.271	0.323

When bees swarmed in the model they travel a distance that is chosen at random from an unrestricted distribution with average distance 630m. The shape of this distribution is shown in Figure 9 in Appendix 2.

In any particular month, bees from one hectare will travel and interact with bees in other hives. We assumed bees travel on average 300m to forage, with probability decreasing exponentially with distance (Figure 10, Appendix 2). The values of this curve show the probability of an interaction that leads to transmission of the pest for hives at the specified distance.

Swarming rates that increase with age

Following feedback from researchers and representatives of the honeybee industry we assume further that when a pathogen arrives in a particular hectare it takes time for the pathogen to settle into that hectare. The swarming rates for bees with pathogens were assumed to increase linearly from zero up to lambda over a time period of three years.

Running a Simulation

We selected values for Pdetect and lambda and simulated the arrival of a pathogen on the edge of our 6km by 6km grid, and modelled the subsequent movement and transmission of the pathogen through the grid on a monthly time-step. We recorded how long it took to detect the pathogen, how far the pathogen had travelled in that timeframe and how much of the grid was covered by the pathogen by the time it was detected. This process is repeated 1,000 times in total for each combination of Pdetect and lambda.

Appendix 3 shows an example where the progress of one simulation is shown for every two-month time-step until the pathogen is detected after eleven months. The series of images begin with Figure 14 and Figure 15 showing very little movement of the pathogen. By May in Figure 16 and July in Figure 17 the pathogen has started to move from the starting location. By September in Figure 18 and November in Figure 19 the spread of the pathogen is quiet extensive, at which point it is detected.

Results of Simulation

The table below indicates the average number of months that a pathogen was present in the grid before it was detected at the sentinel hives, under 16 experimental conditions. In general the less often that swarms occurred the longer it takes for detection to take place. Also, the time taken to detect a pathogen dropped as the ability to detect it increased.

Table 9 Simulated average time to detect a pathogen under sixteen experimental model conditions.

	Lambda=0.25	Lambda=0.5	Lambda=1	Lambda=2
Pdetect=0.05	20.5	20.1	20.2	19.3
Pdetect=0.1	15.5	15.3	15.1	14.6
Pdetect=0.2	12.3	12.5	12.1	11.9
Pdetect=0.5	9.6	9.6	9.5	9.3

Table 10 Std. errors for average time to detection under sixteen experimental conditions via simulation.

	Lambda=0.25	Lambda=0.5	Lambda=1	Lambda=2
Pdetect=0.05	0.31	0.29	0.31	0.29
Pdetect=0.1	0.18	0.19	0.18	0.16
Pdetect=0.2	0.13	0.13	0.13	0.13
Pdetect=0.5	0.10	0.11	0.10	0.10

The histograms in Figures 11, 12 and 13 in Appendix 2 highlight the simulation distributions for the time taken to discover the pathogen, the distance travelled and the area of the grid affected by the pathogen in that time. These histograms are plotted for each of the sixteen situations. Clearly in Figures 8 and 9 the limitations of the spatial dimensions of our simulation are apparent. In both sets of histograms for low values of Pdetect many there were many simulations that achieved the maximum values for distance travelled (6.71km) and 100% of area covered. For larger values of Pdetect this was not a problem.

The simulation code developed here and reported above can be used to simulate how long it would take for an incursion to be detected. Evaluations of real-life detection strategies can better inform the setting of the Pdetect term. Individual preferences for swarming and foraging behaviour can be substituted into our approach to model particular types of honeybees, pathogens etc. Larger simulations are also possible given appropriate computing facilities. All simulations were carried out using the R programming environment version 2.5.0 (2007). Code for this algorithm can be made available upon request to the first author.

5. Development and Use of the Risk-Based Framework

Introduction

The analysis presented in the previous three Chapters produced methodologies for assessing the efficiency of components of the surveillance process. In this section we have brought these pieces together to provide a logical framework for considering the benefits and costs of surveillance of exotic bee mites (*Varroa* and *Tropilaelaps*).

In this Chapter we also report feedback received at the workshop from the Reference Group. The attendees and agenda of the workshop are provided in Appendix 4.

Integrative framework

To integrate the pathway analysis, the economic analysis and the information on surveillance efficiency using a risk-based framework we proceeded as follows. The pathway analysis provides an assessment of the probability of entry, establishment and spread. If this is assessed as p based on all the trade, then we argue as follows. Assume that there are k locations (typically ports at this time but these could vary in the future) under threat from a pest in Australia. If we put surveillance at a subset of locations we need to assess the proportion, g, of the threat that is covered by the surveillance. For instance, if 40% of trade from risk regions went to locations where there is surveillance then the proportion of the threat covered by surveillance is 40%. At each site assume we have designed a surveillance system with efficiency e calculated using the simulation tool and our beliefs about the efficiency of the eradication procedures. The efficiency is the probability that an incursion will be detected and successfully eradicated. In this case we can calculate the new probability of entry and establishment and spread, after surveillance is in place, as

Pr(Incursion with surveillance)=

Pr(Incursion)Pr(Occurs at port with surveillance|incursion)Pr(Surveillance system doesn't detect|Incursion and occurs at port with surveillance)+ Pr(Incursion)Pr(Occurs at port without surveillance|incursion)Pr(Surveillance system doesn't detect|Incursion and occurs at port without surveillance)

where Pr() denotes probability and Pr(A|B) is the probability of A given B has occurred. Based on the quantities defined above this is

$$h = p \times g \times (1 - e) + p \times (1 - g)$$

which is the expected probability of entry, establishment and spread after the surveillance system is implemented.

The values p and h can then be used in the economic model in Chapter 3 to calculate the expected return on the surveillance effort as an annual cost. This can be compared to the proposed cost of the surveillance system to determine the cost-benefit ratio, and this can then be used in the decision-making process.

We note that more complicated models could be considered but this would be inconsistent with the quality and extent of the available data. The approach provides a simple framework for transparently assessing the logic of abstract surveillance options. Decision-making needs to integrate these insights with the other knowledge and facts that are not integrated into the modelling before final decisions are made.

Application to future pests

Before considering the application of the framework it is important to highlight a number of issues. The workshop strongly endorsed the view that pre-border prevention is much more efficient than attempting post-border detection and then mounting an eradication attempt. Eradication is costly and its success uncertain. The active engagement of exporters, importers and shippers in ensuring that bees and their associated pests and pathogens do not have the opportunity to establish is vital. The group strongly endorsed AQIS continuing targeting of bees as serious threats to the Australian honeybee and horticulture industry. The workshop also saw further opportunities to strengthen port operations involvement to ensure an educated and proactive work force actively involved in achieving biosecurity for bee pests and pathogens.

As discussed in the Scope section of the report (Chapter 1) the following pests were identified as being worthy of further analysis:

- *Varroa destructor*
- *Varroa jacobsoni*
- *Tropilaelaps sp (T. clareae and T. koenigerum)*
- *Apis cerana*
- *Apis dorsata*

Chapter 2 provided a detailed assessment of the risk posed by these pests. There is a clear pathway for each of them and the likelihood of arrival is rated high for both *Varroa destructor* and *Varroa jacobsoni*. The majority of this risk occurs at international shipping ports. Thus there is a significant probability of one of the Varroa mites arriving in Australia via *Apis cerana* or *A. mellifera*. The probability of entry, establishment and spread of *Tropilaelaps* mites is rated as very low. Thus Varroa mites represent the major risk. This data is supported by international experience and was supported at the workshop.

For the pests considered in this analysis, the major impact will arise from the impacts on pollination services. Direct impacts on honey production costs will occur, but there will be potential benefits from new economic opportunities providing pollination services. In the economic analysis in Chapter 3 we have considered only the economic impacts on the pollination services. In this analysis the expected cost of a pest that would impact on *Apis mellifera* pollination services is detailed in Table 11 (below).

Table 11 Expected costs of pests that impact on A. mellifera pollination services

Probability of entry, establishment and spread	Expected cost (Millions) per annum
High	47.1
Moderate	43.2
Low	33.5

The workshop considered the use of sentinel hives. There was a clear view among participants that the National Sentinel Hive Program represented a viable approach to early detection of some pests. In considering the potential costs and benefits of using sentinel hives the key assessment that needs to be made is that of their efficiency in detecting particular pests. While most surveillance systems will inevitably detect a disease at some stage after an incursion, if it occurs too slowly for successful management action it will not provide useful information. There is insufficient empirical data to objectively determine how soon pests need to be detected to mount a successful eradication. What is known is that eradication of pests and diseases are typically difficult, especially if there are non-managed populations or regions that can harbour the pest or disease. Recent examples in Australia include Red Imported Fire Ants in Brisbane and Asian Green Mussel and *Apis cerana* in Cairns. The wide distribution of feral bees in Australia and their significant density therefore represents a significant challenge to any eradication strategy for bee pests and diseases.

There was a range of views expressed at the workshop about the probability of eradication of any incursion of honeybee pests or pathogens. While the likelihood will obviously depend on the specifics of any incursion there was a general agreement that failure to detect an incursion at an early stage would lead to significant difficulties. From the results presented in the simulation studies reported here it is apparent that in the simulation presented (four sentinel hives) detection at greater than 12 months after the incursion would lead to movement of mites at least six kilometres. This would typically be beyond the port environment and potentially into residential or peri-urban areas, posing significant detection issues. Thus we propose setting a cut-off time of 12 months between the time of detection from initial incursion, for eradication to be possible. While it is technically attractive to formulate a mathematical relationship between the eradication probability and the time to detection, the lack of data cautions about overcomplicating the model. Realistically, other factors beyond the model mean that even if detection occurs within 12 months, eradication may not be feasible. This includes human mediated transport, misunderstanding of biology, system failure etc. Based on discussions at the workshop we estimate the likelihood of success if detected within 12 months to be 50%. This may seem pessimistic, but reflects experience that eradication of pests in non-managed environments is difficult.

Detection within 12 months can be achieved by a number of strategies. For example, the number of traps can be increased or the detection rate can be increased. It was the strong view of the workshop that major efficiency gains in the surveillance program could come from increasing the efficiency of detection. There was a range of concerns with the current approach. If a single chemical is used for controlling mites we might be building up resistance to that single chemical through our testing process. The protocol of using sticky mats for 48 hours seems inadequate based on the lifecycle of the mite. Treating for seven days would be necessary for any chance to observe one or two mites. Rubbish builds up on the mats if they are left for more than 48 hours, which makes it harder to identify materials captured. Some inspectors may not be adequately trained causing further difficulty.

Overall, there was a belief that more thought and experimentation needed to be done to optimise the National Sentinel Hive Program. This might include better training, experimentation in countries that possessed the relevant pest in order to determine the empirical performance of particular protocols, and for examining the spread rates of pests. In addition, genetic techniques could be developed to streamline the identification process and remove the need for extensive dissection/identification work. The feedback from the workshop was that the improvement of detection rates was one of the most important avenues for improving the current system. In the present context we can achieve detection within 12 months with four hives if the probability of detection within the sentinel hive is greater than approximately 20%. We note that, as an incursion is a spatial phenomenon, at some point there is no alternative but to increase the number of traps to provide adequate spatial coverage.

For Australia we consider a surveillance system that covers 95% of risk. Risk in this context relates to trade whose origin is infected with one of the species of mites. Origin in this case could be beyond the last port of call because the bees can persist. Achieving 95% coverage is potentially possible in Australia due to the concentration of trade in a limited number of ports. Appendix 5 contains cargo statistics for the 2006/2007 financial year. From these data we can feasibly cover 95% of the importation volume (in tonnes) by monitoring only 14 ports (but note the analysis in Boland (2005)). This analysis assumes that the total tonnage is a reasonable de-facto measure of risk. It assumes that the risk scales with the number of vessels arriving, as well as the weight of the cargo. In addition it rates all source regions equivalently. As vessels can visit a number of ports before they arrive in Australia this is a conservative assumption.

We calculate the change in the probability of entry, establishment and spread as follows. Indicatively, if we use .85 (the mid point of the high range) for the unrestricted probability we have:

$$h = 0.85 \times (1 - 0.5) \times 0.95 + 0.85 \times (1 - 0.95) = 0.45$$

Using the economic analysis summarised in Table 11 this leads to a reduction of risk from High to Moderate, which gives an expected reduction in cost of damage of \$3.9 million per annum. Alternatively, we could analyse these results quantitatively using the model in Chapter 3. In this case we use the probability 0.45 in the model to form the cost distribution. The mean of this distribution is \$42.7 million. From Table 11, the benefit is thus 47.1-42.7 = \$4.4 million per annum. Given the scarcity of available data the qualitative analysis is probably sufficient.

The indicative cost of a sentinel hive has been costed at \$1700 per annum per hive (Iain East, personal communication). This is costed as \$1000 for diagnostic services and \$700 for maintenance of the hive. Thus four hives at 14 locations gives 56 hives, which would cost, under this formula, \$95200 per annum. This would obviously increase with administrative overheads, but is significant lower than the potential benefit. It would involve a modest increase to the current program (Iain East, personal communication).

The alternative was to consider the use of bait hives. Bait hives are hives that are either empty or baited with honey or a pheromone. It was noted that honey is impractical if other bees are in the vicinity, as robbing will quickly occur. For direct detection of *Apis cerana* and *Apis dorsata* sentinel hives were considered impractical and bait hives represent the only feasible, widely applicable alternative available at this stage. As was noted earlier, the efficiency of bait hives was considered by the experts rather than being explicitly modelled.

We have not been able to find relevant literature providing empirical evidence for the efficiency of bait hives. Expert's views on the efficacy of bait hives were mixed. While many participants at the workshop saw them as useful, the probability that they would detect an incursion was unclear. There are a wide variety of locations for swarms to move to in the port environment, and a bait hive is simply one of those locations. Also, use of pheromones means that the hives would need to be emptied frequently in swarming season to remove feral swarms rather than new incursions. Sentinel hives for bee pests can benefit from interactions between bees, rather than requiring a complete swarm to find the location. There was general agreement that the bait hives needed to be targeted for different species. For example, *Apis cerana* favours hollow logs and these can be utilised as bait hives.

The integrated analysis for *A. cerana* and *A. dorsata* is much more speculative. We calculate the reduction in the probability of importation, establishment and spread over a range of values for detection efficiency as follows.

Efficiency	**Calculation**	**Results**
5%	$h = .85 \times .95 \times (1-.05) + .85 \times (1-.95)$	0.81
10%	$h = .85 \times .95 \times (1-.1) + .85 \times (1-.95)$	0.77
15%	$h = .85 \times .95 \times (1-.15) + .85 \times (1-.95)$	0.73
20%	$h = .85 \times .95 \times (1-.2) + .85 \times (1-.95)$	0.69

If bait hives are only 5% efficient (i.e. the chance that an incursion is detected by them and then successfully eradicated) we have only a marginal reduction in the detection probability. As a qualitative analysis it does not change the category, and as a quantitative analysis its effect is approximately $400K per annum. While 5% may seem pessimistic, it reflects the considerable uncertainty about their effectiveness. For larger efficiencies the benefit increases. At 20% efficiency there is a decrease in the likelihood category, and an approximate benefit of $1.6 million per annum. While considerably uncertain, a 20% efficiency would appear to be associated with a larger number of bait hives deployed per hectare than four or five.

6. Application of the model to the National Sentinel Hive Program

Introduction

The modelling framework provides an opportunity to explore potential options for the deployment of sentinel hives at chosen locations as part of the National Sentinel Hive Program. In order to gain perspective on ways of improving a detection system it would be useful to note the effects of:

- distance of hives to coast
- the number of sentinel hives and
- the sensitivity of the detection method at hives

on the overall time taken to detection an incursion. To address these questions we have run a number of simulated incursions based on the model presented in Chapter Four. In these simulations the following values were used as defaults unless they are varied as part of the investigation:

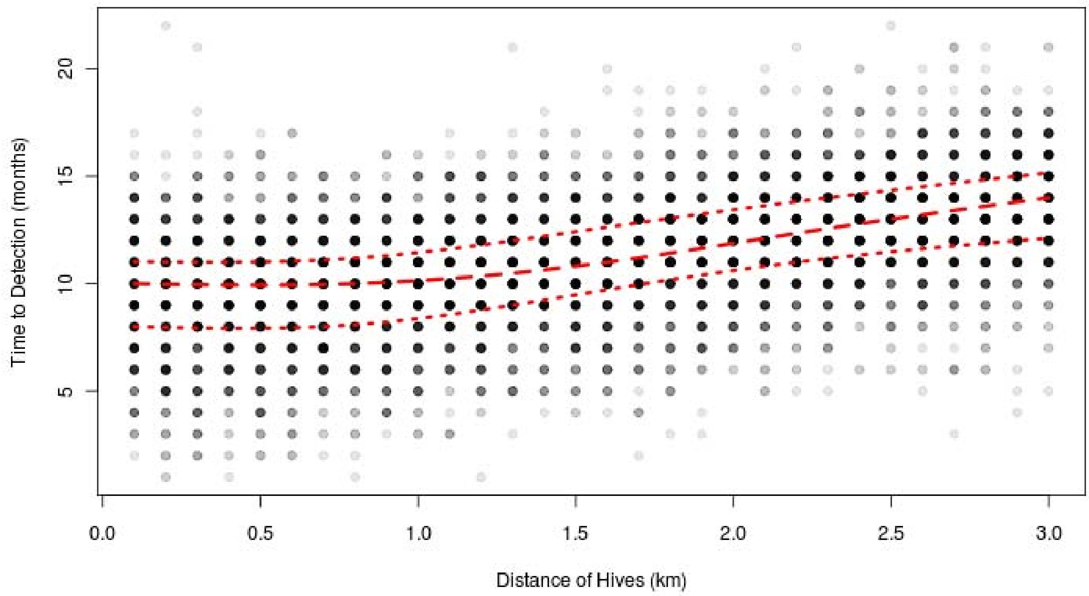
- parameter lambda (the average rate of swarming per hecatare is set to 0.5
- probability of hives dying off is 0.2
- probability of detection is set to 0.1
- distance from hive to coast is 0.5 km
- the number of sentinel hives is 4

Distances travelled during foraging and swarming are as noted in Chapter 4.

Effect of Distance of Hives to Coast

The distance of the hives was varied from 100m to 3km away from the coast in increments of 100m. For each distance, we simulated 250 incursions and record the time taken to detection. These values are plotted in Figure 6. Increasing the distance between the hives and the coast leads to increased time to detection however, the time to detection is not very sensitive to distance to the coast. Note that this effect would increase the further from the coast the traps where located and the area infected would increase exponentially.

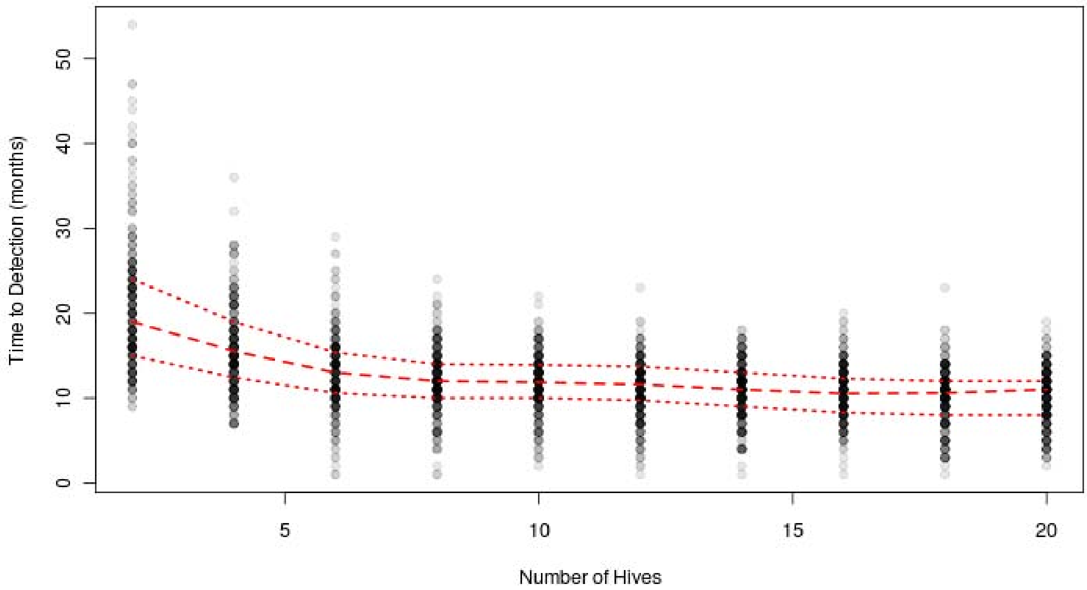
Figure 6 Estimated change in time to detection as the sentinel hives are moved from the coast



Effect of Number of Sentinel Hives

The number of sentinel hives was varied between two and twenty in increments of two hives. For each value for the number of hives we simulated 250 incursions and noted the time taken to detection. These values are plotted in Figure 7. Increasing the number of hives leads to smaller detection times but, most of the possible gains in efficiency (reduction in detection time) was achieved once six to eight hives were deployed.

