

Queen Sector Analysis Report: Size and Scope of the Australian Queen Bee Industry

Project Report:

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Photo credit: Wildflower Meadows

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Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
ABPV	Acute Bee Paralysis Virus
ACT	Australian Capital Territory
AFB	American Foulbrood
AGBU	(UNE) Animal Genetics and Breeding Unit
AHBIC	Australian Honey Bee Industry Council
AI	Artificially Inseminated (queen)
ALOP	Appropriate Level of Protection
ANU	Australian National University
AQBBA	Australian Queen Bee Breeders Association
AUD	Australian Dollars
BLUP	Best Linear Unbiased Prediction (forecasting breeding values)
CBPV	Chronic Bee Paralysis Virus
CIE	Centre for International Economics
DAFF	(Aust Government) Department of Agriculture, Fisheries and Forestry
DAWR	(Aust Government) Department of Agriculture and Water Resources (now DAFF)
DPI	(state based) Department of Primary Industries
DPIRD	(NSW) Department of Primary Industries and Regional Development
DWV	Deformed Wing Virus
EBVs	Estimated Breeding Values
FOB	Free On Board (on vessel/aircraft for export)
GRDC	Grains Research and Development Corporation
GVP	Gross Value of Production
IP	Intellectual Property
NM	Naturally Mated (queen)
PEQ	Post Entry Quarantine
RD&E	Research, Development and Extension
RIRDC	Rural Industries Research and Development Corporation (now AgriFutures Australia)
RND4P	Rural Research and Development for Profit (program funded by the Aust Government)
ROI	Return on Investment
SCOT	Strengths, Challenges, Opportunities and Threats (Analysis)
SHB	Small Hive Beetle
SBPV	Slow Bee Paralysis Virus
SCU	Southern Cross University
T2M	Transition to Management (Program for Varroa mite in Australia)
UBO	Unique Brood Odour (also written as UbeeO)
UNE	University of New England
USDA	United States Department of Agriculture
VRS	Varroa Resistant Stock
VSH	Varroa Sensitive Hygiene
WA	Western Australia

Executive Summary

This report on the Australian queen bee sector was funded under the National Varroa Transition to Management Program. It was to profile the sector, identify barriers to growth and deliver actionable recommendations.

The queen bee sector consists of queen breeders who practice genetic selection, queen producers who mass produce queens, and queen buyers – commercial beekeepers, recreational beekeepers and overseas beekeeping industries. Products range from queen cells which sell from as little as \$8 through to artificially inseminated breeder queens priced at \$2,000 or more.

The industry is nationally distributed with the population of queen suppliers (breeders and producers) aligning with the number of hives in each state. The largest number of beekeeping operations is found in northern NSW and southern QLD.

There is no published data on the number of participants in the industry or the value of the sector. The best estimate of size and value is 63 queen suppliers and a gross value of production (GVP) of \$8.8 million. The Australian Queen Bee Breeders Association (AQBBA) reports that GVP may be as high as \$17.6 million.

Queen bee breeders select for a range of heritable traits with a focus on honey production, disease resistance and a calm temperament. This study identified a number of Australian breeding groups that are using different techniques to select for queens that suppress Varroa mite. Industry leaders note that breeding for Varroa suppression is the only long-term solution to the mite. Barriers to progress include:

- Breeding groups that do not have the resources (money, skills) to make scientifically informed selections for Varroa suppression.
- A lack of industry funds for queen bee breeding – the sector's R&D levy was discontinued in 2014, and the Honey Bee and Pollination R&D program has multiple priorities.
- A lack of return on investment in breeding for Varroa suppression while miticides are effective and Varroa is not impacting colonies in all jurisdictions.
- Cessation of the National Honey Bee Genetic Improvement Program (Plan Bee) which was developing tools and technical support for genetic selection.
- Difficulty in importing queens and drone semen that have been bred for Varroa suppression in the US and EU (viruses, Africanised genes, a difficult to navigate/expensive quarantine system).
- A history of stop/start nationally focussed and government supported breeding programs that have contributed to sector scepticism of cooperative endeavours.

Rather than attempting a publicly funded breeding program that sells queens and “crowds out” specific trait and market focussed private breeders, this study recommends an integrated approach that: 1) focusses on private breeders, 2) delivers technical support for their endeavours – this is beyond private breeder capacity and funding, and 3) facilitates the importation of genetics for Varroa suppression. Imports will reduce the time required to establish Varroa suppression in the Australian honey bee population. Importation is also likely to be more cost effective than a breeding program.