Figure 7 Estimated change in time to detection as the number of sentinel hives is increased



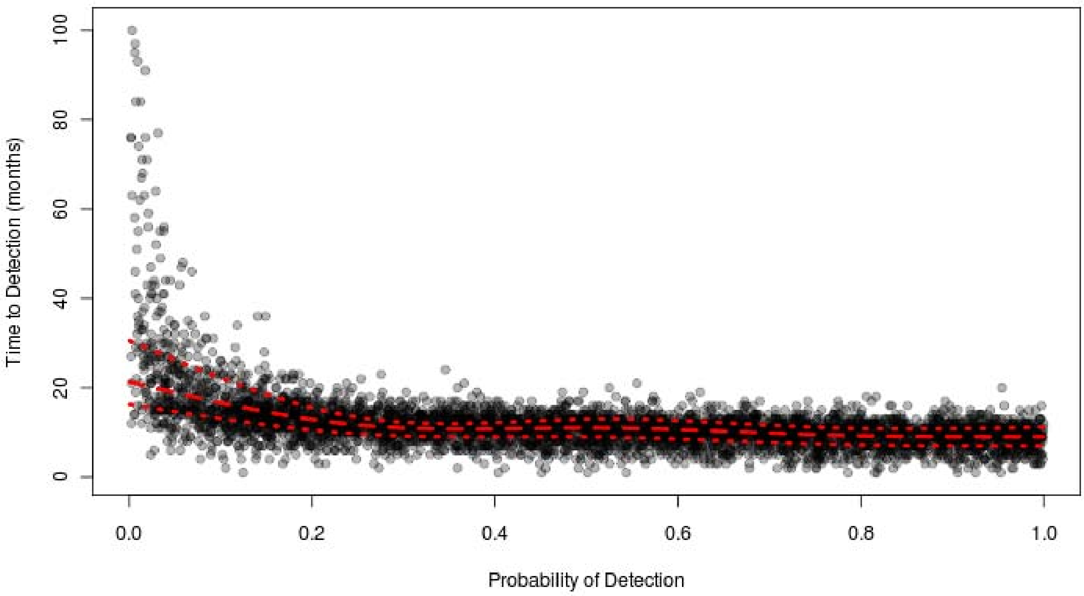
Effect of Sensitivity of Detection Method:

The probability of detection was varied between 0 and 1. This is equivalent to varying the sensitivity of the detection (trapping) system. We have generated 5000 values in this interval and for each one simulated a single incursion. The time taken to detection is plotted against the corresponding probability of detection in Figure 8. As the probability of detection increases, the time to detection of the incursions decreases. For poor detection methods (sensitivity less than 0.15), the time to detection can be extremely large. However, even if a highly sensitive detection method is employed, the time to detection can still be of the order of several months.

Discussion

In attempting to provide a practical assessment of Australia's bee surveillance system, the National Sentinel Hive Program, a number of points should be noted. Firstly, the model and the results above are applicable to any trapping system eg. sentinel hives, log traps, bait hives, sticky sugar stations (a new technique developed by Biosecurity Queensland) but the efficiency of detection and transmission must be chosen appropriately for the particular pest, parasite or disease of interest. For example, log traps will not be applicable to detecting incursions of species other than *A. cerana* due to the particular pheromone lure used, and would therefore have a probability of detection of zero for other species.

Figure 8 Change in time to detection as the probability of detection for each sentinel hive is varied



Secondly, the results are not objective inferences because the model is dependent upon the input parameters. Whilst these input parameters have been estimated by expert opinion, they are still only opinion. The value of the model and the results is in the trend patterns reported in the results. Whilst a formal sensitivity analysis was not conducted, the results above show very little variation in the overall time to detection once the number of hives is at least six, the distance from the hives to the coast in less than 1.5 km and the sensitivity of the trapping system is at least 0.2. It should however be noted that even when these parameters are optimised, the time to detection is still likely to be of the order of 10 months after the incursion occurs.

Thirdly, the ability to detect any incursion is limited by other factors not included in the model including the chance that pathogens will be present in the sentinel hives when testing is carried out. For parasites that continuously occupy the hive such as Varroa, the sensitivity of the trapping system will still increase as time from the incursion increases eg. as the number of Varroa in a sentinel hive increases, the probability of detecting the Varroa will increase.

7. Discussion, Implications and Recommendations

Discussion

A major limitation of this analysis is the lack of clear empirical data about the efficiency of bee pest surveillance systems. Experiments should be performed outside Australia to determine the ability of sentinel hives to detect pest incursions, as well as the rate that this occurs over time. For example, uninfested hives could be placed at varying distances from infested hives and observed over time to track the process of infestation. Different detection systems could be used and contrasted to determine the most cost-effective regime. While this would be expensive it could be cost-effective when recurrent expenditure is considered.

The economic analysis could be further developed in a number of ways, particularly in terms of the way it could be communicated to the bee surveillance community and used in risk mitigation strategy formulation. There is always a danger in using probabilistic models for prediction, particularly when there are non-market goods that may be affected by policy decisions (i.e. environmental, social and cultural factors). In these circumstances probability models add limited value. However, given the significant pollination (i.e. private) benefits, there may be a case for revising the model to improve its explanatory power. A spatially explicit modelling approach may be more appropriate given the large geographic spread of honeybee surveillance beneficiaries. The full extent of inter-temporal benefits and costs also need to be clarified since the choice of time-frame over which surveillance activities are to be viewed has a large impact on results due, in part, to the process of discounting. Given this, it is important in any modelling exercise that all components reflect the overall quality of the information. It is typically unwise to have a very detailed model of one component of the system when other components are very uncertain. If this is the case, the impact of the uncertain component dominates and the additional effort may be wasted.

The analysis suggests that sentinel hives have the potential to deliver positive cost-benefit outcomes. This is consistent with the views of the participants at the project workshop. Bait hives appear more problematic and the reasoning behind their effectiveness is not as clear. As well, there is not a consensus among the experts that they will be an effective measure. More work needs to be done to consider the potential benefits of their use.

With finite resources there will always be competition for available funds. Other biosecurity programs/choices may also have positive cost-benefit outcomes and choices may need to be made between them. For instance, resources could be concentrated on pre-border activities if it was thought to be more efficient. Any attempt at establishing such a ranking is beyond the scope of this analysis.

An option that was considered and has not been discussed previously in the report was the use of honeybee exclusion zones. At their most extreme, these zones could be maintained by active poisoning of honeybees. They would thus provide a barrier to spread and ultimate establishment of invasive bee species and associated pests. Maintenance of a partial exclusion system would make it a more manageable task to investigate all hives found within the zone. While the workshop was unanimous in agreeing that bee exclusion zones would significantly improve surveillance systems, the general view was that it was unlikely to be practical to maintain such zones by chemical means. Concerns about potential impacts on wildlife and contamination of honey products for human consumption meant that it was unlikely to be a general approach, but that it could be used in specialised circumstances after appropriate risk assessment and mitigation. Active management of bees within port areas, as already occurs in some locations, was seen as an achievable goal and was strongly encouraged.

The qualitative analysis used here has significant limitations. While it is the standard approach applied by Biosecurity Australia, its reliance on qualitative descriptors means that there is potential ambiguity in its meaning. Thus it is important that users consider carefully the indicative probability ranges to ensure the interpretability of the results of the analysis. The objective analysis of the costs and benefits requires clear communication of assumptions and meanings. All techniques that can limit the ambiguity should be considered. Note that this is not an argument against simple assessment, in line with the quality of the available data. It is an argument for clear communication.

Implications

This framework will assist in further design of strategies and procedures for protecting the Australian honeybee and horticulture industries.

Recommendations

- That the risk-based framework developed here be adopted as the mechanism for determining future costs and benefits of improved surveillance for honeybee pests and diseases.

- That the current National Sentinel Hive Program be maintained and improved for the early detection of exotic bee mites using information provided in this report.

- That the active management of honeybees within port areas, as already occurs in some locations, be strongly encouraged.

- That targeted studies be funded to obtain clear empirical data of the efficiency of sentinel hives to detect exotic bee mites. Experiments should be performed outside Australia to determine the sensitivity of sentinel hives to detect low numbers of bee mites.

- That surveillance for the early detection of A. cerana be re-examined urgently with the aim of developing a new surveillance system that can detect low numbers of bees at remote locations.

- That AQIS continue to target bees as serious threats to the Australian honeybee industry and other industries that depend on honeybees for pollination and that port operations be strengthened to ensure a well educated and proactive work force to safeguard biosecurity for bee pests and diseases.

Appendix 1 Assessment methodology

(From Pathway analysis for the entry of exotic bees and exotic bee pests into Australia)

Assessment of the probability of entry, establishment and spread

Details of how to assess the probability of entry, probability of establishment and probability of spread of a pest are given in ISPM 11 (FAO 2004). A summary of this process is given below, followed by a description of the qualitative methodology used in this impact risk analysis.

Probability of entry

The probability of entry describes the probability that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the pest risk analysis (PRA) area and subsequently be transferred to a host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its use in Australia and the generation and disposal of waste. In particular, the ability of the pest to survive is considered for each of these various stages.

The probability of entry is divided into two components:

1. **Probability of importation**: the probability that a pest will arrive at the quarantine boundary; and
2. **Probability of distribution**: the probability that the pest will be distributed in the PRA area and subsequently transfer to a susceptible host.

Probability of establishment

Establishment is defined as the ‘perpetuation for the foreseeable future, of a pest within an area after entry’ (FAO 2004). In order to estimate the probability of establishment of a pest, reliable biological information (lifecycle, host range, epidemiology, survival, etc.) is obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs and expert judgement used to assess the probability of establishment.

Probability of spread

Spread is defined as ‘the expansion of the geographical distribution of a pest within an area’ (FAO 2004). The probability of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the probability of spread of the pest, reliable biological information is obtained from areas where the pest currently occurs. The situation in the PRA area is then compared with that in the areas where the pest currently occurs and expert judgement used to assess the probability of spread.

Assigning qualitative likelihoods for the probability of entry, establishment and spread

The term 'likelihood' is used for the descriptors of probability of entry, establishment and spread. Qualitative likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible. Descriptive definitions for these descriptors and their indicative probability ranges are given in Table 12 (below). The indicative probability ranges are only provided to illustrate the boundaries of the descriptors. These indicative probability ranges are not used beyond this purpose in qualitative PRAs. The standardised likelihood descriptors and the associated indicative probability ranges provide guidance to the risk analyst and promote consistency between different risk analyses.

Table 12 Nomenclature for qualitative likelihoods

Likelihood	Descriptive definition	Indicative probability (P) range
High	The event would be very likely to occur	$0.7 < P \leq 1$
Moderate	The event would occur with an even probability	$0.3 < P \leq 0.7$
Low	The event would be unlikely to occur	$0.05 < P \leq 0.3$
Very low	The event would be very unlikely to occur	$0.001 < P \leq 0.05$
Extremely low	The event would be extremely unlikely to occur	$0.000001 < P \leq 0.001$
Negligible	The event would almost certainly not occur	$0 \leq P \leq 0.000001$

The likelihood of entry is determined by combining the likelihood that the pest will be imported into the PRA area and the likelihood that the pest will be distributed within the PRA area, using a matrix of rules (Table 13). This matrix is then used to combine the likelihood of entry and the likelihood of establishment and spread to determine the overall likelihood of entry, establishment and spread.

Table 13 Matrix of rules for combining qualitative likelihoods

	High	Moderate	Low	Very low	Extremely low	Negligible
High	High	Moderate	Low	Very low	Extremely low	Negligible
Moderate		Low	Low	Very low	Extremely low	Negligible
Low			Very low	Very low	Extremely low	Negligible
Very low				Extremely low	Extremely low	Negligible
Extremely low					Negligible	Negligible
Negligible						Negligible

Appendix 2 Figures (Efficiency of Surveillance)

Figure 9 Distances travelled while swarming

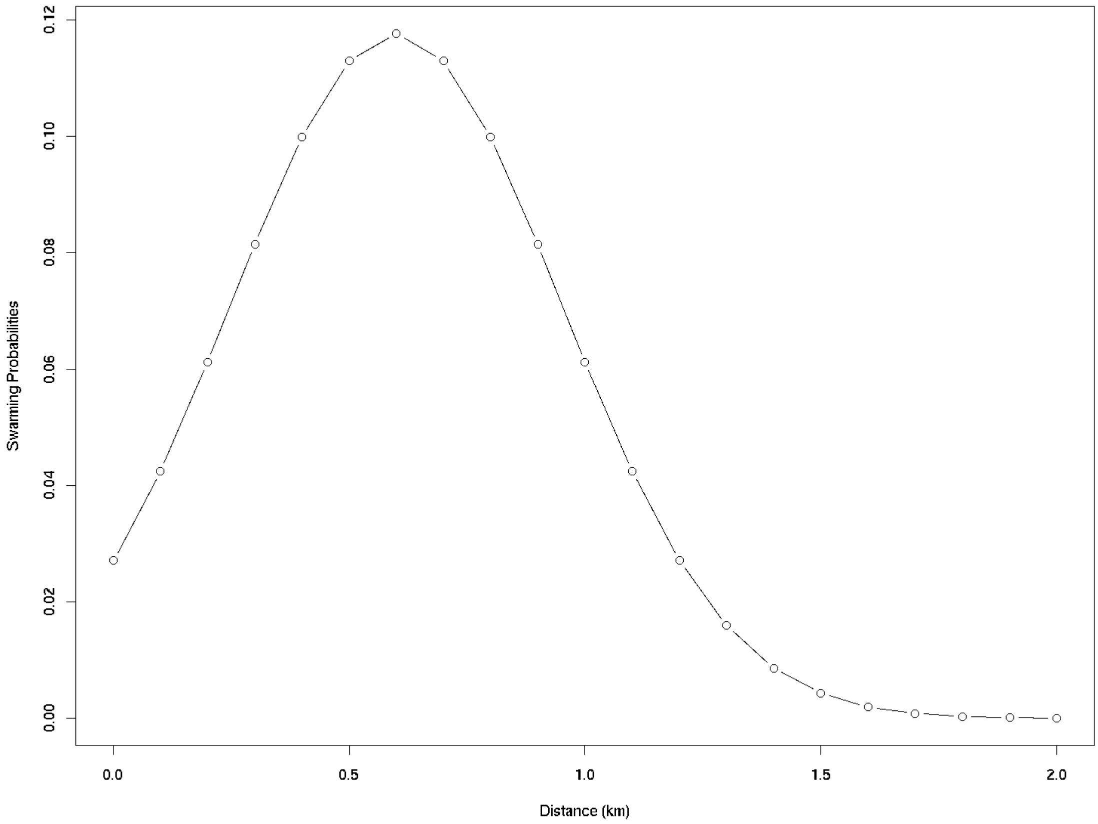


Figure 10 Distances travelled while foraging

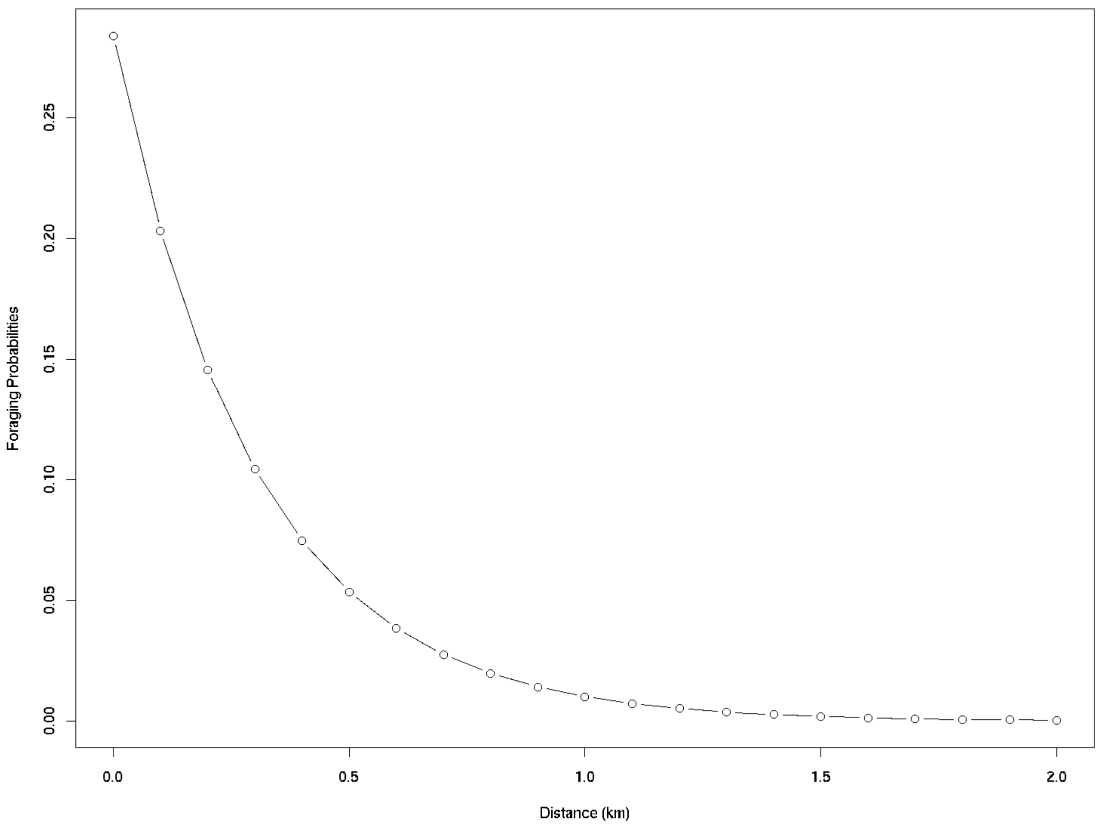


Figure 11 Histograms of time to discovery under sixteen situations

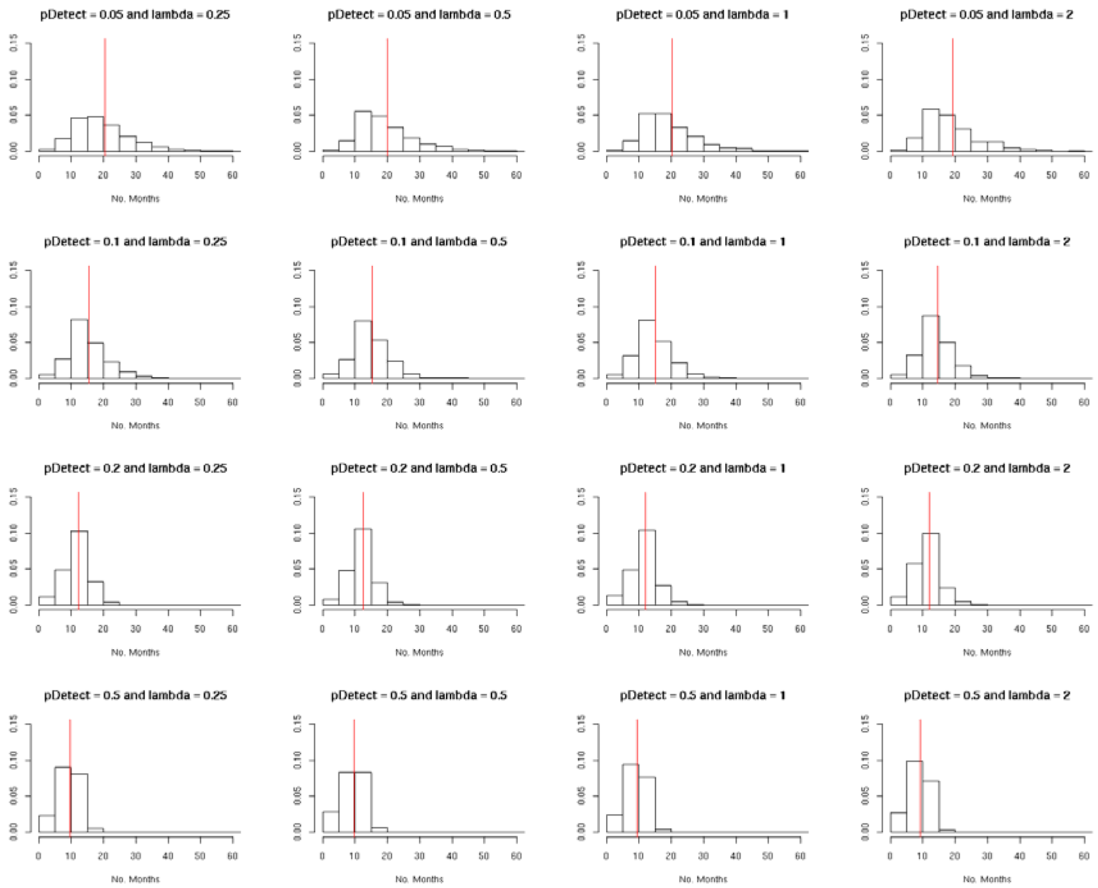


Figure 12 Histograms of distance travelled until time of discovery for sixteen situations

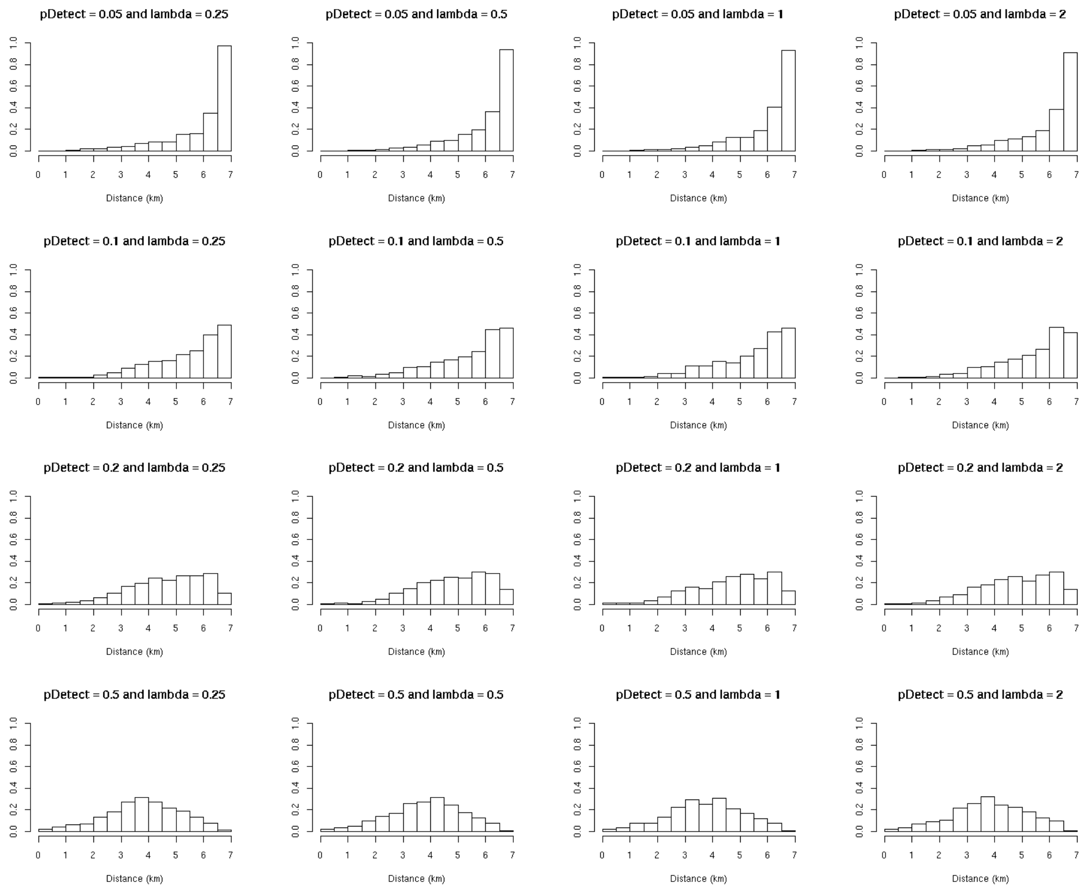
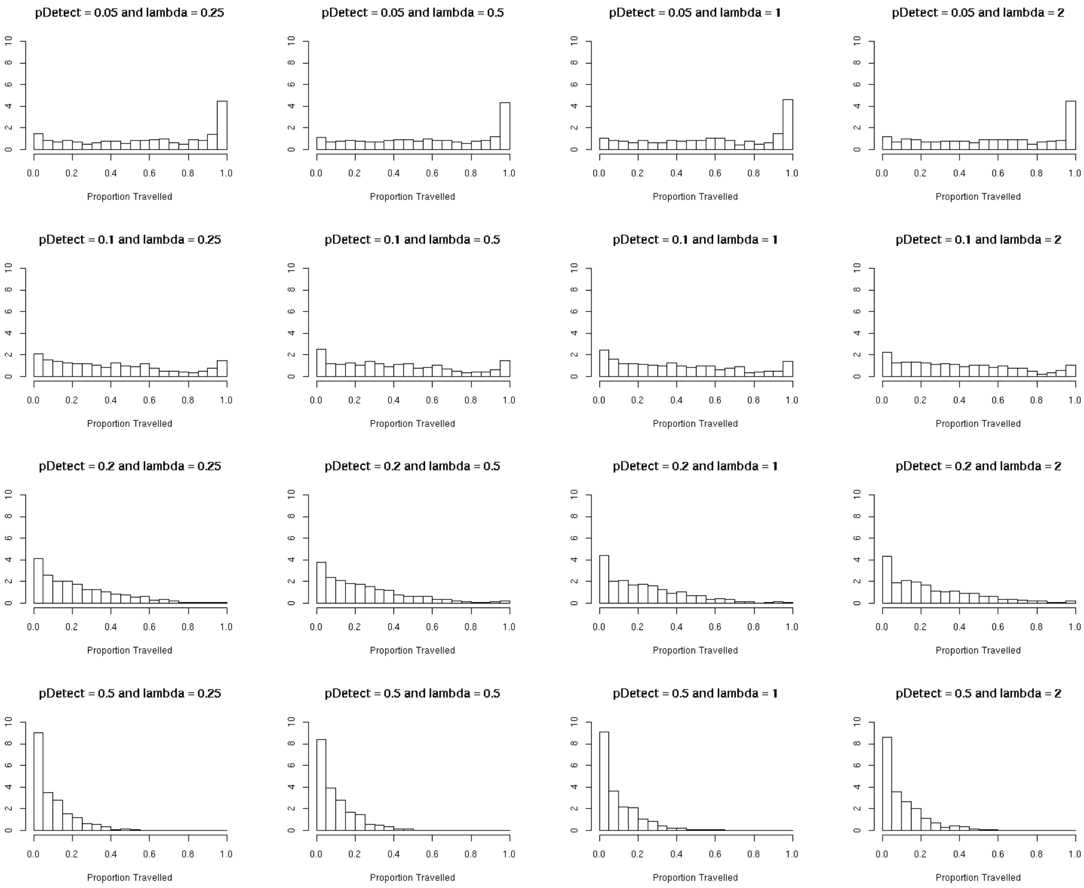


Figure 13 Histograms of area of grid affected by pathogen by time of discovery for sixteen situations



Appendix 3 Simulation Example

The following series of figures show a particular simulation run. The simulation is carried out on a monthly time step but we give figures from every two months starting in January. This particular simulation ends in November with detection. The colour of individual hectares indicates the age of the pathogen incursion at that hectare.