Recommendations to facilitate production of Australian honey bees that suppress Varroa mite are:

- Capacity building for existing breeding groups – skills in leadership, working in groups, and breeding techniques spanning the simple (e.g., rearing tips) through to the advanced (e.g., executing a breeding plan). When Bee Foundation may consider funding a public good, leadership program for the queen sector.
- Plan Bee type technical support – resources to assist with phenotyping, pedigree recording, hive marking, scoring for mite suppression and other traits important to industry, genomics, and marker assisted selections. Private breeding groups cannot afford technicians for data collection and accurate data is needed if genetic progress is to be made. This capacity needs to be funded by multiple organisations e.g., more than one state-based DPI.
- Plan Bee type technical support – genetic testing by UNE’s Animal Genetics and Breeding Unit and recording of trait information in a database to allow progression toward honey bee Estimated Breeding Values (like those created for, and highly valued by, the Australian cattle and sheep industries).
- Imported genetics - implementation of Hort Innovation project MT18019 (Roberts 2021) recommendations in relation to mitigation of a cold environment and supplementation of staff capacity, Post Entry Quarantine (PEQ) Facility, Mickleham Victoria.
- Imported genetics - investigate measures to reduce the cost of importing queens. Measures may include temporarily waving fees currently levied on a full cost recovery basis for use of the PEQ Facility, Mickleham Victoria.
- Imported genetics -systems to support the importation of drone semen including the NSW DPI proposal to offer imported semen fee-for-service testing in Australia (for viruses and Africanised genes). Drone semen has a disproportionate impact on breeding for genetic progress.
- Imported genetics – support simultaneous importation of queens and semen to speed genetic progress and avoid the dilution of Varroa suppression genes that occurs when breeders mate imported queens to local drones.

Additional recommendations to strengthen the Australian queen sector are:

- Queen sector information dissemination – preparation of a register of Australian queen sector participants that clearly differentiates between queen breeders and producers, identifies traits and the climate that the breeder is selecting for and creates a sound basis for breeders to secure a return for the effort they put into genetically selected queens. The register might also include information directed at educating beekeepers on the benefits of genetically superior queens and why it is worth spending more on this type of stock.
- An extension program – that would address both the value of genetically selected queens and educate beekeepers on how to get the most out of their current queens. Queens are the “engine room” of the colony and not enough beekeepers know what to ask for when purchasing queen bees.
- A research project is needed to test the feasibility, cost and benefits of identifying and preserving the genetic diversity of Australian honey bees. Genetic diversity was lost when Varroa disrupted overseas industries and quality Australian stock was destroyed during attempted Varroa eradication in 2022 and 2023. Consideration needs to be given to a “seedbank” before more of this stock is destroyed by the Varroa mite. AgriFutures Australia might consider an R&D project to test “seedbank” feasibility.

- Investment in a publicly funded breeding program that produces and sells queen bees is not recommended by this study. Publicly funded breeding programs have a long stop/start history with governments withdrawing funding before goals are met and industry becoming increasingly cynical about the activity's merits. Private sector breeders are used to working on their own or in small groups, a national program would need broad based support, and this is not likely to be secured from individuals who are competitive and focussed on their own breeding priorities. Honey bee breeding requires continual investment if genetic drift/dilution is to be avoided. Public programs, that sell queen bees, risk the "crowding out" of private sector breeders and the industry has insufficient resources to fund a national breeding program on its own. Industry estimates that a minimum of \$700k pa for ten years would be needed to "fix" Varroa suppression in the Australian population, industry does not have these resources, and public funds would be better allocated to Plan Bee type technical support for individual breeder priorities.

1. Introduction

Background

Varroa destructor (Varroa) was first detected in the Port of Newcastle in June 2022 and deemed non-eradicable in September 2023. As part of the National Varroa Transition to Management (T2M) Program a series of projects were initiated to strengthen the Australian honey bee and pollination Industries. One such project was the Queen Sector Analysis Report. The queen sector plays a vital role in minimising the impacts of Varroa – quality queens produce strong colonies and potentially, queens might be used as a vehicle for delivering genes that suppress Varroa.

Purpose and Approach

The purpose of the Queen Sector Analysis Report was to provide a sector overview. The overview was to identify the queen bee sector's characteristics, challenges, and growth opportunities through a combination of literature review and interviews with sector participants. The analysis was to cover the Queen Sector's current state, challenges, and opportunities in a way that would inform stakeholders and guide strategic decisions. The analysis was to identify the sector's economic and geographical scope, key issues, and future potential.

The goals of the Queen Sector Analysis Report project were to:

- Establish an accurate and detailed understanding of the queen breeding sector's size, value, and geographic distribution.
- Identify barriers to growth, sector challenges, and opportunities for genetic improvement.
- Provide actionable insights and recommendations to support sector expansion and sustainability.

The project was delivered through literature review, use of literature review findings to prepare a series of interview guides, extended interviews with stakeholders, analysis, and synthesis of findings into a project report. The Varroa T2M Program provided comment on the draft report.

Literature consulted included both published and unpublished sources identified by the author and other stakeholders (see Reference list at the end of this document). Consultation focussed on queen bee breeders. Other stakeholders consulted included the executive of the Australian Queen Bee Breeders Association (AQBBA), researchers who contributed to the National Honey Bee Genetic Improvement Program (Plan Bee), the Australian Honey Bee Industry Council (AHBIC), the NSW Department of Primary Industries and Regional Development (DPIRD), policy professionals in the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) as well as additional researchers and biosecurity officers relevant to the queen bee sector (see Persons Contacted at the end of this document).

2. Size and Scope of the Queen Sector

Queen Bee Products and Businesses

The Australian Queen Sector produces a range of products and supports different business types serving multiple markets. A summary of Australian queen bee product types is provided in Table 1.