Figure 14 Example Simulation – January

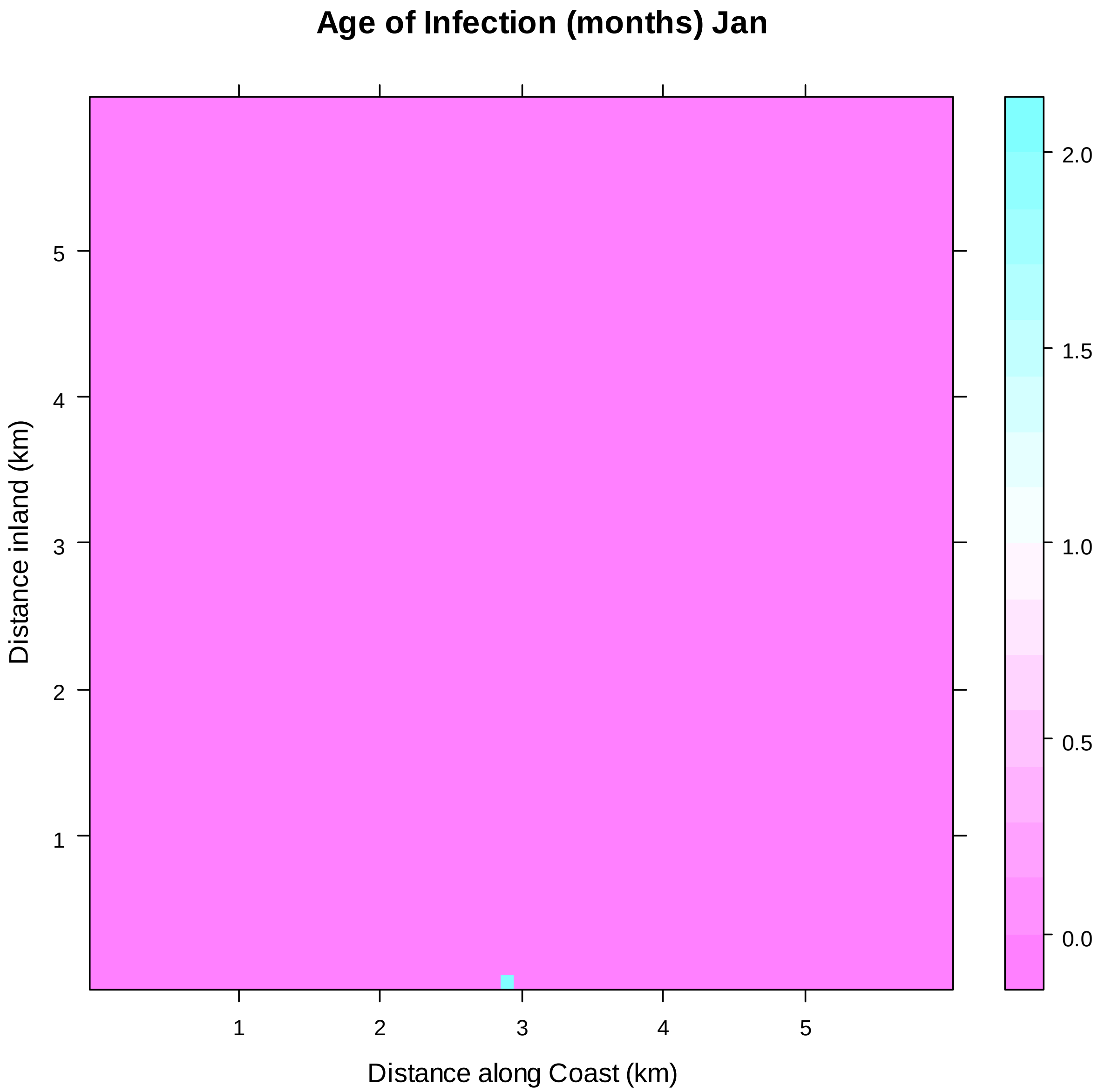


Figure 15 Example Simulation – March

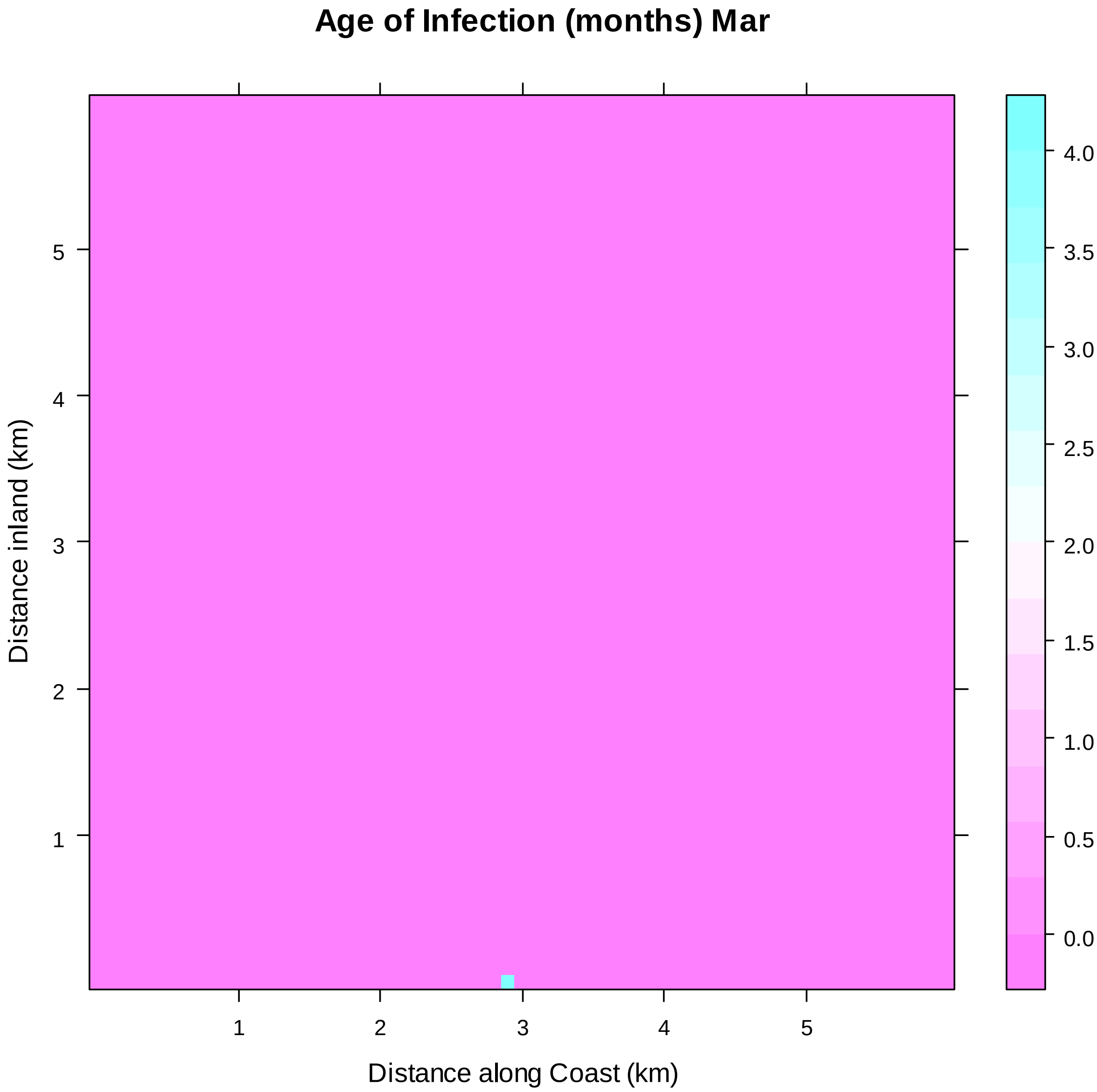


Figure 16 Example Simulation – May

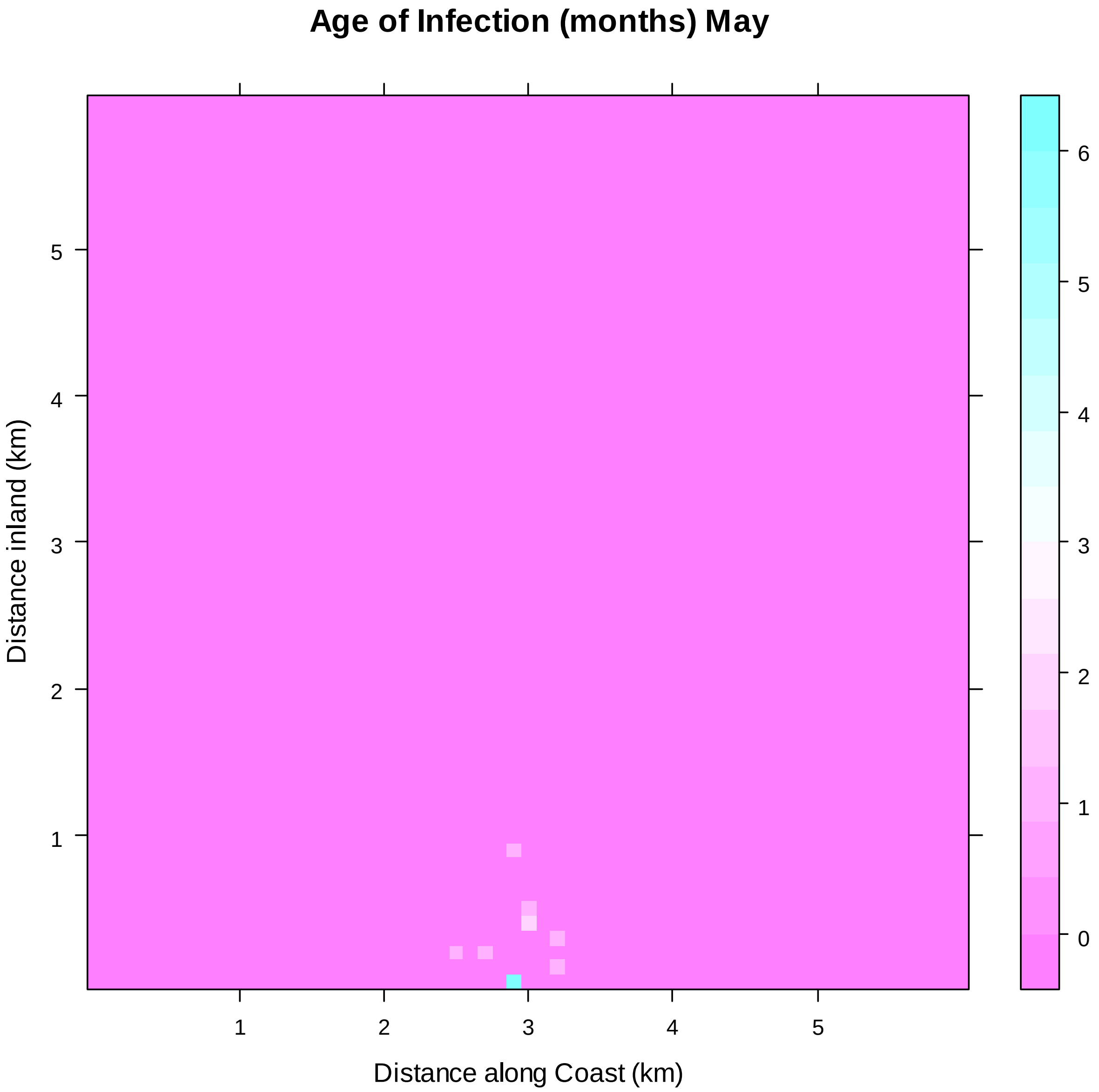


Figure 17 Example Simulation – July

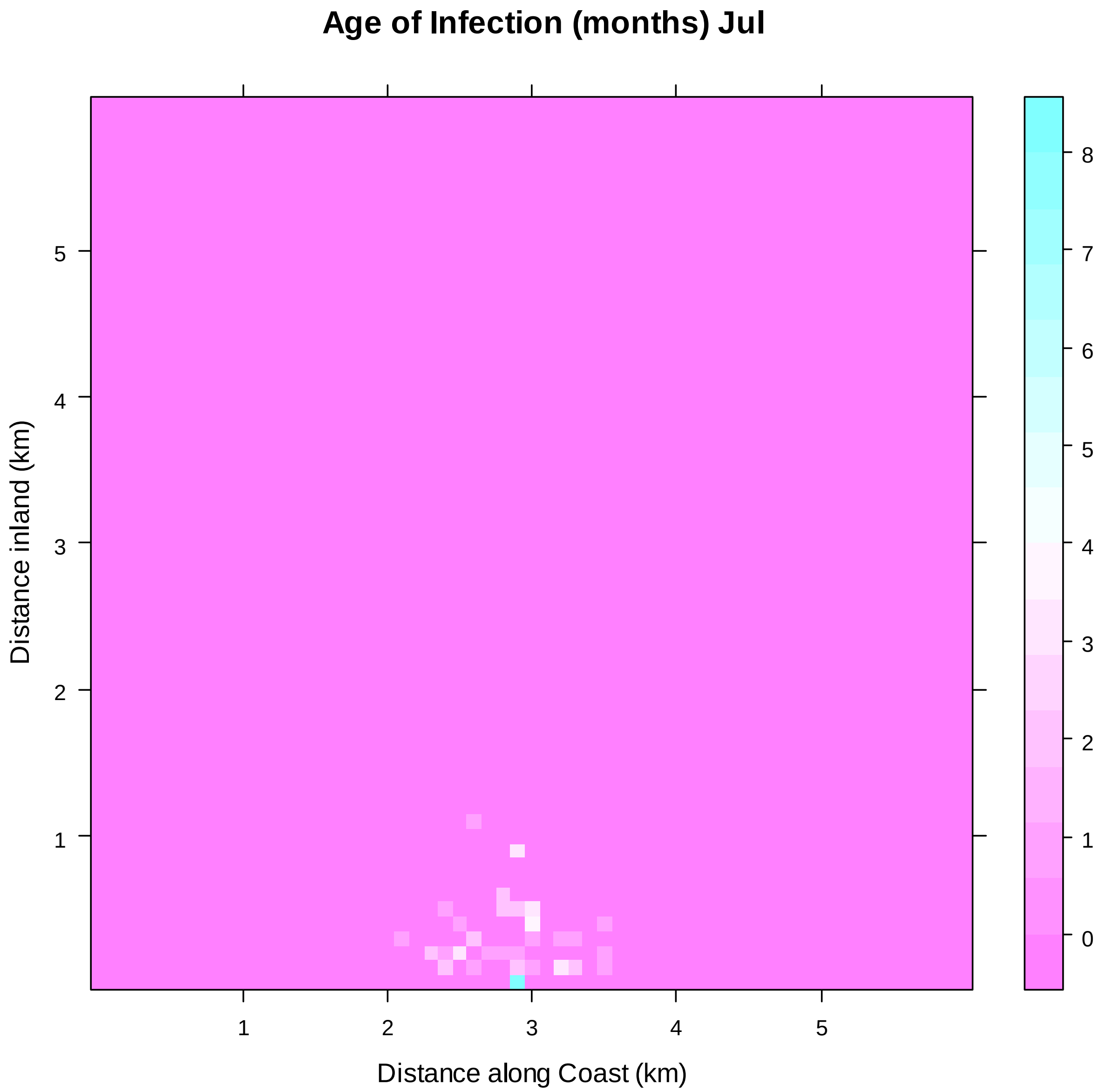


Figure 18 Example Simulation – September

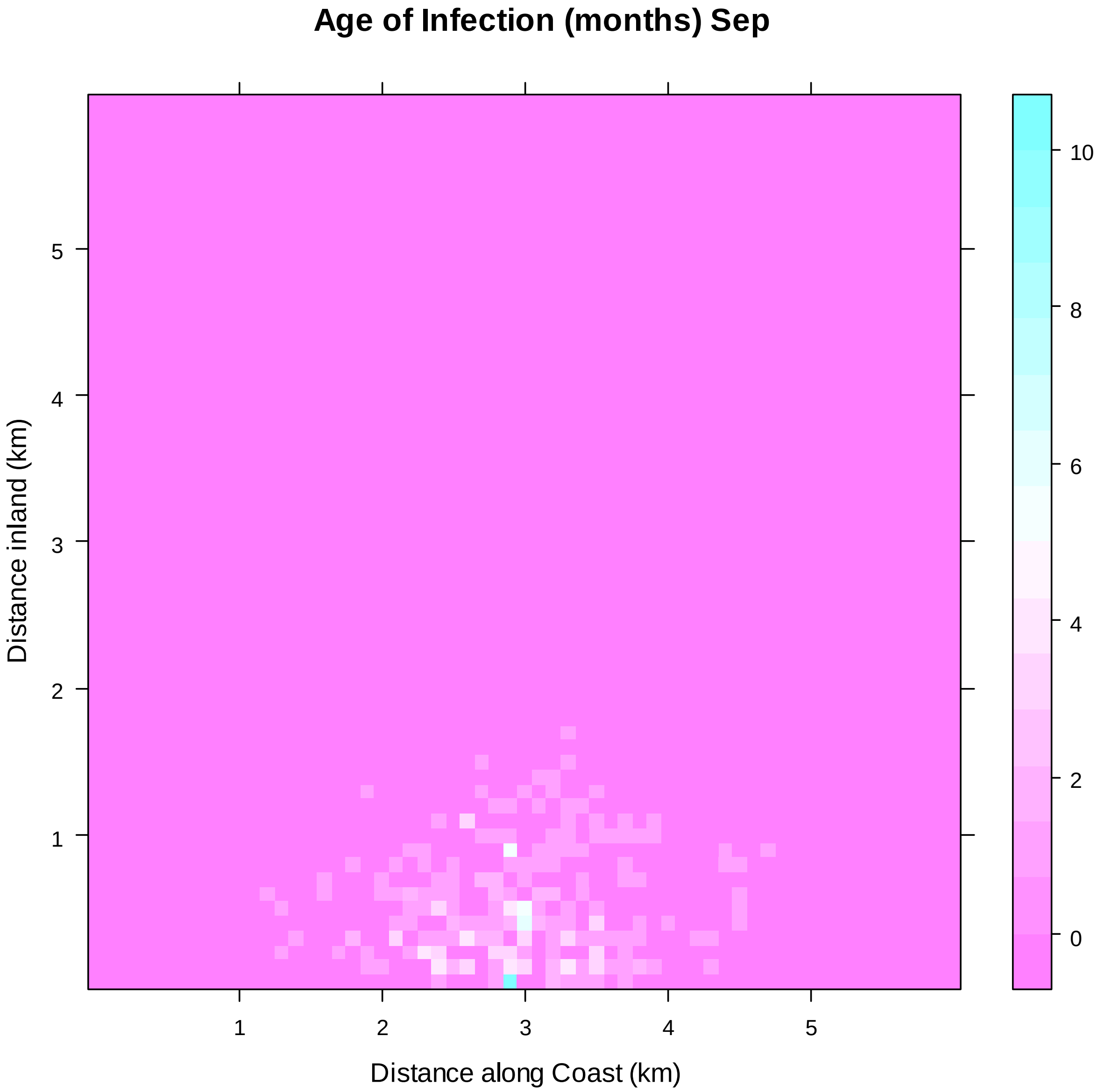
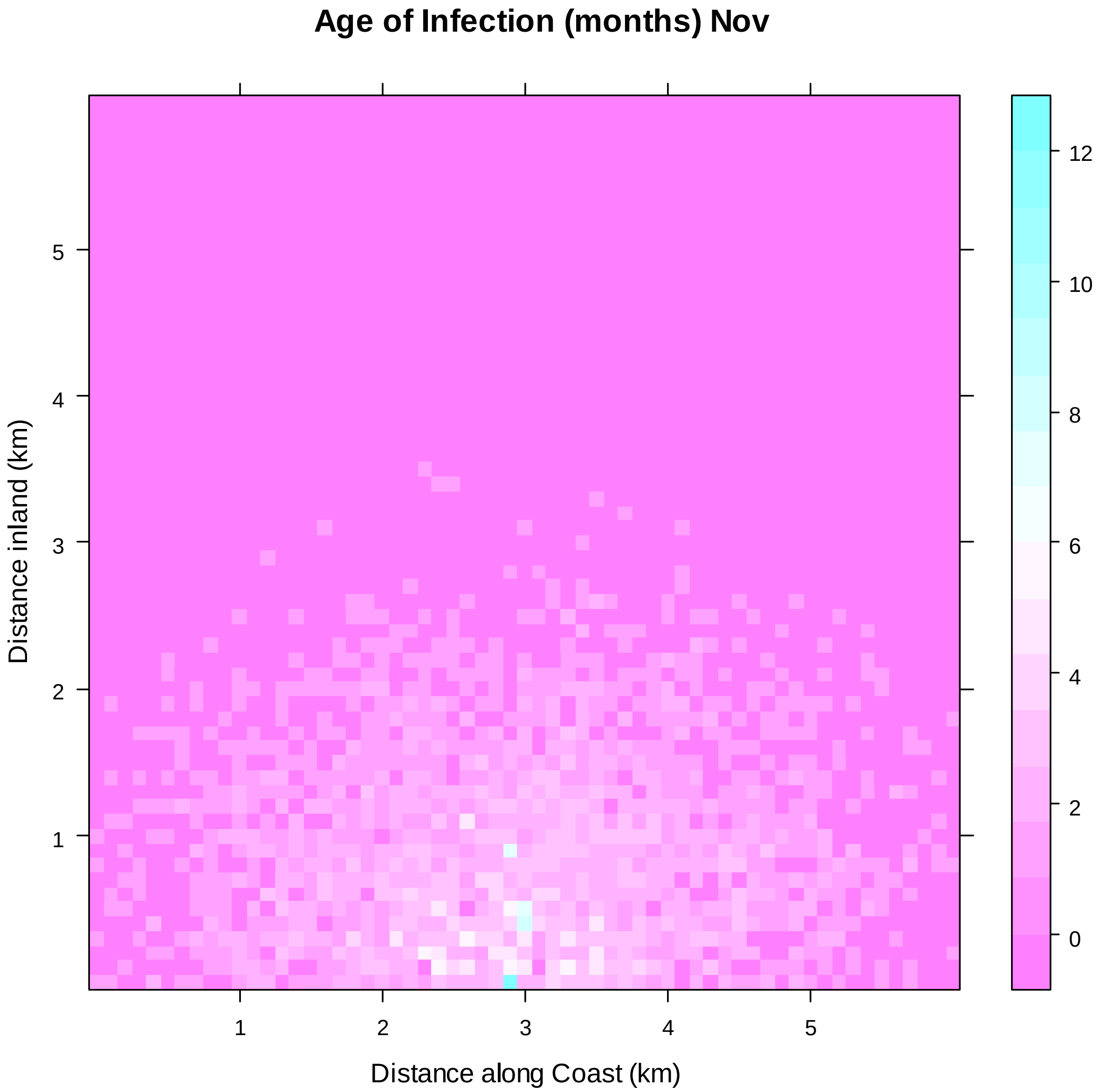


Figure 19 Example Simulation – November



Appendix 4 Workshop Attendees and Agenda

Simon Barry, CSIRO

Iain East, Australian Government Department of Agriculture Fisheries and Forestry

Nick Annand, NSW State Representative

Lindsay Burke, Chair, Biosafety Committee, AHBIC

Denis Anderson, CSIRO

David Clifford, CSIRO

Rob Duthie, Kalang Pty Ltd

Gerald Martin, Agreresults Pty Ltd

David Dall, RIRDC

Michael Stedman, SA State Representative

Joe Riordan, VIC State Representative

Hamish Lamb, QLD State Representative

Doug Somerville, NSW State Representative

David Cook, CSIRO

Greg Hood, Australian Government Department of Agriculture Fisheries and Forestry

Bruce W, Member of RIRDC Honey Bee Research and Development Committee

WORKSHOP Tuesday 16 June 2009

Hosted by CSIRO Mathematical and Information Sciences, Australian National University, Canberra, ACT.

Background: A small team has been funded by RIRDC to consider a risk-based assessment of possible surveillance systems for pests and diseases of honeybees. The aim is to produce a framework such that policy makers can assess the risks and consequences of any decision. As part of this project a working group of relevant experts is to be convened and this workshop is the group's first meeting. A proposed methodology will be presented for discussion.

Workshop aim: To assess a proposed methodology for estimating the costs and benefits of surveillance systems for bee pests and to identify data sources and expert knowledge for key parameters.

Agenda

10:00am	Welcome and introduction (Simon Barry)
10:15am	Policy background and existing programs (Iain East DAFF)
10:30am	Project background and methodology (Simon Barry)
11:30am	Pathway analysis (Rob Duthie)
12.15am	Surveillance efficacy (David Clifford)
1.00 pm	Lunch
1:45 pm	Economic impacts of honeybee pests (David Cook)
2.45 pm	Integration and summary of results (Simon Barry/All)
3.15 pm	Afternoon tea
3.30pm	Alternative approaches
5.00 pm	Finish

Appendix 5 National Cargo Statistics

2006/2007 International Cargo Statistics, Department of Infrastructure, Transport, Regional Development and Local Government, Bureau of Transport and Regional Economics.

Port	import('000 $)	import(Tonnes)kg	Proportion of total trade
Total	**133030516**	**77538252**	
Sydney	42916202	15687719	0.20232232
Melbourne	39960079	12191929	0.359559924
Brisbane	20373322	12025169	0.514646848
Fremantle/Perth	12437371	8947751	0.630044742
Darwin	1910455	5164451	0.696649945
Geelong	3372034	5120860	0.762692961
Townsville	1093761	4064398	0.815110934
Adelaide	3415874	2229086	0.843859145
Gladstone	588767	2126811	0.871288329
Port Kembla	384862	2103394	0.898415507
Newcastle	606919	1144133	0.913171231
Conf NT Ports	666964	1139939	0.927872865
Bunbury	154397	1094024	0.941982339
Port Hedland	497559	623739	0.950026614
Whyalla	75606	482013	0.956243068
Mackay	305382	472003	0.962330425
Dampier	1942952	451126	0.968148534
Portland	232499	357476	0.972758852
Cairns	344891	349847	0.97727078
Esperance	201777	321673	0.981419352
Launceston	213119	234993	0.984450023
Hobart	47370	180455	0.986777326
Port Lincoln	89693	132047	0.988480318
Burnie	138020	118177	0.99000443
Weipa	72570	114261	0.991478038
Broome	365382	113406	0.99294062
WA Offshore Terminals	15371	107602	0.994328348
Westernport	61870	81330	0.995377249
Wyndham	55646	80176	0.996411268
Port Walcott	57866	73364	0.997357433
Albany	37231	73328	0.998303134
Geraldton	259121	52264	0.998977176
Devonport	10540	34357	0.999420273
Other Ports NT	13393	18894	0.999663947
Wallaroo	5753	15025	0.999857722
Other Ports WA	46431	5920	0.999934071
Other Ports Vic	44094	1564	0.999954242
Port Pirie	445	1177	0.999969422
Bundaberg	5827	851	0.999980397
Thursday Island	5444	815	0.999990908
Other Ports NSW	241	248	0.999994106
Other Ports SA	2060	158	0.999996144

Port	import('000 $)	import(Tonnes)kg	Proportion of total trade
Total	**133030516**	**77538252**	
Conf Aust Ports	0	96	0.999997382
Other Ports Qld	319	63	0.999998194
Carnarvon	286	47	0.999998801
Twofold Bay	382	36	0.999999265
Cape Lambert	29	32	0.999999678
Coffs Harbour	342	25	1

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Australian Government
Department of Agriculture, Fisheries and Forestry

COMMUNIQUE

2 February 2011

Update on Response to Asian Honeybees

The Asian Honeybee National Management Group (AHB NMG) met on 31 January 2011 to consider advice provided by the Consultative Committee on Emergency Plant Pests on the Asian honeybee (*Apis cerana*) incursion in North Queensland on whether it continued to be technically feasible or not to eradicate the Asian honeybee. The AHB NMG view is that it is no longer technically feasible to achieve eradication although consensus was not reached.

The Asian honeybee is an invasive species which adversely impacts populations of European honeybees by competing for floral resources, robbing managed hives and transmitting disease. It is a natural host for varroa mite *jacobsonii* - a parasite that attacks developing bee larvae or adult bees.

Following the first detection of an Asian honeybee nest near Cairns in May 2007, a nationally cost-shared program aimed at eradication was implemented, led by the Queensland Government and overseen by the AHB NMG. Since that time, over 342 swarms or nests have been found and destroyed. None of the nests destroyed to date have carried any exotic mites of concern such as varroa, tropilaelaps or tracheal.

Activities to eradicate Asian honeybees in the Cairns region have been funded by the Australian Government, State and Territory Governments and the Australian Honey Bee Industry Council (AHBIC) on behalf of its members at a cost of approximately $3 million. Other industries reliant on bees and bee pollination services were approached at peak representative level to be involved in the management of the response but declined to contribute resources.

The AHB NMG's decision, that it is no longer technically feasible to eradicate Asian honeybees, is based on a number of factors including:

- the tendency for the bees to swarm;
- the bee breeds rapidly and can travel long distances, particularly with assisted movement on vehicles and trains; and
- limitations of current surveillance methods which makes it difficult to locate all nests and destroy them.

The AHB NMG agreed to recommend continued funding for residual activities being carried out under the current program until 31 March 2011. It was also agreed that a group of Senior Biosecurity Officials should meet to determine whether any further national action is warranted.

The AHB NMG expressed its appreciation to the beekeepers of Cairns and districts and the Queensland Government staff for their hard work and perseverance in attempting to eradicate the pest.

The AHB NMG is comprised of the chief executive officers of the national and state/territory departments of agriculture and primary industries across Australia, representatives of AHBIC, Plant Health Australia and is chaired by the Commonwealth.

Australian Government

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COMMUNIQUE

Further advice on Asian honeybees and response actions to date can be found on Biosecurity Queensland's website.

Australian Government
Department of Agriculture, Fisheries and Forestry

COMMUNIQUE

DAFF **7 September 2010**

Response to Asian Honeybees

The Asian Honeybee National Management Group (NMG) met on 3 September 2010 to consider the current program to contain and eradicate the Asian honeybee (Apis cerana) http://www.dpi.qld.gov.au/4790_13530.htm in Queensland.

The first Asian honeybee nest was detected in the mast of a fishing boat in Portsmith, Cairns in May 2007. Since that time, 188 swarms or nests have been found and destroyed.

Most of the Asian honeybee detections have been found in the city and port areas of Cairns, immediately to the south of Cairns including Mareeba and Lake Eacham and in the Gordonvale and Aloomba districts. The strain of Asian honeybees found in the Cairns region is the Java strain, which is common in Asia, particularly in Indonesia and Papua New Guinea.

The Asian honeybee is an invasive species which adversely impacts populations of European honeybees by competing for floral resources, robbing managed hives and transmitting disease. It can become a pest in urban areas through establishing nests in houses and by its aggressive stinging behaviour.

The Asian honeybee is slightly smaller than the European honeybee and its abdomen has more distinctive brown and yellow stripes. Unlike the European Honeybee, Asian honeybees do not adapt to domestication and are not suitable for commercial honey production or commercial pollination services.

Asian honeybees are a natural host for varroa mite – a parasite that attacks developing bee larvae or adult bees. Laboratory tests on the bees and comb from nests indicates that none of the nests destroyed to date carry any exotic varroa, tropilaelaps or tracheal mites.

Information and reports from the public have been vital in locating swarms and nest sites. Anyone in the north of Queensland who sees a swarm of bees or foraging bees that resemble Asian Honeybees should report it to Biosecurity Queensland on 13 25 23.

Activities to eradicate Asian honeybees in the Cairns region are funded by the Australian Government, State and Territory Governments and the Australian Honey Bee Industry Council (AHBIC) on behalf of their members. Industries reliant on bees and bee pollination services have been approached at peak representative level to assess whether they would be beneficiaries if the Asian honeybees were eradicated and so may wish to contribute resources. No industry body other than AHBIC, has agreed.

The NMG reaffirmed its commitment to the current program, aimed at gathering surveillance and other data to assist further decisions on the feasibility of eradicating Asian honeybees. The NMG also noted that the current program will be reviewed prior to the end of 2010.

The NMG is comprised of the chief executive officers of the national and state/territory departments of agriculture and primary industries across Australia, representatives of the Australian Honey Bee Industry Council and Plant Health Australia. The group is chaired by the Secretary of the Australian Government Department of Agriculture, Fisheries and Forestry, Dr Conall O'Connell.

Further advice on Asian honeybees and actions to suppress the pest can be found on Biosecurity Queensland's website. http://www.dpi.qld.gov.au/4790_13530.htm

NATIONAL MANAGEMENT GROUP	**MEETING NUMBER**: xxx **LOCATION**: Teleconference **DATE**: 31 January 2011 **TIME**: 2.00 pm
AGENDA PAPER	**ITEM**: **xx**

CCEPP review of the Asian Honey Bee (AHB) eradication program

FOR DECISION

RECOMMENDATIONS

1. That the National Management Group (NMG):
   a. **NOTES** that the Consultative Committee on Emergency Plant Pests (CCEPP) convened on 25 January 2011 to consider the technical feasibility of eradication of Asian honey bee from Australia, taking into account the current situation and a plan from Queensland for a proposed six months of activities from the beginning of January 2011 (Attachment 1) and the outcomes of the epidemiological review by AusVet Animal Health Services in October 2010 (Attachment 2);
   b. **NOTES** that at its meeting on 29 October 2010 the CCEPP met to consider the draft AusVet report and were unable to reach consensus as CCEPP members held mixed views on the feasibility of eradication of AHB;
   c. **NOTES** that on 25 January 2011 the CCEPP agreed that the positions of each contributing jurisdiction, including industry, would be presented to NMG for consideration as there is no immediate likelihood that consensus will be reached on the technical feasibility of successful eradication of AHB or the Queensland plan for actions to gather more information to support such a decision by the end of June 2011;

ISSUES

1. On 23 April 2010 Primary Industries Ministerial Council (PIMC) agreed to fund the continuation of the Asian Honey Bee eradication program until 31 December 2010. In December 2010, PIMC agreed to a further three months extension of funding to continue the program until 31 March 2011 to allow for NMG consideration of the technical feasibility of eradication.
2. At its meeting on 25 January 2011, the CCEPP agreed to present NMG with jurisdiction positions in relation to the technical feasibility of eradication, positions in relation to supporting the Queensland action plan for January to June 2011 and views on what the plan will deliver since consensus on the former was not likely to be reached. These are summarised in Table 1.
3. Background information referenced by CCEPP included the AusVet Animal Health Services review of the program, noting that this recommends the collection of further data on which technical feasibility of eradication can be assessed; the proposal from Queensland; a technical paper from Roger Paskin (Victoria) assessing eradicability of the bee; and the summary outcomes of the CCEPP workshop on AHB convened in Canberra on 29 October 2010.

4. At the October 2010 workshop, participants analysed factors to consider when assessing technical feasibility of eradication that are summarised in Appendix 12 of PlantPlan. These include factors favouring eradication and those favouring alternative action. These are summarised in Table 2.

Table 1: **Jurisdiction consideration of technical feasibility of eradication of AHB and position in relation to the proposed actions on AHB from January to June 2011.**

Jurisdiction	**Is eradication of AHB technically feasible?**	**Position in relation to support of the proposed Action Plan**	**Consideration in what Action Plan will deliver**
NSW	No	Wouldn't be supportive of spending more money to get additional information.	Have concerns that the program has been going for a long time and still finding a lot of swarms.
Vic	No	Appreciative of Qld intentions but too expensive and not optimal time for surveillance.	Need more pointed outcomes.
ACT	No	Understand intentions but don't know if assumptions are correct.	Outcomes may be too unrealistic.
Tas	No	Good plan and would gather more information but would not be in any better position to determine eradicability.	Does not focus on epidemiology.
SA	Yes	Supports Plan – Option 1.	Information collected over next six months will provide data for epidemiological determination on whether AHB technically feasible to eradicate.
WA	No	Unlikely to be in better position to determine eradicability.	Plan outcomes are unlikely to provide confidence that eradication is achievable.
NT	Yes	Supportive of Plan and program continuing.	Plan will provide data so that determination can be made about eradication.
Qld	Yes	Support Plan.	Plan will get the information needed for final decision.
AHBIC	Yes	Support Plan.	Plan will deliver vital information for eradication of AHB.
AG	No	Plan would provide information for evaluation of the program.	Actions will assist with delimitation but not provide confidence whether AHB can be eradicated.

Table 2: **Summary of analysis of factors favouring eradication or alternative actions (Ref. Appendix 12, PlantPlan)**

Factors favouring eradication	AHB considerations
Cost/benefit analysis shows significant economic loss to industry or the community if the organism establishes.	BCA not yet finalised, assumptions on industry impact reviewed
Physical barriers and/or discontinuity of hosts between production districts.	No. Major risks spread to north and south
Cost effective control difficult to achieve (e.g. limited availability of protectant or curative treatments).	Mixed – baits, spray, traps are available to destroy hives, however further development of their effective delivery is needed Broader strategy to protect pollination and secure biosecurity outcomes not in place
The generation time, population dynamics and dispersal of the organism favour more restricted spread and distribution.	No
Pest biocontrol agents not known or recorded in Australia.	No
Vectors discontinuous and can be effectively controlled.	Bee-related vectors controlled, others such as containers, trucks, trains not regulated but under voluntary management
Outbreak(s) few and confined.	340 swarms or nests to 24 January 2011. As bees are social animals, infective agents are nests, not individual bees Large areas not populated meaning there is little passive surveillance
Trace back information indicates few opportunities for secondary spread.	No
Weather records show unfavourable conditions for pest development.	No
Ease of access to outbreak site and location of alternate hosts.	No

Factors favouring alternative action	AHB considerations
Cost/benefit analysis shows relatively low economic or environmental impact if the	BCA not yet finalised, assumptions on industry impact reviewed

organism establishes.	
Major areas of continuous production of host plants.	Yes
Cost effective control strategies available	Yes
Short generation times, potential for rapid population growth and long distance dispersal lead to rapid establishment and spread.	Generation time and dispersal makes for population doubling every 4 months - can fly and form hives and fly on (can take 5-10 km leaps
Widespread populations of known pest biocontrol agents present in Australia	No
Vectors unknown, continuous or difficult to control.	Has propensity to hitch-hike; spread is not restricted; (can form nests on objects of trade) risk of assisted spread
Outbreaks numerous and widely dispersed	Refer above
Trace back information indicates extensive opportunities for secondary spread.	Yes
Weather records show unfavourable conditions for pest development.	No
Weather records show optimum conditions for pest development.	Yes, but may be some seasonal variation
Terrain difficult and/or problems accessing and locating host plants	Yes

BACKGROUND

Asian Honey Bees incursion

The Asian honey bee was detected in Portsmith, Cairns in 2007. An emergency response under the Emergency Animal Disease Response Agreement commenced. The pest was thought to have been successfully eradicated by the end of 2007 but a further nest was discovered in July 2008 around 7 km to the south of the previous outbreak.

A response was resumed with a focus on detection and destruction of AHB swarms and nests. A total of 340 swarms and nests had been found and destroyed to 24 January 2011.

Management of AHB was transferred from EADRA to the Emergency Plant Pest Response Deed in September 2010 and the Consultative Committee on Emergency Plant Pests met in October 2010 to receive a comprehensive briefing on the program and to discuss draft outcomes from the AusVet review of technical feasibility of eradication. The CCEPP considered that additional information may inform the question of eradication and this was taken into account in most recent discussions along with the current outbreak situation and program outcomes.

CONSULTATION

All Australian governments and the Australian Honey Bee Industry Council were consulted in the preparation of this paper.

FINANCIAL IMPLICATIONS

The CCEPP did not consider financial matters at its teleconference as this is outside the scope of the Committee.

Prepared by: Consultative Committee on Emergency Plant Pests
Date: 25 January 2011

ATTACHMENTS

Attachment 1**:** Proposed Activities for *Apis cerana* in North Queensland January to June 2011
Attachment 2: Eradicability of Asian Honey Bees in Queensland – AusVet Animal Health Services

Senate Rural Affairs and Transport References Committee

Inquiry into the science underpinning the inability to eradicate the Asian Honey Bee

Public Hearing – Thursday, 24 March, 2011

Question Taken on Notice

Dr Denis Anderson, CSIRO

Question 1

The Committee would appreciate it if you could provide information regarding the positions Dr Anderson has held on the DAFF CCEAD and CCEPP Committees and the role he played in meetings, discussions and decisions in relation to the eradication program (Asian Honey Bees).

Could the Committee please have copies of correspondence, minutes, advice etc between Dr Anderson and the CCEAD/CCEPP Committees regarding his official position on these DAFF Committees.

Question 2

The Committee would also appreciate it if Dr Anderson could provide further information about the Darwin incursion (he indicated had been eradicated) some years ago.

Senate Rural Affairs and Transport References Committee

Inquiry into the science underpinning the inability to eradicate the Asian Honey Bee

Public Hearing – Thursday, 24 March, 2011

Question Taken on Notice

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Question 1

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Could the Committee please have copies of correspondence, minutes, advice etc between Dr Anderson and the CCEAD/CCEPP Committees regarding his official position on these DAFF Committees.

Answer to Question 1

When I refer to CCEAD (the Consultative Committee on Emergency Animal Diseases) in my evidence I should have been referring to the Consultative Committee on Asian honey bees (CCAHB). When the Asian honeybee was initially detected at Cairns in May 2007 the national response to it was coordinated by the CCEAD, as the bee may have been carrying the Varroa mite, which was officially categorized as an emerging animal disease (EAD) and thus formed part of the Emergency Animal Disease Response Agreement (EADRA).

However, when it was determined (by CSIRO) that the Asian honeybee at Cairns was not carrying the Varroa mite, all further responses to it could not be coordinated by CCEAD, as Asian honeybees by themselves were not listed as an EAD under the EADRA. At that point a committee (CCAHB), which mirrored the CCEAD, was formed to deal with technical aspects of the bee. I was a member of a Scientific Advisory Panel that provided technical advice to CCAHB. I attended two teleconference meetings of this Scientific Advisory Panel, the first on 26 October 2009 and the second on 30 November 2009. Comments that I made at the 26 October meeting can be seen in the attached minutes (**Attachment 1**). I have no record of receiving the minutes of the 30 November meeting, but I was invited to that meeting and did receive the agenda (**Attachment 2**) and a SAP report discussed at that meeting was sent to attendees after the meeting for comment (**Attachment 3**).

When the Asian honeybee became officially listed as an emerging plant pest (EPP) in April 2010 the national response to the bee was then coordinated by the Consultative Committee on Emerging Plant Pests (CCEPP). There were 2 meetings of the CCEPP Asian Honey Bee before the National Management Group (NMG) decision on 31 January 2011 that the Asian honeybee at Cairns was not eradicable. I attended the first of these meetings, on 29 October 2010 and made comments and gave advice, but most comments and inputs given at that meeting were not attributed to individual attendees (**Attachment 4**[1]). I did not attend the second meeting of the CCEPP on 25 January 2011, for the reasons given in my evidence.

Question 2
The Committee would also appreciate it if Dr Anderson could provide further information about the Darwin incursion (he indicated had been eradicated) some years ago.

Answer to Question 2

A single colony of Asian honeybee (*Apis cerana*) was detected in Darwin on 14 June 1998. This was the only colony detected during that particular incursion. The colony was destroyed and that effectively eradicated the incursion. Some specific details associated with that incursion are attached (**Attachments 5 & 6**). Some valuable lessons learnt from the incursion were published in a scientific journal (**Attachment 7**).

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[1] The minutes incorrectly list my affiliation as the Australian Honey Bee Industry Council. For the reasons covered in my evidence to the hearing regarding the committee secretary use of an incorrect email address I did not receive a copy of the minutes in time to correct this error.

CONSULTATIVE COMMITTEE ON ASIAN HONEY BEES
SCIENTIFIC ADVISORY PANEL

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Consultative Committee 2009 – Asian Honey Bees (CCAHB)
Scientific Advisory Panel
Teleconference 01
1400hrs AEST, Monday 26 October 2009

FINAL MINUTES

OUTCOMES

The **CCAHB SAP AGREED**

- that *A. cerana* needs a constant food and water source available and access to hive sites. They could survive in rainforests but disturbed area is their preferred habitat. They would only move into the rainforest if the population density was high enough to drive them into the forest out of their preferred habitat.
- that movements of 7-10km maximum could be expected without assistance.
- that based on the knowledge to date of the strain of *A. cerana* involved in the incursion it will be more of a problem in tropical than temperate areas.
- another meeting will be held to consider the beneficiary analysis as it requires all potential beneficiaries to be at in attendance.

ACTIONS

Qld to develop a structured surveillance program for eradication and then proof of freedom, including costing to go to CCAHB. This will be circulated via email to the CCAHB SAP.

Qld to include appropriate surveillance of fomites in plan for eradication. PHA and Glynn Maynard will provide input in consultation with Qld.

Attendees:

Rodney Turner, PHA (Chair) Sophie Peterson, PHA Nicole Bresolin, PHA Glynn Maynard, DAFF Iain East, DAFF Luke Halling, NAQS Jennifer Davis, DAFF	Dennis Anderson, CSIRO Warren Jones, AHBIC Trevor Weatherhead, AHBIC Karen Skelton, DEEDI Qld Charlotte Greer, BQ Wim DeJong, BQ Rob Manning, WA

1. Introduction and welcome: attendance, confidentiality requirements, review terms of reference and confirmation of agenda

The Chair welcomed members and reminded participants that although the SAP was a ‘deed-like process’ and not bound by the rules of either the plant or animal deed the confidentiality requirements of the deeds applied.

2. Situation Update

Queensland provided an update on the current situation. There are 49 official IPs (nests and swarms of AHB detected) and 1 completing final confirmation with entomologists. The most recent 2 IPs have been at Portsmith (the port area where the first swarms were found). Surveillance at Mareeba and Yarrabah has found no foraging bees. Foraging bees have been found south of Trinity Inlet (east of IP20, north of IPs 8 and 9). The restricted area has been extended to include Mareeba. This has resulted in an increase in the number of requests for movement permits received by Qld authorities.

A question was asked regarding the impact of rising temperatures on the swarming of the bees. BQ indicated that the behaviour was similar to previous years with an increase in swarms in spring (August, September) and then a decrease with the onset of the wet season.

3. Bee survival in rainforests

A NAQS botanist has indicated that there are a large variety of plants in the rainforest with various plants flowering throughout the year. There is also reasonable disturbance through the rainforest (roadways, railway) and weeds in these areas providing sufficient food at all levels for bees to survive in the rainforest. The ability of the bees to use these flowers as food source was questioned; just because there is a flower doesn’t mean it can be used by bees.

It was discussed that the preferred habitat of the *Apis cerana* was the edges of the rainforest and cultivated areas where food was more readily available. The domestic habitat was more successful than the rainforest and *A. cerana* were commonly found around houses; roofs, eves, gaps in timber etc. *A. cerana* do not store reserves of honey like *Apis mellifera* and therefore this limits their ability to survive in the rainforests compared to urban and rural areas. The low density of bee population was also discussed. At this stage, there is no pressure for the *A. cerana* to move outside its preferred environment.

The effect of drought and lack of permanent water supply in some rainforest areas was discussed. The foraging limit of the AHB is 3km and they are likely to carry water less distance than this. CSIRO indicated that the temperature affects the ability of the bees to carry/ travel to water. Extreme temperatures prohibit travel to water. But the water requirement of the bees is greatly dependent on the food source, e.g. nectar is 90% water so additional water requirements are low.

BQ indicated that in their experience there was no *A. mellifera* or *A. cerana* through the higher altitude rainforest. CSIRO indicated that in other countries there were different biotypes of *A. cerana* at higher altitudes. In both Borneo and Sulawesi, *A. cerana* was found at lower altitudes (<400 m) and altitude may provide a barrier to dispersion of the *A. cerana*. Bees in the *A. cerana* group live across a wide spectrum of climate. The incursion around Cairns involves the Java strain which has an inclination towards more tropical environments and therefore is probably eradicable in Cairns.

A question was raised about the level of surveillance that had been performed in the canopy of the rainforest.
BQ indicated that they had performed unrecorded surveillance observing the canopy, flowers and parrots feeding on them. The difficulties of performing surveillance due to terrain and accessibility were raised.

The **CCAHB SAP AGREED** that *A. cerana* needs a constant food and water source available and access to hive sites. They could survive in rainforests but disturbed area is their preferred habitat. They would only live in the rainforest if the population density was high enough to drive them into the forest out of their preferred habitat.

4. Ability of surveillance to detect all nests and swarms

Current surveillance methods were discussed. Qld indicated that the main method of active surveillance was sweep netting of flora, observation by residents and reporting of bees. About 960 public calls accounted for 27 detections. The other 23 were through sweep netting and bee lining and door-to-door examination of premises.

Sugar feeding was used along the east and west boundaries of the agricultural (sugar cane growing) areas south of Cairns. The limitations of sugar feeding stations were discussed. The stations rely on opportunistic feeding of the foraging bees rather than being directly attractive like pheromone traps. Stations are examined on a weekly basis at varying times of day. The sensitivity of surveillance is enhanced by examination of flora in the area around the sugar feeding stations. Lavender oil is used in the stations as an additional attractant.

There was discussion on the use of bee lining and the differences in foraging behaviour between *A. mellifera* and *A. cerana*.

There was discussion on how proof of freedom would be determined. There are a lot of potential food sources for the bee and no way of drawing them in. PHA indicated that knowledge of the flowers used by the bees throughout the year, location of plants and a structured grid surveillance of these would be required.

BQ has been keeping a record of what *A. cerana* have been found feeding on for the last 18 months. There has been no recording of what flowers *A. cerana* do not use as food sources. It was indicated that often they will only feed on a certain stage of the flower. This knowledge could be used to direct surveillance activities towards these species when they are in flower.

Actions:

Qld to develop a structured surveillance program for eradication and then proof of freedom, including costing to go to CCAHB. This will be circulated via email to the CCAHB SAP

5. How far can bees move?

Literature indicates spread of 50-100km. This may be the case in PNG where there is a high density of bees and a front moving into a new uninfested area but in Cairns the population density is low and there is no incentive for *A. cerana* to make long distance movements. In Cairns, movements of 7-10km have been detected on three occasions. This probably represents the maximum distance of unassisted movement .

The **CCAHB SAP AGREED** that movements of 7-10km maximum could be expected without assistance.

5.1. Risk of fomite transmission

There was a potential for transmission of bees on fomites such as containers or machinery. Shipping containers may remain in yards for several months before being moved on trucks out of the area. If aiming for eradication an inspection program needs to be implemented for containers, machinery, rail carriages etc as deemed appropriate leaving the Cairns area.

Actions:

Qld to include appropriate surveillance of fomites in plan for eradication. PHA and Glynn Maynard will provide input in consultation with Qld.

6. Impact of AHB on tropical versus temperate regions

As a tropically adapted bee, *A. cerana* should have greater impact in tropical areas compared to temperate areas. The Java strain of *A. cerana* tends to favour tropical areas and in temperate areas in Papua New Guinea *A. mellifera* out-competes *A. cerana*. The impact on existing bees in tropical areas will be much greater than temperate regions. It is expected that *A. cerana* will be a lot harder to manage in tropical areas but it was acknowledged that there are a lot of unknowns.

The **CCAHB SAP AGREED** that based on the knowledge to date of the strain of *A. cerana* involved in the incursion that it would be more of a problem in tropical than temperate areas.

7. Beneficiary analysis

The **CCAHB SAP AGREED** another meeting will be held to consider the beneficiary analysis as it requires all potential beneficiaries to be in attendance.

8. Other matters

None raised.

9. Advice to CCAHB

9.1. Bee survival in rainforests

A. cerana needs a constant food and water source available and access to hive sites. They could survive in rainforests but disturbed area is their preferred habitat. They would only live in the rainforest if the population density was high enough to drive them into the forest out of their preferred habitat.

9.2. Ability of surveillance programs to detect all nests and swarms

Queensland will develop a structured surveillance program for eradication and then proof of freedom, including costing to go to CCAHB.

9.3. How far can bees move?

Movements of 7-10km maximum could be expected without assistance.

9.3.1. Risk of fomite transmission

Fomite transmission was regarded as a risk and appropriate surveillance of fomites will be included in the plan for eradication being prepared by Qld.

9.4. Impact of AHB on tropical versus temperate regions

Based on the knowledge to date of the strain of *A. cerana* involved in the incursion it would be more of a problem in tropical than temperate areas.

9.5. Beneficiary analysis

Another meeting will be held to consider the beneficiary analysis as it requires all beneficiaries to be at the table.

10. Next meeting

TBC. Possibly 4th, 5th or 6th November 2009.

Ends

CONSULTATIVE COMMITTEE ON ASIAN HONEY BEES
SCIENTIFIC ADVISORY PANEL

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Consultative Committee 2009 – Asian Honey Bees (CCAHB)
Scientific Advisory Panel
Teleconference 02
1600hrs AEST, Monday 30 November 2009

AGENDA

Dial-in details:

- If you are dialling in from within the (02) area code please call 02 8524 1000
- For all other areas of Australia call 1800 735 510
- The Guest Passcode is 32233172 followed by the hash (#) key.
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1.	Introduction, welcome and attendance	*Chair*
2.	Situation Update	*Qld*
3.	Consideration of Queensland Surveillance Plan	
4.	Advice to CCAHB	*Chair*
5.	Next meeting	*Chair*
6.	Close	

FW: SAP Report - Draft for circulation to SAP [SEC=UNCLASSIFIED]

CCEAD [ccead@daff.gov.au]

Sent: Thursday, December 03, 2009 4:46 PM

To: Rodney Turner [rturner@phau.com.au]; Peterson, Sophie [speterson@phau.com.au]; Maynard, Glynn [Glynn.Maynard@daff.gov.au]; East, Iain - Product Integrity [Iain.East@daff.gov.au]; Skelton, Karen V [Karen.Skelton@deedi.qld.gov.au]; jones.pinecrest@bigpond.com; queenbee50@bigpond.com; rob.manning@agric.wa.gov.au; Halling, Luke - AQISNT [Luke.Halling@aqis.gov.au]; Anderson, Denis (Entomology, Black Mountain); doug.somerville@industry.nsw.gov.au

Cc: Carroll, Andy - Product Integrity [Andy.Carroll@daff.gov.au]; Ransom, Lois - PIAPH [Lois.Ransom@daff.gov.au]; Sharma, Shashi B [shashi.sharma@agric.wa.gov.au]; Walker, James - AQISFNTH [James.Walker@aqis.gov.au]; Nicole Bresolin [nbresolin@phau.com.au]; CCEAD [ccead@daff.gov.au]; Scanlan, Bill - Product Integrity [Bill.Scanlan@daff.gov.au]

Attachments: 091202_SAP report to CCAHB.doc (76 KB) [Open as Web Page];

Dear All,

Please find attached the draft report from the SAP to CCAHB for your comment and approval. Please send any comments to Sophie Peterson at PHA, whose address is in the To: address line, by **COB Friday 4 December (tomorrow)**.

Kind regards,

Emma
+61 2 6272 4828

From: Sophie Peterson [mailto:speterson@phau.com.au]
Sent: Thursday, 3 December 2009 4:29 PM
To: CCEAD
Cc: Rodney Turner
Subject: SAP Report - Draft for circulation to SAP

Hi Emma.

Please find attached the draft report from the SAP. Please circulate this to the SAP for approval prior to sending it to CCAHB. Hopefully they will be able to get back to you with comments / agreement by tomorrow afternoon or Monday.

Also, would you be able to add Rod Turner and me to the CCAHB mailing list?

Cheers,

Sophie.

Dr Sophie Peterson
Program Manager (Emergency Plant Pest Response Deed)

Plant Health AUSTRALIA

Dir: (02) 6215 7721 Main: (02) 6215 7700 Fax: (02) 6260 4321 Mob: 0402 313 170
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Keep informed about plant health. Become a subscriber to PHA's weekly e-newsletter *Tendrils*

Consultative Committee on Emergency Plant Pests:

Asian honey bees

DRAFT MINUTES

Meeting Number:	1	**Date:** Friday 29 October 2010	
Location: M2.02		**Time:** 10.00am (ADT)	

Participants		
Name	**Organisation**	**State/Terr.**
Lois Ransom (Chair)	Biosecurity Services Group, DAFF – Office of the Chief Plant Protection Officer	C'Wealth
Fiona Macbeth	Biosecurity Services Group, DAFF – Office of the Chief Plant Protection Officer	C'Wealth
Glynn Maynard	Biosecurity Services Group, DAFF – Office of the Chief Plant Protection Officer	C'Wealth
Sue Jones	Biosecurity Services Group, DAFF – Office of the Chief Plant Protection Officer	C'Wealth
Sharne Gibbons	Communications, DAFF	C'Wealth
Rose Hockham	Biosecurity Services Group, DAFF – Partnerships	C'Wealth
Iain East	Biosecurity Services Group, DAFF – Animal Biosecurity	C'Wealth
Louise Sharp	Biosecurity Services Group, DAFF – Animal Biosecurity	C'Wealth
Kathy Gott	Industry and Investment, NSW - Primary Industries	NSW
Rick Symons	Department of Employment, Economic Development and Innovation, Primary Industries and Fisheries	QLD
Russell Gilmour	Department of Employment, Economic Development and Innovation, Primary Industries and Fisheries	QLD
Wim de Jong	Department of Employment, Economic Development and Innovation, Primary Industries and Fisheries	QLD
John Hannay	Department of Primary Industries and Resources South Australia (Biosecurity)	SA
Michael Stedman	Department of Primary Industries and Resources South Australia (Biosecurity)	SA
Andrew Bishop	Department of Primary Industries, Parks, Water and Environment	TAS
Bill Washington	Department of Primary Industries	VIC
Russell Goodman	Department of Primary Industries	VIC
Stephen West	Department of Resources	NT
Rod Turner	Plant Health Australia	IGL*
Nicole Bresolin	Plant Health Australia	IGL*
Amy Forbes	Plant Health Australia	IGL*
Evan Sergeant	AusVet Animal Health Services Pty Ltd	Consultant
Lindsay Bourke	Australian Honey Bee Industry Council (AHBIC)	
Trevor Weatherhead	Australian Honey Bee Industry Council (AHBIC)	
Dennis Anderson	Australian Honey Bee Industry Council (AHBIC)	

*Industry Government Liaison

Apologies

Satendra Kumar	Industry and Investment, NSW - Primary Industries	NSW
Peter Dinan	Department of Territory and Municipal Services	ACT
Shashi Sharma	Department of Agriculture and Food	WA

Opening

Welcome and roll call

Participants were welcomed and introduced to meeting.

Confidentiality requirement

The Chair reminded the meeting that proceedings are to remain confidential. No conflict of interest was declared.

All participants were covered by the Deed Poll.

Background and History

Russell Gilmour from the Cairns Control Centre gave a presentation on the history and background of AHB, including maps of the restricted area. (Attachment 1)

- In 2009 a detection at Mareeba resulted in the Restricted Area (RA) being extended
- On 23 April 2010 PIMC agreed to fund the continuation of the AHB eradication program until 31 December 2010.
  - Increased surveillance has detected outliers at Innisfail and in the Malanda area.
  - Where possible rainforests have been surveyed with no detections of AHB to date.
- New initiatives in 2010 have included development of sugar traps, improvements to surveillance techniques, improvement to community engagement and acquiring the services of a detector dog and trainer to begin in November 2010.

These bees can carry varroa mite but no mites have been detected on the bees identified in Australia. The bees detected are still from the same genetic line as the first incursion in 2007.

Qld has developed good working relationships with staff from all modes of transport into the Cairns area, including barges to and from Torres Strait.

Wim de Jong from the Cairns Control Centre gave a presentation on technical considerations. (Attachment 2)

The CCEPP noted:

- Technical aspects of *Apis cerana* behaviour
- Swarming distance observed in Cairns was approximately 7 km (Dennis Anderson's study was approximately 10 km)
- Targeted surveillance within the RA is on the 7 km and 14 km buffer zone
- Outside buffer zones surveillance is conducted by
  - Targeted floral sweeping
  - General grid sweeping
  - Bee traps – intervals of 1 km in the suspected flight path

- *A. cerana* are smaller than *A. mellifera* but can challenge other social insects for resources.

Program Analysis and Review - Evan Sergeant

- Surveillance outside RA - long distance jump would be biggest threat to eradication, there is a north-south corridor but could go anywhere and it would be a real challenge to contain and eliminate a second incursion.

Highlights of report:

- Numbers of swarms are down 20% and this seems to be a good sign
- Age of nests – the younger the nest the better but the average has had peaks during 2010; generally at October the nest age has declined
- Surveillance activity is now more targeted and is more efficient than the random grid sweeps
- 50% of nests and swarms detected are as a result of public call out
- PIDS – individual foragers (not nests or swarms) are mostly found in trap or sweep; sweeping resulted in biggest number; but trap and floral sweeping were more efficient in identifying bees.

Estimating the nest numbers present was not easy to model as there were too many unknowns.

One problem was starting with the one nest in Cairns (and it is not known when the nest began).
Five nests were destroyed in May 2007 (but it is not known how many were missed).
Then a model based on detecting 10 swarms a months (and it is not known what percentage of swarms this represents).
Then recognising that between 20-50% of swarms are detected.
Using the 50% result this could mean that there are 300-400 nests undetected at present.

Isolated Positive Identifications (PIDs) and where does this fit in - essentially a number of occasions where detections have not led to nests as bee-lining relies on more bees coming back to same locations. These PIDs sites have been in Atherton, Malanda, the southern end of Yarrabah and in the beach suburbs to the north of Cairns. PIDs may indicate that:

- a bee could have been blown off course;
- there is only a small nest that has a very small number of bees and is not very active;
- the bee belongs to a nest that is dying.

But if there are too many in this category then surveillance may not be sensitive enough to pick up these bees.

To date no records have been collected about comb spotting but CCEPP noted this data would give information about the age of hives.

Evan concluded that in six months time there would be more knowledge to give confidence that the bee is being eradicated. As there has only been three full months of operating at maximum efficiency the results to date are not showing any trends.

Technical feasibility of eradication

The CCEPP noted:

- the difficulty of tracing bees;
- that seasons play a role in bee activities and the best time for detection is June through to December;

  - the improvements made since mid-year with trapping and floral sweeping;
  - all detections have been free of exotic diseases and mites and all are genetically linked;
  - the setting up of the detector dog program which is to start in November 2010 which may help find smaller nests that are not very active (also noting the public interest in detector dogs);
  - research into the use of Fipronil
  - AHB has had a severe effect on European honey bees in the Solomons and has almost wiped them out.

The CCEPP **agreed** that a proposal be put to NMG that the current program be extended for a further 12 months with a review after 6 months and that realistic exit criteria be set. Indicators that would trigger discussion could be a detection say 200km away / a real outlier.

A paper, compiled by Roger Paskin Vic, concludes that AHB is not considered eradicable. This paper is to be sent to CCEPP Secretariat for circulation to CCEPP. The paper has another model to estimate decimation ratio – if this ratio was at .8 then there could be confidence that eradication is achieved. The paper reports that at no time in this campaign has this ratio been below 1 (and has had an average of 2.5).

> **Action:** Paper compiled by Roger Paskin, Vic to be sent to CCEPP Secretariat for circulation to CCEPP.

The CCEPP discussed other opportunities / tools that could be applied to help the eradication effort.

- An industry scheme, with self-inspection, to inspect cargo moving out of Cairns.
  - Would government inspection give more confidence?
  - Perhaps used trained people
  - Inspections at road blocks.

  Currently Qld is relying on self-inspection and reporting and have the cooperation of all the transport types and the meeting agreed that it is better to work with industry than replace industry inspections with government regulators.

- Fipronil – trials have been documented and reviewed with peers (fire ant scientists) and Qld is waiting to find a nest to observe while the destruction is being undertaken. This treatment would help where there are tough areas and high cliffs to get to. The application is a remote bait and relies on foraging bees to take back and poison the nest. It would be set up as a sugar station with an amount of poison and staff would observe the numbers of foragers and how long it takes the hive to die. It is hoped to start this trial in two months but there is a need to have a hive where bee numbers can be counted and that can be observed.

- Sterilising drones – this work has not been done before. It was noted that there was just one swarm into the Solomons and this has now inbred but is still surviving. Even if one colony survives it may be enough for eradication to be unsuccessful.

- Acoustic recordings – this work has been trialled by Jerry Bromenshenk in the US. If there were recordings of *A. cerana* this may be able to be applied to determine the bee species.

- Laser – this has been developed to detect landmines with bees. This would need a lot of research for development and would be a long-term alternative.

Categorisation

When AHB was assessed the categorisation panel also discussed the viruses associated with the bee. The pest was categorised as an EPP 2.

It was noted that not all of the pollination industry accept that AHB will be an issue, particularly not in the southern parts of Australia. AHBIC was disappointed with the pollination industry position. Their position is that AHB will affect the honey bee industry and early crops would be the most affected – almonds, applies, pears, cherries because the honey bee industries are still breeding up their hives after their winter losses (up to 25% each winter).

Benefit:Cost Analysis

Qld has prepared a BCA which is in draft with governments but has not yet been circulated.

At this point it is understood that the pollination and honey industry nor environment has been included in the BCA.

> **Action:** CCEPP Secretariat to obtain copy of BCA prepared by Qld and circulate to CCEPP.

Views on technical feasibility of eradication

If indicators don't indicate that it is not feasible then it is feasible (to eradicate).

Evan Sergeant – nothing to indicate that it is not feasible to eradicate (but need more information).

Qld – feasible and possible – indications that it is contained, finding nests that are young, finding swarms.

NSW – industry would like to think it is feasible, government would need strong evidence (more than is currently available) and more information.

Tas – no on the basis of continued detections and the potential of non-detections and opportunities for further entry. Similar to other Consultative Committee and PlantPlan alternative action needs alternative action.

NT – yes but need more data so supports a continuing program. There will always be outliers.

Vic – Consider AHB not eradicable, but there is a need for more data as it is extending range within RA.

WA – no and would need to be convinced. Need more data.

ACT – not in attendance

C'wealth – has concerns on technical level. There are a number of outliers outside of RA. If they are assisted movements they are not unusual. How significant are the single detections of outliers. Extent of risk of non-detection. Nothing to stop it – climate, physical barriers, and may be more around the margins than just in Cairns; and the difficulty of detection in non-urban areas.

Appendix 12 – PlantPlan

Factors favouring eradication	Factors favouring alternative action
• Cost/benefit analysis shows significant economic loss to industry or the community if the organism establishes.	• Cost/benefit analysis shows relatively low economic or environmental impact if the organism establishes.
• Physical barriers and/or discontinuity of hosts between production districts.	• Major areas of continuous production of host plants.
• Cost effective control difficult to achieve (e.g. limited availability of protectant or curative treatments).	• Cost effective control strategies available.
• The generation time, population dynamics and dispersal of the organism favour more restricted spread and distribution.	• Short generation times, potential for rapid population growth and long distance dispersal lead to rapid establishment and spread.
• Pest biocontrol agents not known or recorded in Australia.	• Widespread populations of known pest biocontrol agents present in Australia.
• Vectors discontinuous and can be effectively controlled.	• Vectors unknown, continuous or difficult to control.
• Outbreak(s) few and confined.	• Outbreaks numerous and widely dispersed.
• Trace back information indicates few opportunities for secondary spread.	• Trace back information indicates extensive opportunities for secondary spread.
• Weather records show unfavourable conditions for pest development.	• Weather records show unfavourable conditions for pest development.
	• Weather records show optimum conditions for pest development.
• Ease of access to outbreak site and location of alternate hosts.	• Terrain difficult and/or problems accessing and locating host plants.

Discussion re Appendix 12 of PlantPlan

General elements –

- Yes – can kill (using Mortein)
- Cost:benefit - not yet available
- Survey data represents up to date information -yes

Factors affecting eradication:

- Physical barriers – and/or discontinuity of hosts between food sources – no; major risk is north/south
- There is a probability of being reintroduced – potential for new incursions
- Cost effective treatment – yes
- Generation time and dispersal makes for population doubling every 4 months - can fly and form hives and fly on (can take 5-10 km leaps);
- has propensity to hitch-hike; spread is not restricted; (can form nests on objects of trade) risk of assisted spread
- point of infestation rather than a continuous infestation;
- social insect
- pest biocontrols – not known

- o With assisted 'stuff' - can these be controlled, commercial trade, is there much residual risk (don't know - some vector controls via commercial controls).
- o Outbreaks are few and confined within current situation – yes, especially as it is an insect.

- Trace back indicates few opportunities for secondary spread – yes – passive surveillance.
- Where records show favourable conditions for spread – favourable conditions but may be some seasonality.
- Ease of access for surveillance/trapping – access issues with terrain and vegetation; feeds off multiple pollen sources.

Factors favouring alternative action

Cost effective controls – are strategies are available

- spraying and baiting to protect whatever is affected
- pollination in area to maintain the status quo
- no control strategies to protect sectors affected
- large areas not populated to aid passive surveillance
- no indications of tracing
- optimum conditions for pest development

The above discussion on the table from PlantPlan picked up the major points and CCEPP noted that there were arguments on both sides, and that there was not consensus. This outcome will be notified to NMG that while there is not consensus on the eradicability of AHB that there needs to be an additional program from 1 January 2011 so that ongoing detection and destruction can occur and further data can be obtained.

The NMG to note:

- that the CCEPP is not confident of successful eradication but the consequences for not continuing with an eradication program are high
- that CCEPP has an increased confidence in detection as a result of the efficiencies in surveillance since July 2010 using innovative methods (floral sweeping, sugar stations)
- further data and ongoing detection and destruction will inform the decision on technical feasibility
- indicators to measure progress and/or trigger review to be developed
- that further knowledge of the behaviour of AHB has been gained (food sources/floral sweeping/seasonality)
- that alternative detection and destruction programs are being pursued – use of pheromones, detector dogs; Fipronil (this still needs to be tested)
- that increased community engagement will enhance passive surveillance
- that there will be a six month review of the additional program to help inform the decision on technical feasibility
- that the benefit:cost analysis will further inform NMG on the likely eradicability of AHB.

Is there opportunity for innovation to be a cost offset:

- revisiting pheromones (to develop would cost a lot of money) could use floral attractants
- if drone areas could be identified these could be destroyed (harmonic radar has been used in this regard for honey bees which worked well in open countries and where there was a lot of bees but not so well in built up areas)
- port trapping with surveillance, NAQS.

Information from whiteboard:

Whiteboard 1:

Yes		No
AHBIC – age nests younger; 85% than 12 months ago SA – indicators – don't indicate not feasible so it is; outbreaks within RA contained Qld – not 100%; contained; swarms younger; finding nests; need more info NT – more data; outliers; continue program Vector controls via community and transport Tracing		Can fly (swarm) 5-7km (characteristics tha allow it to spread) As a nest risk assisted spread Contiguous food No physical barriers
	Lack of information for convincing evidence	
Can kill – cost effective Delimitation actions undertaken - passive - active - within/outside RA Generation time – unknown - 4-6 months? Social insect – point infection – low numbers No biocontrols		Favourable conditions – some seasonality access difficulties – terrain Range of food sources – vegetation C'Wealth – outliers - assisted movements – where else
		Tas – extent of detection - extent of non-detectio - potential for further en - alternative action Vic – more data to support eradication - extension range with RA – basis o concern
	ACT - ?	
	NSW – need stronger evidence than currently available	
	WA – need to be convinced;	

Whiteboard 2:

- Not confident of successful eradication but consequences high < BCA – pollination
- Increased efficiency – surveillance; data; ongoing detection and destruction
  - Indicators to measure progress/trigger reviews
  - Six month review - >inform decision on technical feasibility
- Increased confidence of detection – surveillance/detection >taking into account biology
- Pheromones/florals – targeting (food sources (florals), seasonality)
- Detector dogs
- Fipronil – test and apply
- Surveillance strategy around RA? – long distance; port trapping (How?); swarm lure; NAQS
- Alternative control strategies?
- Community engagement/enhances passive surveillance

ACTIONS
1. Paper compiled by Roger Paskin, Vic to be sent to CCEPP Secretariat for circulation to CCEPP.
2. CCEPP Secretariat to obtain copy of BCA prepared by Qld and circulate to CCEPP.

Other business

Nil.

Meeting close

The meeting closed at 4.20pm.

Department of Primary Industry and Fisheries
Asian Honey Bee Eradication Program
Darwin
14 June 1998 to 30 June 1999

Compiled by Andrew Moss BVSc.

Table of contents Asian Honey Bee Eradication Program Darwin 1998 -99

Detection of Asian honey Bee nest

The detection was made on Sunday, 14 June 1998 after a local apiarist contacted Northern Territory Quarantine with what he considered was a nest of Asian honey bees. The nest had been collected from a Darwin suburb on Thursday, 11 June 1998. This suburb is situated close to mangroves and in the Darwin metropolitan area. The nest had been kept by the apiarist in his backyard for three days, in the northern suburbs of Darwin, until reported. The bees were identified as *Apis cerana* on Sunday, 14 June 1998 and the nest placed in a deep freeze to kill the bees.

How the bees reached the suburban address is not known. There were pallets of pavers moved from an area close to the port facility to the address where the bees were detected. We were unable to confirm this as the point of introduction of the bee nest to this address. We examined origins and destination of these pavers but found no further evidence of Asian honey bee or comb.

DNA testing in the USA by Deborah Smith, University of Kansas detected mitochondrial DNA Java 1. This has been found in *Apis cerana* originating from Java, Bali, Timor, Flores and Sulawesi.

Australia is free of three major mite pests of bees*, Varroa jacobsoni, Tropilaelaps clarae* and *Acarapis woodi*. One of the major concerns following detection of Asian honey bee is its possible introduction of these species of mites.

No evidence of bee mites was detected in brood or bees from the feral nest. No testing, during the course of the eradication program, of feral nests and managed *Apis mellifera* hives in the Darwin region has detected any exotic bee mites.

Feral nest - *Apis cerana*

The nest of *Apis cerana* was thought to be approximately two months of age. Local apiarists estimated the nest age and it was confirmed by the residents of the house where the nest was detected. The lower storey of the home had been organised prior to a party two months previously, a wooden board was placed in the laundry on which the nest was established. Pavers had been moved into the yard on pallets just after this time. The nest contained 570 worker and 170 drone cells. Local apiarists concluded that the nest had not yet swarmed but the high number of drone cells suggested that the colony was preparing to swarm.

Initial response

The Ausvetplan 1996 Bee Diseases was used as a guide in the conduct of the eradication program.

Disease control legislation was in place by the 18 June 1998. The Stock Diseases Act was used as the legislative tool to regulate movement of bees and other items as detailed in appendix 1. Areas were declared to restrict the movement of high-risk items to reduce the chance of spread of exotic bee mites or bees while the eradication program was running. Four areas were declared in the Northern Territory.

1. Eradication area – this enclosed an area within 6 km of the original detection, including all of Darwin City and suburbs.

2. Restricted area – this enclosed an area from the eradication area to a radius approximately 18 km from the original detection.

3. Control area – this enclosed an area from the edge of the restricted area to a radius approximately 50 km from the detection site. This followed property boundaries and was the same boundary being used for exotic fruit fly eradication, a program underway at that time. Roadblocks being used for restricting the movement of fruit were also used to restrict the movement of commercial bee hives.

4. Protected area – this area comprised the rest of the Northern Territory. There are no movement restrictions imposed within this area.

Following the end of the eradication program all movement restrictions relating to the Asian Honey Bee Eradication Program have been lifted.

See **Appendix 1** for movement controls enforced as part of the eradication program.

Movement restrictions – not part of the disease control program

There are restrictions on the introduction of honey bees from other states into the Northern Territory. Bees from Tasmania are prohibited, bees from other states require a certificate from the apiarist countersigned by an inspector declaring 12 months apiary freedom from American foul brood and current apiary freedom from European foul brood and chalk brood.

Destruction of feral nests

Detection and destruction of all feral nests within the eradication area was instituted. There were feral *Apis mellifera* living in tree hollows and buildings in the Darwin area. They were at relatively low density and were hard to detect. Most reports were received from homeowners or people living in the area of a feral nest.

We have destroyed 15 feral nests. A local pest control firm carried out the destruction. Prior to destruction all feral nests were sampled for exotic bee mite testing. We feel that the majority of feral hives within the eradication area have been sampled and destroyed. Reports of bee swarms and bee activity toward the end of the campaign when investigated were attributed to managed hives within the eradication area. As most feral nests were in cavities in trees and houses (no access to the brood), adult bees were sampled and washed in alcohol (see **Appendix 2** for laboratory procedures). These bees were also tested for tracheal mite. We collected, sampled and destroyed five *Apis mellifera* swarms within the eradication area.

Media campaign

An awareness program was run for the first three months consisting of the following:

- A rapidly produced community announcement was produced for television and broadcast on stations in the Darwin area until a commercial was produced.
- A television commercial was produced and run on all stations in the Darwin area.
- Television news both Channel 8 and ABC ran stories following the incursion.
- Newspaper advertisements were placed in the NT News.
- Newspaper stories were run in the NT News and Litchfield Times.
- Several radio talk shows discussed the incursion including the ABC gardening show on Saturday morning.
- The ABC country hour ran stories on Asian honey bee.
- A display on Asian honey bees was presented and manned at the two major shopping centers in Darwin (Casuarina and Palmerston).

A hot line number was established to receive reports from the public. The telephone number adopted was the 1800 number used Australia wide for exotic disease reporting.

A second media campaign was launched on the 15 March 1999.
This campaign was targeted at the eradication area and consisted of the following:

- ¼ page newspaper advertisements in the NT News run for two months.
- Newspaper advertising run in the Weekender for two months.
- Articles were run in the Litchfield Times, NT News and Weekender relating to the Asian Honey Bee Eradication Program.
- Television Stations; Imparja, Channel 7 and the ABC continued to run as community announcements an Asian honey bee awareness advertisement we had produced.
- The ABC TV produced a news item on bee-eater research being conducted as part of the program.
- Regular contact was made with the ABC radio gardening show on Saturday morning. The ABC radio also ran a news item on the country hour.
- A program was produced on TEABBA radio and broadcast to coastal aboriginal communities in the Northern Territory.
- Displays on Asian honey bee were presented at the Casuarina library and Freds Pass rural show.

The second media campaign resulted in renewed public interest.

The database statistics give some idea of the volume of calls. This underestimates the number of calls, as not all calls, especially where information only was given out, were recorded.

See **Appendix 4** for details of the public response.

Field response

For the first two months between three and four field teams, two people per team, searched for bee activity in the immediate area of the detection. This was achieved by examining flowering plants and water sources, door knocking and the placing of extracted frames soaked in honey at strategic sites in the eradication area.

In addition to work in the eradication area testing for exotic bee mites was carried out in the restricted and control area and some testing was done in the protected area around Katherine.

Two staff were employed after this initial stage to respond to public inquiries, issue permits, continue monitoring by mite testing of hives and nests and searching for bee activity in the eradication area. Public reports responded to included: bee activity, swarms, insect samples for submission and people seeking information.

In the 12 months since the incursion, no further discoveries of Asian honey bee have been made. There has been no evidence of the presence of exotic bee mites despite extensive testing of both managed hives and feral nests within a 50 km radius of Darwin.
Appendix 3 details laboratory testing.

Managed hives within the eradication area

The number of managed hives increased from 15 to over 20 during the course of the program in the eradication area, comprising Darwin City and suburbs. Movement restriction prevented any movement of managed hives, however natural increase resulted in more hives. Bees from these hives have undergone testing for exotic bee mites on three occasions following the incursion.

Data recording

A database was set up to record details of telephone reports and laboratory testing.

Northern Territory Honey Bee Industry

The industry is based on pollination of crops and honey production. Queen breeding is carried out in the Darwin region by one apiarist and is small in scale. These bees were subject to movement controls already in place.

There is a melon farm close to Berrimah that is pollinated by commercial hives. This area is within the restricted area. These hives were the closest commercial operation to the original incursion detection. They were bound by the movement restrictions to stay within this zone and could move within this zone only after testing and issuing of a permit.

The Darwin rural area, contained within the control area, is the major area in the Darwin region where pollination using honey bees is carried out. This is still a relatively small-scale operation with a maximum of 300 hives used within this area. These hives were able to move within this area after testing and on issuing of permits.

There are a group of hives used for commercial honey production in the Adelaide River area about 60 km south east of Darwin. The majority of honey production is carried out in the Katherine region, 300 km south of Darwin. Honey production is carried out from time to time on the Barkly Tableland by operators in the Katherine region. Some bee keeping is carried out in the Alice Springs region but it is small in scale.

The Northern Territory is a large area that is sparsely populated. Bee keeping is a small industry carried out by fewer than half a dozen commercial operators and a number of hobbyists.

Research

During the course of the eradication program new techniques were considered to assist in the detection of either Asian or European honey bee. One technique, which needs further development but has shown promise, is the collection and analysis of bee-eater pellets for body parts of bee species.

Rainbow bee-eaters, *Merops ornatus* are a species of bird; whose diet is composed of insects including bees. These birds regurgitate pellets, at their roost sites, composed of insect parts following feeding.

These pellets have been examined from species of African bee-eaters and used to identify species of insects upon which the birds were feeding.

Beekeepers often blame this species of bird for heavy predation on their bees.

The bird is present in Darwin in large numbers at certain times of the year.

Glenn Bellis has been developing this technique with some success in the eradication area. Pellets have been collected from a number of roosting sites of birds within the eradication area. The parameters of this technique have not been quantified. Parameters that require quantification include the size of the area over which roosting birds are collecting insects and the sensitivity at detecting bee nests or hives. The technique has great potential, it could be used to help prove absence of species of bees or detect feral nests and managed hives in urban areas.

Discussion

We found that the public awareness campaign was the key for collection of information on *Apis spp* in the Darwin area. Field teams searching areas considered suitable for bee activity found very little evidence of *Apis spp* due to the low population density of this insect in the Darwin suburbs. Public interest was maintained over the 12-month period of the eradication program. People were still responding to recent radio interviews or TV adds right up to the end of the eradication program.

Appendix 1 – movement conditions

REQUIREMENTS FOR THE MOVEMENT OF BEES, BEE HIVES, BEE PRODUCTS, AND EQUIPMENT USED IN THE MANAGEMENT OF BEES AND THE EXTRACTION OF BEE PRODUCTS.

Movement conditions apply to

- bees,
- bee hives
- bee products and
- equipment used in the management of bees and the extraction of bee products.

Processed honey and refined wax is excluded from the movement restrictions. Processed honey is honey that has been extracted and stored in a bee proof container. Refined wax has been cleaned and melted into blocks.

Four areas are recognised in the control program, **eradication**, **restricted, control** and **protected**. The centre of the eradication area is Ludmilla. The disease risk increases as you travel closer to the eradication area. Refer to the maps provided for the boundary details.

The movement conditions are designed to assist in eradication of the Asian honeybee (***Apis cerana***) and diseases that may have been introduced by this bee. The diseases that movement conditions are designed to help eradicate are ***Varroa jacobsoni**, **Tropilaelaps clarae*** *and* ***Acarapis woodi***. There is no evidence that these diseases have been introduced. All testing on the Asian honey bees collected in Darwin has proven negative.

When permits are required for movement they can be obtained from the **Chief Veterinary Officer (CVO)** in the Northern Territory or his delegate. Permits will detail conditions under which the movement is permitted. Permits may be issued for a period of time or for specific events.

Where bee is mentioned it refers to *Apis mellifera* the European honeybee.

Government officers will be allowed to carry capped brood, live bees, sticky boards used in Varroa mite testing or any other material related to the eradication program direct to Berrimah Laboratory from areas within the control area or outside it. These materials will be carried in a way which does not pose a risk of disease spread.

1. ERADICATION AREA:

The eradication area is defined by a radius approximately 6 km from the original detection, following recognised property boundaries. It includes Darwin city and suburbs. There will be no movement of items detailed above out of this area or within this area. Consideration will be given, on application to the CVO, to movement of equipment for bee handling and bee product extraction out of this area where no risk of potential disease spread exists.

Managed hives within this zone will require intensive testing.

- Movement is not permitted to areas outside the eradication area.
- Movement is not permitted within the eradication area.

2. RESTRICTED AREA:

The area is defined by a radius close to 18 km from the original detection but including the Cox Peninsula and following recognised property boundaries. This area includes Palmerston.

- Movement is not permitted to areas outside this area.
- Movement is allowed within this area under permit.
- Permits may be granted following tests to ensure freedom from disease.

3. CONTROL AREA:

This zone is defined by a line approximately 50 km from the original detection, the same line that has been used for the fruit fly eradication program. The inner boundary of this zone is the outer boundary of the restricted zone.

- Movement is not permitted to areas outside this area, except to the restricted area. Upon entering the restricted area movement conditions in the restricted area will apply to further movements.
- Movement is allowed within this area under permit.
- Permits may be granted following tests to ensure freedom from disease.

4. PROTECTED AREA

This area includes the rest of the Northern Territory outside the control area.

- There are no movement conditions within this area.
- Movement of bees interstate will be subject to movement controls imposed by the states. Processed honey is subject to previous movement arrangements.
- Monitoring activity will occur in this area to ensure freedom from disease.

Movement to the control area is permitted but movement conditions in the control area will apply to further movements.

MOVEMENT OF BEE HANDLING AND HONEY PROCESSING EQUIPMENT

It would be preferable if the movement of equipment used for the management of bees or the extraction of bee products were kept to a minimum between the four areas.

In general, equipment used in handling of bees and in the extraction of bee products will be allowed to move under permit between zones where no disease risk is thought to exist.

The following components are considered of risk to the spread of disease and are subject to movement restrictions.

- empty bee boxes
- stickies
- boxes of honey
- honey comb
- Any component attractive to foraging bees has the potential to transfer disease when the equipment is shifted to areas regarded as being of lower disease risk. This would include tools from which wax and honey had not been cleaned after use.

These components can move into areas of increased disease risk without any restriction. Movement out of these areas will require a permit.

Eradication area to other areas

- Movement is not permitted

Restricted area to Control area or Protected area

- Components require storage in an approved bee proof enclosure, at room temperature, for 10 days immediately prior to movement. Alternatively components can be stored at -20°C for 24 hours immediately prior to movement provided that core temperatures of items concerned reach -20°C.
- Movement of components must not be in daylight hours.
- Movement should be direct to the nominated destination. Movement will require a permit.

Control area to Protected area

- Components require storage in an approved bee proof enclosure for 10 days immediately prior to movement.
- Movement of components must not be in daylight hours.
- Movement should be direct to the nominated destination. Movement will require a permit.

Movement Testing

A minimum of 100 capped brood cells will be removed for laboratory examination. Drone cells are preferable but in their absence, cells from the edge of comb should be collected. In addition 30 adult bees will be taken for tracheal mite testing.

Bayvarol® strips technique may be allowed as an alternative to examination of capped brood at the **CVO's** discretion.

Adult bees can be examined for presence of mites. A minimum of 280 bees is collected for laboratory examination (30 of these for tracheal mite testing). This is a less sensitive testing method and would be used where capped brood or Bayvarol® technique could not be used.

There may be some variation to this protocol at the Chief Veterinary Officer's or his delegates discretion.

General Issues

Road blocks used for the restriction of movement under the exotic fruit fly eradication program will be used to enforce movement restrictions.

Transit through the control area will be permitted under permit, issued under specific conditions. This would apply where movement originates outside the control area and the destination is also outside the control area.

These conditions may be modified by the CVO at any time in response to further developments.

Movement restrictions are expected to remain in force for at least the next 12 months.

The success of the eradication measures requires cooperation. The movement requirements are framed to permit the NT bee keeping industry to continue while placing the NT Department of Primary Industry and Fisheries, working in conjunction with the honey industry, in a position where eradication of Asian honeybee and associated diseases is most achievable.

Movement of queen bees imported from interstate

The following conditions apply as a result of the detection of Asian honeybee and are aimed at reducing the risk of spread of exotic mites that may have been introduced by these bees.

Bees from interstate must be eligible to enter the Northern Territory.

A Permit is required to move queen bees that are received in the eradication, restricted and control areas.

The preferred method of handling imported queen bees is their direct transport from freight agent or post office to the hive to be re-queened. Where this is not practical, queen bees may be staged in an approved bee-proof area prior to direct transport to the hive. An inspector of stock will approve (or otherwise) the proposed staging area. This will most likely be a fly-screened area of a house.

There will be no barrier (other than the need to obtain a permit, and to have a bee-proof area approved, if staging is necessary) to movement of imported bees that meet NT entry requirements, until they come in contact with local bees. Their status in terms of movement conditions then becomes identical to those bees.

ALLEN BRYCE
Chief Veterinary Officer

Appendix 2 – laboratory procedures

- **Comb examination -** 100 cells of capped brood are examined, drone brood is preferred otherwise cells on the edge of the brood are collected. Pupae or larvae are removed and examined for the presence of mites under a dissecting microscope. The empty brood is shaken onto paper which is examined under a dissecting microscope to detect any mites that may have not come out with the pupae or larvae.
- **Mite wash** - A minimum of 250 adult workers are washed in 25 % alcohol. The alcohol is filtered and the filtrate is examined under a dissecting microscope for the presence of mites.
- **Sticky board** - Bayvarol® [1]strips are placed in the hive for 24 hours, a sticky board is placed on the floor of the hive at the same time to collect mites. These boards are examined under a dissecting microscope for the presence of mites.
- **Tracheal mite** - Tracheae are dissected from worker bees collected and mounted on slides and examined under a compound microscope using 100X magnification.

The testing regime that we follow is influenced by several factors:

- **Tracheal mites -** At least thirty adult worker bees from each single nest or hive are collected with a hand held vacuum cleaner. Where multiple hives exist a sample of 5 adult worker bees from each hive with a minimum of 50 adult worker bees collected per apiary.
- **Varroa and Tropilaelaps -** Comb examination is the preferred method followed by the sticky board method and lastly the mite wash method. In the case of many of the feral nests it was often not possible to collect comb. In these cases adult bees were collected and tested using the mite wash method. In the eradication area managed hives are generally sampled by collection of comb. Where hives have been weak we have allowed the sticky board method to be used. In the control area the sticky board method will be used as a monitoring tool.

[1] Bayvarol® 3.6 mg flumethrin per strip a Bayer product. Four strips are used for testing of strong hives and two strips for weak hives. NRA registered for emergency use.

Appendix 3 – laboratory test results

Please note that a record refers to bees collected in Timor. They were declared to quarantine officers by a passenger off a flight from Kupang Indonesia but are a prohibited import and were confiscated. We tested the bees for exotic bee mites prior to treatment/destruction.

Tracheal Mite *Acarapis woodi* testing

Apis cerana

eradication area

Date		no. of hives	adult bees	no. Trachea	exotic mites
14/06/98	feral nest	1	30	60	nil
	Totals	**1**	**30**	**60**	

Timor area

Date		no. of hives	adult bees	no. Trachea	exotic mites
23/09/98	feral nest	1	30	60	nil
	Totals	**1**	**30**	**60**	

Apis mellifera

control area

Date		no. of hives	adult bees	no. Trachea	exotic mites
30/06/98	feral nest	1	30	60	nil
02/07/98	managed hive	4	120	233	nil
05/07/98	managed hive	1	30	60	nil
07/07/98	managed hive	4	120	239	nil
07/07/98	managed hive	6	180	360	nil
07/07/98	feral nest	1	30	60	nil
17/07/98	managed hive	1	30	60	nil
21/07/98	managed hive	5	50	100	nil
21/07/98	managed hive	5	50	100	nil
23/07/98	managed hive	1	30	60	nil
04/08/98	managed hive	2	60	120	nil
05/08/98	managed hive	5	150	300	nil
11/08/98	managed hive	15	75	150	nil
12/08/98	managed hive	3	50	100	nil
13/08/98	managed hive	1	30	60	nil
17/08/98	managed hive	3	50	100	nil
22/08/98	managed hive	4	50	100	nil
23/08/98	managed hive	4	50	100	nil
27/08/98	managed hive	1	30	60	nil
02/09/98	managed hive	3	50	100	nil
02/09/98	managed hive	4	50	100	nil

10/09/98	managed hive	9	50	100	nil
15/09/98	N/A	0	16	32	nil
16/09/98	managed hive	5	50	99	nil
02/10/98	managed hive	2	50	99	nil
02/10/98	managed hive	3	50	100	nil
13/10/98	managed hive	2	51	100	nil
14/10/98	feral nest	1	15	30	nil
28/10/98	managed hive	2	50	100	nil
23/11/98	managed hive	5	50	100	nil
24/11/98	managed hive	2	50	100	nil
	Totals	**105**	**1747**	**3482**	

eradication area

Date		**no. of hives**	**adult bees**	**no. Trachea**	**exotic mites**
29/06/98	feral nest	1	30	60	nil
30/06/98	feral nest	1	30	60	nil
02/07/98	feral nest	1	30	60	nil
06/07/98	managed hive	1	30	60	nil
06/07/98	managed hive	1	30	60	nil
08/07/98	feral nest	1	29	58	nil
08/07/98	feral nest	1	30	60	nil
09/07/98	feral nest	1	30	60	nil
10/07/98	managed hive	1	30	59	nil
10/07/98	managed hive	6	180	360	nil
17/07/98	managed hive	1	30	60	nil
21/07/98	managed hive	1	30	60	nil
12/08/98	managed hive	2	60	120	nil
24/09/98	managed hive	1	28	56	nil
25/09/98	managed hive	1	30	60	nil
29/09/98	managed hive	1	30	60	nil
29/09/98	managed hive	1	30	60	nil
27/10/98	swarm	1	30	60	nil
02/11/98	feral nest	1	30	60	nil
03/11/98	feral nest	1	30	59	nil
05/11/98	swarm	1	30	59	nil
17/11/98	managed hive	2	50	100	nil
18/11/98	feral nest	1	19	38	nil
30/11/98	feral nest	1	28	55	nil
24/12/98	managed hive	2	50	100	nil
07/01/99	feral nest	1	30	60	nil
10/02/99	feral nest	1	30	60	nil
22/03/99	managed hive	2	50	100	nil

25/03/99	swarm	1	30	60	nil
26/03/99	swarm	1	30	60	nil
12/04/99	managed hive	1	31	62	nil
12/04/99	feral nest	1	30	60	nil
12/04/99	managed hive	1	30	60	nil
21/04/99	managed hive	1	30	60	nil
21/04/99	feral nest	1	30	60	nil
22/04/99	managed hive	1	30	60	nil
28/04/99	managed hive	1	30	60	nil
29/04/99	feral nest	1	30	60	nil
01/06/99	feral nest	1	30	60	nil
01/06/99	feral nest	1	30	60	nil
08/06/99	managed hive	13	65	129	nil
	Totals	**62**	**1490**	**2975**	

protected area

Date		no. of hives	adult bees	no. Trachea	exotic mites
30/07/98	managed hive	21	105	207	nil
30/07/98	managed hive	18	90	180	nil
30/07/98	managed hive	7	50	100	nil
20/08/98	managed hive	2	12	24	nil
	Totals	**48**	**257**	**511**	

restricted area

Date		no. of hives	adult bees	no. Trachea	exotic mites
20/07/98	managed hive	3	90	179	nil
23/07/98	managed hive	7	80	160	nil
09/10/98	managed hive	3	50	100	nil
27/10/98	managed hive	4	56	112	nil
12/04/99	feral nest	1	30	60	nil
	Totals	**18**	**306**	**611**	
Totals for all areas and species		**235**	**3860**	**7699**	

Comb examination

Apis cerana

eradication	**area**		**Larvae**		**Pupae**		
Date		**no. of hives**	**workers**	**drone**	**workers**	**drones**	**exotic mites**
14/06/98	feral nest	1	0	0	571	172	nil
	totals:	**1**	**0**	**0**	**571**	**172**	

Timor	**area**		**Larvae**		**Pupae**		
Date		**no. of hives**	**workers**	**drone**	**workers**	**drones**	**exotic mites**
23/09/98	feral nest	1	0	0	0	0	nil
	totals:	**1**	**0**	**0**	**0**	**0**	

Apis mellifera

control	**area**		**Larvae**		**Pupae**		
Date		**no. of hives**	**workers**	**drone**	**workers**	**drones**	**exotic mites**
30/06/98	feral nest	1	75	0	35	0	nil
02/07/98	managed hive	4	202	0	252	0	nil
07/07/98	managed hive	6	127	0	451	0	nil
07/07/98	managed hive	4	100	0	300	0	nil
21/07/98	managed hive	5	190	0	501	0	nil
21/07/98	managed hive	5	292	0	412	34	nil
12/08/98	managed hive	3	34	29	340	3	nil
23/11/98	managed hive	5	0	2	742	1	nil
	totals:	**33**	**1020**	**31**	**3033**	**38**	

eradication	**area**		**Larvae**		**Pupae**		
Date		**no. of hives**	**workers**	**drone**	**workers**	**drones**	**exotic mites**
06/07/98	managed hive	1	4	0	136	0	nil
17/07/98	managed hive	1	91	0	54	0	nil
21/07/98	managed hive	1	14	0	111	0	nil
12/08/98	managed hive	2	262	0	0	0	nil
24/09/98	managed hive	1	2	0	130	0	nil
17/11/98	managed hive	2	137	0	21	146	nil
22/03/99	managed hive	2	0	0	336	0	nil
12/04/99	managed hive	1	0	0	131	0	nil
21/04/99	managed hive	1	200	0	0	0	nil
21/04/99	feral nest	1	1	0	110	0	nil
27/04/99	managed hive	1	0	0	103	12	nil
	totals:	**14**	**711**	**0**	**1132**	**158**	

protected	**area**		**Larvae**		**Pupae**		
Date		**no. of hives**	**workers**	**drone**	**workers**	**drones**	**exotic mites**
30/07/98	managed hive	7	93	0	751	0	nil
30/07/98	managed hive	21	227	0	281	0	nil
20/08/98	managed hive	2	0	0	10	0	nil
	totals:	**30**	**320**	**0**	**1042**	**0**	

restricted	area		Larvae		Pupae		
Date		no. of hives	workers	drone	workers	drones	exotic mites
20/07/98	managed hive	3	143	0	315	0	nil
28/06/99	feral nest	0	3	0	181	0	nil
	totals:	**3**	**146**	**0**	**496**	**0**	
totals for all areas and species:		**82**	**2197**	**31**	**6274**	**368**	

Sticky board

Apis mellifera

control area

Date		number of hives	exotic mites
17/07/98	managed hive	1	nil
23/07/98	managed hive	1	nil
04/08/98	managed hive	2	nil
05/08/98	managed hive	5	nil
11/08/98	managed hive	15	nil
13/08/98	managed hive	1	nil
17/08/98	managed hive	3	nil
22/08/98	managed hive	4	nil
23/08/98	managed hive	4	nil
27/08/98	managed hive	1	nil
02/09/98	managed hive	4	nil
02/09/98	managed hive	3	nil
10/09/98	managed hive	9	nil
16/09/98	managed hive	5	nil
02/10/98	managed hive	2	nil
02/10/98	managed hive	3	nil
13/10/98	managed hive	2	nil
28/10/98	managed hive	2	nil
24/11/98	managed hive	2	nil
	totals	**69**	

eradication area

Date		number of hives	exotic mites
10/07/98	managed hive	6	nil
25/09/98	managed hive	1	nil
29/09/98	managed hive	1	nil
29/09/98	managed hive	1	nil
24/12/98	managed hive	2	nil
12/04/99	managed hive	1	nil
22/04/99	managed hive	1	nil
28/04/99	managed hive	1	nil
08/06/99	managed hive	13	nil
	totals	**27**	

protected area			
Date		**number of hives**	**exotic mites**
30/07/98	managed hive	21	nil
30/07/98	managed hive	18	nil
	totals	**39**	

restricted area			
Date		**number of hives**	**exotic mites**
23/07/98	managed hive	7	nil
09/10/98	managed hive	3	nil
27/10/98	managed hive	4	nil
29/03/99	managed hive	1	nil
	totals	**15**	

totals for all areas and species	**150**

Bees washing in alcohol

			no. of hives	drones	workers	exotic mites
species	*Apis cerana*					
area	Timor					
23/09/98	feral nest		1	0	32	nil
		Totals	**1**	**0**	**32**	
species	*Apis mellifera*					
area	control					
30/06/98	feral nest		1	0	693	nil
05/07/98	managed hive		1	0	258	nil
07/07/98	feral nest		1	0	450	nil
		Totals	**3**	**0**	**1401**	
area	eradication					
26/06/98	feral nest		1	0	229	nil
29/06/98	feral nest		1	0	355	nil
30/06/98	feral nest		1	0	438	nil
02/07/98	feral nest		1	0	276	nil
03/07/98	feral nest		1	0	147	nil
06/07/98	managed hive		1	0	489	nil
08/07/98	feral nest		1	0	361	nil
08/07/98	feral nest		1	0	385	nil
09/07/98	feral nest		1	0	423	nil
10/07/98	managed hive		1	0	464	nil
27/10/98	swarm		1	1	527	nil
02/11/98	feral nest		1	0	89	nil
03/11/98	feral nest		1	0	106	nil
05/11/98	swarm		1	0	250	nil
30/11/98	feral nest		1	0	28	nil
07/01/99	feral nest		1	0	196	nil
10/02/99	feral nest		1	6	580	nil
23/03/99	feral nest		1	0	0	nil
25/03/99	swarm		1	4	1047	nil
26/03/99	swarm		1	1	538	nil
12/04/99	feral nest		1	0	264	nil
21/04/99	feral nest		1	2	464	nil
29/04/99	feral nest		1	0	370	nil
01/06/99	feral nest		1	0	176	nil
01/06/99	feral nest		1	0	246	nil
		Totals	**25**	**14**	**8448**	

			no. of hives	drones	workers	exotic mites
area	restricted					
12/04/99	feral nest		1	0	250	nil
		Totals	**1**	**0**	**250**	
Totals for all species and areas			**30**	**14**	**10131**	

Appendix 4 - telephone reports

	Area	report	calls
June 1998			
	control		
		bee activity	4
		boxed hives	18
		feral bee hive	7
		native bee	2
		other	1
		Total	**32**
	eradication		
		bee activity	11
		boxed hives	3
		feral bee hive	8
		insect	3
		native bee	29
		other	4
		specimen	8
		Total	**66**
	not recorded		
		native bee	1
		Total	**1**
	protected		
		boxed hives	1
		feral bee hive	4
		Total	**5**
	restricted		
		feral bee hive	2
		insect	2
		specimen	1
		Total	**5**
	June 1998	**Total calls for month**	**109**
July 1998			
	control		
		bee activity	13
		boxed hives	7
		feral bee hive	6
		other	1
		specimen	6
		Total	**33**

	Area	report	calls
	eradication		
		bee activity	15
		boxed hives	3
		feral bee hive	9
		identify	1
		native bee	2
		other	3
		specimen	24
		Total	**57**
	protected		
		bee activity	2
		boxed hives	1
		feral bee hive	5
		specimen	1
		Total	**9**
	restricted		
		bee activity	5
		boxed hives	1
		feral bee hive	2
		specimen	2
		Total	**10**
	July 1998	**Total calls for month**	**109**
August 1998			
	control		
		bee activity	2
		boxed hives	1
		feral bee hive	1
		specimen	3
		Total	**7**
	eradication		
		bee activity	1
		feral bee hive	2
		insect	1
		other	1
		specimen	4
		Total	**9**
	protected		
		feral bee hive	1
		Total	**1**
	restricted		
		bee activity	2
		insect	1
		specimen	2
		Total	**5**

Month	Area	report	calls
	August 1998	**Total calls for month**	**22**
September 1998			
	control		
		bee activity	2
		boxed hives	1
		feral bee hive	2
		specimen	3
		Total	**8**
	eradication		
		feral bee hive	1
		identify	1
		specimen	3
		Total	**5**
	protected		
		bee activity	1
		Total	**1**
	restricted		
		bee activity	1
		Total	**1**
	September 1998	**Total calls for month**	**15**
October 1998			
	control		
		bee activity	2
		Total	**2**
	eradication		
		bee activity	1
		feral bee hive	1
		Total	**2**
	restricted		
		bee activity	2
		Total	**2**
	October 1998	**Total calls for month**	**6**
November 1998			
	control		
		bee activity	3
		identify	1
		Total	**4**
	eradication		
		bee activity	5
		feral bee hive	1
		Total	**6**
	restricted		
		feral bee hive	1
		Total	**1**

	Area	report	calls
	November 1998	**Total calls for month**	**11**
December 1998			
	restricted		
		bee activity	1
		Total	**1**
	December 1998	**Total calls for month**	**1**
January 1999			
	control		
		feral bee hive	1
		Total	**1**
	eradication		
		specimen	1
		Total	**1**
	restricted		
		bee activity	1
		Total	**1**
	January 1999	**Total calls for month**	**3**
February 1999			
	eradication		
		bee activity	2
		Total	**2**
	February 1999	**Total calls for month**	**2**
March 1999			
	control		
		bee activity	4
		feral bee hive	4
		Total	**8**
	eradication		
		bee activity	15
		feral bee hive	4
		insect	1
		other	1
		Total	**21**
	not recorded		
		feral bee hive	1
		other	2
		Total	**3**
	protected		
		bee activity	2
		feral bee hive	1
		Total	**3**

Area	report	calls
restricted		
	bee activity	2
	other	1
	Total	**3**
March 1999	**Total calls for month**	**38**

April 1999

Area	report	calls
control		
	bee activity	7
	specimen	1
	Total	**8**
eradication		
	bee activity	10
	feral bee hive	8
	native bee	1
	Total	**19**
not recorded		
	insect	1
	other	3
	Total	**4**
restricted		
	bee activity	1
	feral bee hive	1
	insect	2
	Total	**4**
April 1999	**Total calls for month**	**35**

May 1999

Area	report	calls
control		
	bee activity	1
	feral bee hive	1
	insect	1
	specimen	1
	Total	**4**
eradication		
	bee activity	5
	insect	1
	specimen	4
	Total	**10**
not recorded		
	bee activity	1
	insect	1
	other	4
	Total	**6**

Area	report	calls
restricted		
	bee activity	2
	feral bee hive	1
	insect	2
	specimen	1
	Total	**6**
May 1999	**Total calls for month**	**26**
June 1999		
control		
	feral bee hive	1
	Total	**1**
eradication		
	bee activity	3
	native bee	1
	specimen	5
	Total	**9**
restricted		
	feral bee hive	1
	insect	1
	specimen	2
	Total	**4**
June 1999	**Total calls for month**	**14**
	Total calls recorded for program	**391**

DARWIN RESEARCH COULD SAVE AUSTRALIAN HONEY INDUSTRY

20114 NAQS
9 April 2001

The Northern Australia Quarantine Strategy's Darwin-based entomologist, Glenn Bellis, today released the results of a trial conducted last dry season into a new method of detection for exotic honey bees.

The successful trial provides a new tool for detection of exotic bees in the event of a future incursion.

The trial was funded by Australian Quarantine and Inspection Service (AQIS) and involved examining the pellets of the rainbow bee eater to determine their diet and whether parts of honey bees could be detected and identified in the birds' pellets. The rainbow bee eater regurgitates pellets containing indigestible parts of its food.

In 1998 when a single nest of exotic Asian honey bee was detected in Darwin, the public and the media rallied to support the effort to eradicate this bee from Darwin

" The support from the people of Darwin and the media at the time was fantastic," Glenn said. "We had people phoning quarantine all hours of the day to report sightings."

According to Glenn, the outbreak was contained and the bees eradicated only because of this public support. "Darwin people understand the importance of their place as part of Australia's quarantine barrier,"he said.

"However, bees were difficult to detect and I began investigating whether there were other means of detecting bees in case of another outbreak."

Mr Bellis's trial involved finding the roosts of rainbow bee eaters and examining their pellets under a microscope. Results proved it was possible to distinguish the wings of honey bees in the pellets and that the birds could find a single bee nest placed up to 750m from their roost.

"The rainbow bee eaters settle each night in communal roosts of up to 400 birds. Once we had established the roosting sites we could return every morning to collect pellets."

Mr Bellis said the birds tend to return to the same roosts each dry season.

"We now know the location of all roosts in the Darwin area," he said, "and have proof that bee wings are passed in the pellets and the ability to identify them."

Exotic honey bees are present in Indonesia, East Timor and Papua New Guinea. They carry the varroa mite and the tropilaelaps mite. These mites attack European honey bees and the hives sicken and eventually die. No country has yet been able to eradicate these honey bees or the mites once they've become established.

In April last year an outbreak of varroa mites in New Zealand created havoc in the bee-keeping industry and resulted in quarantine restrictions on movement of bees within New Zealand and on live bee exports.

Mr Bellis said it's not only the bee-keeping industry that would be affected if Asian honey bee became established in Australia.

"Agricultural producers of flowers, vegetables, fruits and oil seeds also rely on honey bees to pollinate their crops. A study in 1998 found that pollination by bees contributes $1.2 billion to these industries in Australia every year. The decline in production and deaths of European honey bees because of varroa or tropilaelaps mite would have a terrible impact on Australian agricultural producers," he said.

Quarantine is also concerned with the impact these bees could have on native bees and plants. "They would compete for the same food source as many native bees and could affect the pollination of native plants."

According to Mr Bellis the bees could also compete with possums, parrots and cockatoos for their nesting hollows with serious consequences to these unique native creatures.

The successful bee eater trial provides a new weapon in Quarantine's fight to keep Australia free of exotic pests, weeds and disease.

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Note: Telephone to arrange photo and filming opportunity at the roost of the colourful rainbow bee eaters.

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Rainbow bee-eaters (*Merops ornatus*) as a monitoring tool for honeybees (*Apis mellifera* L.; Hymenoptera: Apidae)

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Abstract Regurgitated pellets were collected from underneath roosts of rainbow bee-eaters in suburban Darwin, Australia, and examined for the presence of wings of honeybees. The proportion of pellets containing wings was compared prior to and after placement or removal of honeybee hives in the vicinity of four roosts. On each occasion, the addition or removal of hives was reflected in proportions of pellets containing wings. The results suggest that examination of pellets beneath bee-eater roosts would be a useful technique for monitoring the occurrence of feral honeybees. Potential uses for this technique in eradication of unwanted bees are discussed.

Key words detection, eradication, quarantine.

INTRODUCTION

The presence of nests of feral honeybees (Hymenoptera: Apidae) can be problematic to the management of commercial honeybees. For example, large numbers of feral drones may interfere with mating programs, feral bees can harbour diseases, or they are just an unwanted nuisance and compete with managed hives. Some species of honeybee, for example Asian honeybee (*Apis cerana* F.) and giant honeybee (*A. dorsata* F), are undesirable in their own right, prompting eradication campaigns as recently occurred following the detection of a single nest of *A. cerana* in Darwin, Australia (Anonymous 1998).

Detection of nests of feral honeybees is difficult and, although techniques are available (Donovan 1980), they mostly rely on being able to find and manipulate foraging workers. This becomes very difficult when low numbers of nests and foraging worker bees are present. Where eradication is desired, an effective means of detecting even single nests is required and the sensitivity of these methods needs to be documented so that small populations can be detected with some degree of certainty. Currently, the only means available to detect honeybees are traps using honey and/or beeswax as an attractant and the collection of insects foraging at flowers. Unfortunately, these techniques were unsuccessful in detecting honeybees during the eradication campaign in Darwin (Moss 1999; G. Bellis unpubl. obs. 1998), possibly due to a lower density of honeybees in Darwin compared to the temperate environments where these techniques were developed. Additionally, the latter technique is generally unsuitable for use in native forests, where flowers are often inaccessible.

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An alternative means of monitoring for bees is to examine the diet of birds that eat bees. The rainbow bee-eater (*Merops ornatus* Latham) has long been recognised as a significant predator of European honeybees (*Apis mellifera* L) in Australia (Goebel 1984), and was also observed eating *A. cerana* workers in the vicinity of the nest discovered in Darwin (G. Bellis unpubl. obs. 1998). The rainbow bee-eater is a small, active bird that hawks for insects, mainly small to medium-sized Hymenoptera (Saffer & Calver 1997), on the wing. Goebel (1984) reports cases of rainbow bee-eaters perching on or near bee hives and catching bees as they depart or arrive at the hive.

Bee-eaters regurgitate the non-digestible portions of their prey in the form of pellets. Much of this material remains intact, enabling researchers to analyse the type of prey eaten (Fry 1984; Asokan 1998). Much of the known diet of the rainbow bee-eater is from studies of prey remains in nests (Serventy & Whittell 1976; Calver *et al*. 1987), examination of gizzard contents (Lea & Grey 1935; Barker & Vestjens 1989), and observation of foraging birds (Draffan *et al*. 1983). However, Saffer & Calver (1997) were able to identify the size and type of prey eaten by rainbow bee-eaters by examining regurgitated pellets collected from beneath roosting sites. Rainbow bee-eaters roost in groups of 30 or more birds (Warham 1957; Bell 1970; Kloot & Aston 1983; Saffer & Calver 1997), enabling collection of large numbers of pellets from below the roost. Each pellet represents the diet of an individual bird.

Rainbow bee-eaters are very seasonal in the Darwin region, with large numbers of birds migrating from southern Australia in March and remaining until the end of August (Thompson 1984). A small resident population is present year round, but it is the large, non-breeding population that provides an opportunity to sample the honeybee fauna. Bellis & Profke (2003) confirmed observations from elsewhere

(Warham 1957; Bell 1970, 1982) that roosting colonies in Darwin exhibit site fidelity over a number of weeks and in successive years. The density of roosting colonies in Darwin led Bellis & Profke (2003) to believe that these birds travel up to 1.25 km from their roosts to forage.

To confirm the presence or absence of a target bee species, reliable means of distinguishing their remains in pellets from those of non-target species are required. Worker castes of *Apis* spp. can readily be distinguished from other insects in the Darwin region by the venation of the forewing (CSIRO 1992). The forewings of *A. mellifera, A. cerana* and *A. dorsata* can be distinguished from each other by size (wings of *A. dorsata* are significantly longer than those of the other species) and the cubital index (Goetze 1940, cited by Ruttner 1988), which is about 4.4 : 1.0 in *A. cerana* and 2.3 : 1.0 in *A. mellifera*.

The presence of intact forewings in regurgitated pellets would therefore enable positive identification of each of these honeybee species and provide evidence of the presence of a particular species. Documenting the absence of a species, however, requires knowledge of the distance over which birds from a roosting colony travel to forage and the sensitivity (minimum number of bee hives able to be detected) of this technique. Our study aimed to quantify the latter in the Darwin region, and to assess the usefulness of pellets from rainbow bee-eaters as a tool for monitoring honeybees.

METHODS

Study site

Darwin (12°24′S 130°52′E) lies in the monsoonal tropics of northern Australia. It receives about 1600 mm annual rainfall with nearly all of this falling between December and March. Maximum temperatures average between 30 and 34°C and vary little throughout the year, but minimum temperatures are considerably lower between May and August than during other months.

One year prior to this study, an eradication campaign for Asian honeybee was conducted throughout Darwin. This included the removal of all known nests of feral honeybees and the recording of all managed bee hives in the city (Moss 1999). Fifteen feral nests and five swarms of honeybees were detected and destroyed in Darwin during the 12-month eradication campaign.

Examination of pellets

Roosts of rainbow bee-eaters were located as described by Bellis & Profke (2003). Briefly, either information from an informed public led to the detection of roosting sites, or in the 30 min prior to sunset, birds were visually followed to their roost.

Initial attempts to locate pellets underneath roosts were unsuccessful because many had disintegrated on impact and were concealed amongst the vegetation underneath the roost. The use of sheets spread on the ground under the roost and left overnight greatly increased the number and quality of pellets obtained. When pellets had disintegrated on impact with the sheet, the material associated with that pellet could still be recognised as a discrete pile of debris that could be collected into an individual bottle for later examination. Up to five sheets per roost were used at any one time but nearly all of the pellets could be collected on two or three sheets. An experienced operator could service seven roosts with two or three sheets per roost in a day.

Regular collection of pellets was still difficult, as birds did not always roost in the same part of a tree and sometimes roosted in neighbouring trees. Additionally, sheets were occasionally disturbed by humans and the collection of pellets at some roosts had to be abandoned due to continued removal of sheets, presumably by local people.

Pellets were dissected dry using forceps under a stereo microscope. All insect wings were removed to 70% ethanol and examined for the venation characteristic of each *Apis* species. All pellets collected on each day from each roost were examined, except for those from the roost at Millner from which only 40 pellets (about 70% of the total) per day were examined.

Introduction of bee hives

Four roosts (Millner, The Narrows, Marrara and Fannie Bay) were selected to examine the effects of introduction, removal and movement of hives of honeybees on the proportions of pellets containing wings of honeybees. These roosts were selected because they enabled reliable collection of pellets and represented a variety of habitats (including native forest) in their forage range. Of these four roosts, only the roost at Millner had managed honeybee hives present within a 2-km radius of the roost, with three hives located 600 m and three others approximately 750 m from the roost site.

Managed hives of *A. mellifera* were introduced at measured distances from the roosts at Fannie Bay, Marrara and The Narrows. These were generally nucleus hives of approximately 2500 workers, but on one occasion a larger hive of approximately 5000 workers was used (see Table 1 for details). Pellets were collected on successive week-nights for at least 9 days.

After sufficient pellets had been collected to enable analysis, these hives were moved to a position more distant from the roost. The aim was twofold: to ascertain the maximum distances from a roost at which a hive could be detected, and to determine if sensitivity declines with increasing distance of the hive from the roost. In addition, two managed hives of approximately 5000 workers each were removed from a site where bee eaters from the Millner roost were known to be foraging.

Generalised linear models assuming a binomial error distribution and logit link were performed to compare the proportion of pellets containing wing of honeybees before and after introduction, removal, or movement of hives.

RESULTS

Examination of pellets

A total of 6177 pellets was examined, with an experienced operator processing about 40 pellets per hour. The number of honeybee wings per pellet at the Millner roost, which had the highest proportion of pellets containing wings, averaged 5.6 (range 1–74; $n = 4303$) with more than 50% of the pellets examined containing 8 or fewer wings and 90% containing 23 or fewer wings (Fig. 1). Pellets collected from the roosts at Fannie Bay, Marrara and The Narrows had much lower numbers of wings per pellet, averaging 0.76, 0.42 and 0.57, respectively.

Introduction of bee hives

Hives were detected at all four roosts at distances of up to 750 m, but not at a distance of 1000 m, as indicated by significant increases in the proportion of pellets with honeybee wings (Table 1). Rainbow bee-eaters were observed at all newly moved hives within 2 days of placement, excepting the 1000 m hive. The removal of two hives located about 750 m from the roost at Millner was reflected in consequent significantly lowered proportions of pellets containing honeybee wings.

DISCUSSION

The results from moving hives to or from the extremities of the roosting colonies at The Narrows, Marrara and Millner agree with the estimate of the forage range of those roosts obtained by Bellis & Profke (2003) using extrapolation of minimum distances between neighbouring roosts and observation of bee eaters at hives. The distance rainbow bee-eaters travel from their roosting site to forage may differ for

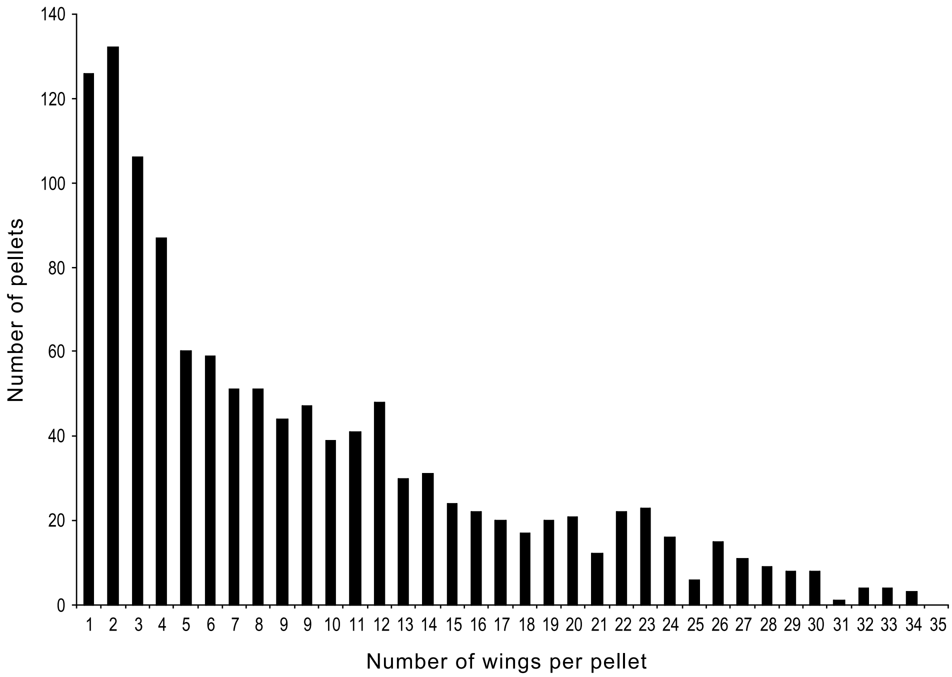

Fig. 1. Distribution of wing numbers per pellet collected from rainbow bee-eaters roosting at Millner (1681 pellets contained no wings).

Table 1 Changes to proportions of regurgitated bee-eater pellets containing honeybee wings following movement of honeybee hives within foraging range of roost

Roost site	No. birds†	Baseline mean proportion of pellets with wings‡ (SE, no. days)	Experimental manipulation	Post-experiment mean proportion of pellets with wings§ (SE; no. days)	Significance of change P
Fannie Bay	65	0.070 (0.014, 15)	Addition of hives at 250 m	0.164 (0.038, 15)	0.034
The Narrows	50	0.077 (0.037, 11)	Addition of hives at 60 m	0.297¶ (0.076, 7)	0.019
	50		Addition of hives at 1 km	0.041¶ (0.026, 12)	0.408
Marrara	50	0.016 (0.014, 9)	Addition of hives at 250 m	0.174†† (0.041, 12)	0.008
	50		Addition of hives at 750 m	0.149†† (0.028, 11)	0.010
Millner	310	0.460 (0.022, 27)	Removal of 2 of 7 hives at 750 m	0.338 (0.036, 11)	0.009

†Approximate; ‡before placement or removal of hives; §after placement or removal of hives; ¶significant difference ($P = 0.003$) between value when hive at 60 m to that at 1000 m; †† no significant difference between values when hive at 250 and 750 m.

different roosting colonies, but the colonies at Marrara and Millner clearly contained birds that were feeding on bees from hives located at least 750 m away. Birds roosting at the colony at The Narrows, however, were not feeding at a hive placed 1000 m from this roosting site.

Pellet analysis was able to detect individual hives placed at two different distances from the Marrara roost. The ability to detect honeybee hives would appear not to be proportional to their distance from the roost, although a point is reached where hives can no longer be detected, such as observed at 1000 m from the roost at The Narrows. This suggests that the density of foraging birds surrounding a roost is evenly distributed rather than concentrated close to the roost and decreasing with increasing distance from the roost. This is not surprising as suitable bee-eater habitat is likely to be similarly evenly distributed.

Both the higher proportion of wing-containing pellets and the number of wings per pellet observed at Millner when compared to the other roosts is probably a reflection of the relatively high density of honeybee hives within the forage range of this roost.

Monitoring honeybees using bee-eaters

The examination of regurgitated rainbow bee-eater pellets for evidence of honeybee remains is clearly a useful means of detecting the presence of honeybees. Five experienced operators would be able to locate bee-eater roosts and collect and examine pellets over all of suburban Darwin and surrounding areas confident of comprehensive coverage. There is some evidence that the presence of bee nests can be detected by examining only a fraction (i.e., minimum of 40 pellets or 70% of total) of all pellets produced by a roost but maximum sensitivity will result from examination of all pellets. Additionally, the fidelity of rainbow bee-eaters for roosting sites in successive years (Bell 1982; Bellis & Profke 2003) would likely reduce the amount of effort required to locate roost sites as the location in suburban Darwin of most of these is now known. The intermittent movement of roosts into different trees posed some problems for reliable collection of pellets, but as roosts were relocated only a short distance it was easily overcome by visiting the site and locating the new roost tree.

The tendency of rainbow bee-eaters to frequent honeybee hives was noted by Goebel (1984) and observed at almost all known hives in Darwin during this study. The establishment of birds at hives within one day of placement suggests that they are attracted to hives as a food source and lends confidence that the majority of honeybee colonies are visited by rainbow bee-eaters.

The pellet examination technique can detect the presence of honeybees but cannot pinpoint the location of the nest. An estimate of the maximum area that contains the nest can be made but care must be exercised when extrapolating from a single positive pellet as honeybees can travel up to 13.7 km from their nest (Eckert 1933) and may be eaten by a rainbow bee-eater a considerable distance from the bee's nest. Methods of locating honeybee nests (see Donovan 1980) could then be concentrated in the area known to harbour a nest. Some correlation was apparent between density of honeybee hives and proportion of wing-containing pellets so it may be possible that the number of nests could also be estimated from the proportion of wing-containing pellets but further research would be required to verify this.

Generality of technique

The key to the success of this technique in Darwin is the seasonal influx of rainbow bee-eaters between March and September (Thompson 1984). The large population during this period facilitates roost locating and the simultaneous sampling from many birds that are intensively consuming the insect fauna. The relative lack of birds in Darwin at other times reduces the usefulness of this technique considerably, as the success of both of these factors are significantly reduced.

The transportability of this technique to other places is highly dependant on the population size of both rainbow bee-eaters and non-target honeybees. Rainbow bee-eaters are found throughout the Australasian region; west to Bali, east to the Solomon Islands and south to Victoria and southern Western Australia, but are highly migratory spending spring and summer in southern Australia and autumn and winter in the north. Only small, resident populations are present during spring and summer in the north (Higgins 1999). Communal roosts have been seen throughout much of this range; southern Western Australia (Warham 1957; Saffer & Calver 1997), Papua New Guinea (Bell 1970), northern Queensland (Kloot & Easton 1983) and southern Queensland (Lord 1933; Saunders 1994), so the collection and examination of pellets are likely to be possible at least in these areas. The majority of rainbow bee-eaters breed in southern Australia from about October until January and prefer to roost in pairs or in their nest while breeding (Higgins 1999). The lack of communal roosts over this period will significantly reduce the ability to collect pellets from a large number of birds and decrease the usefulness of this technique to detect honeybees.

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