Table 1: Australian queen bee products

Product or Type	Definition
Queen	- An adult female honey bee with fully developed reproductive organs. - One mated queen lays all the eggs in the colony which is made up of her female worker bee and male drone offspring. - One mated queen bee is required per colony for the colony to survive.
Virgin queen	- An unmated, adult queen bee. - A virgin queen will need to be either naturally mated (NM) or artificially inseminated (AI). - Virgin queens are a lower cost alternative to purchase of a NM or AI queen bee.
Queen cell	- Capped, grafted cell produced by a queen producer and sold prior to hatching. - Cell can contain either a potential breeder or production queen. - Low-cost alternative to mated and virgin queens.
Naturally mated (NM) queen	- An adult female with fully developed reproductive organs who mated naturally. - Natural mating occurs when a virgin queen reaches sexual maturity, takes one or more mating flights to a drone congregation area, mates with an average of 28 drones, returns to the colony and starts to lay fertilised eggs.
Artificially inseminated (AI) queen	- An adult female with fully developed reproductive organs who mated via AI. - AI is a mating control method used by queen bee breeders and researchers to ensure the queen is mated to known drones, typically to speed up selection for particular traits. - When a virgin queen reaches sexual maturity, the AI technician inseminates the queen with semen from selected drones, she subsequently lays fertilised eggs. - AI requires specialist equipment and training, thus queens produced using this method are more expensive than NM queens.
Breeder queen	- A queen that has been selected based on performance for traits, is of a known pedigree, and is used to produce the next generation. - NM queens mated under specific geographically isolated breeding conditions to ensure mating achieved with drones consistent with breeding objectives. - Breeder queens may also be control mated using AI.
Production queen	A queen for general use by commercial honey producers, pollination contractors or recreational beekeepers.
Nucleus (nuc) colony	- A smaller hive (typically five or fewer frames of food stores and developing bees) consisting of worker bees in all stages of development, a single laying queen, and enough workers to cover three to five frames. - Nucleus hives are typically used to replace failed hives or increase the scale of a beekeeping enterprise.
Packaged bees	- A quantity of adult honey bees (1.5 to 2 kg) with a queen bee, contained in a screened shipping cage (i.e. a package) with a food source. - Package bees are typically used to replace failed hives or increase the scale of a beekeeping enterprise through the creation of new hives.

Source: Chapman et al. 2024

Businesses and markets supplied by the Australian queen bee sector are shown in Table 2.

Table 2: Businesses and markets supplied with Australian queen bee products

Business Type and Market Supplied	Definition
Queen breeder	• A beekeeper who selects queens and drones to produce the next generation based on recording of colony performance for traits (genetic selection). • Produce elite queens (stud stock used to breed commercial queens).
Queen producer	• A beekeeper who mass produces queens for commercial use (i.e., a multiplier). • Often, queen producers use stock purchased from a queen breeder. • A queen producer is less likely to perform genetic selection and mating control.
Honey producer - commercial	• Enterprises who obtain queens from queen breeders or multipliers and produces honey from hives containing these queens. • In practice, honey producers may retain some queens from their own hives. Honey producers may or may not record or observe hive performance.
Pollination contractors	• Obtain queens (or hives) from queen breeders and/or queen multipliers and use them for pollination services. In practice, pollination contractors are likely to retain queens from their own hives. • Most pollinators are also honey producers.
Export markets	• Queen breeders and queen producers export Australian genetics, mostly to Canada and to a lesser extent islands in the Pacific including Fiji.
Recreational beekeeper	• Buy queens directly from a queen producer or via a retailer. • Tend to replace queens on an <i>ad hoc</i> basis.

Source: AgEconPlus 2022 and Frost and Chapman 2023

Prices Paid for Queen Bee Products

Data on prices paid for Australian queen products is shown in Table 3. Prices range from \$8 for a queen cell through to \$2,000 for an artificially inseminated breeder queen.

Table 3: Domestic and export prices for queen products (\$AUD each)

Product	Domestic	Export
Naturally mated queen	37	300
Naturally mated breeder queen	842	-
Artificially inseminated queen	2,000	900
Packaged bees	266	68
Nucleus colony	241	-
Queen cells	8	-
Virgin queens	20	-

Source: Frost and Chapman 2023 and project consultation

Enterprise Number and Location

There is no published data on the number of queen breeders and queen producers in Australia. CIE 2005 estimated that there were ten major queen breeders in Australia. In 2025, AHBIC has indicated that there are a small number of major breeding groups and that these groups have multiple members (pers. comm., March 2025). AQBBA report that they have approximately 80 members, and these members span queen breeders and queen producers as well as those with a general interest in beekeeping (pers. comm., May 2025).

Frost and Chapman 2023 note that there is no clear delineation between queen breeders, queen producers and beekeepers and that some beekeepers produce their own queens and sell a small number of their progeny.

As part of the Plan Bee program, Frost and Chapman compiled an inventory of known queen breeders and producers. Data, alongside total hive numbers, is shown by state and territory in Table 4.

Table 4: Estimated population of queen breeders and producers and total hive numbers

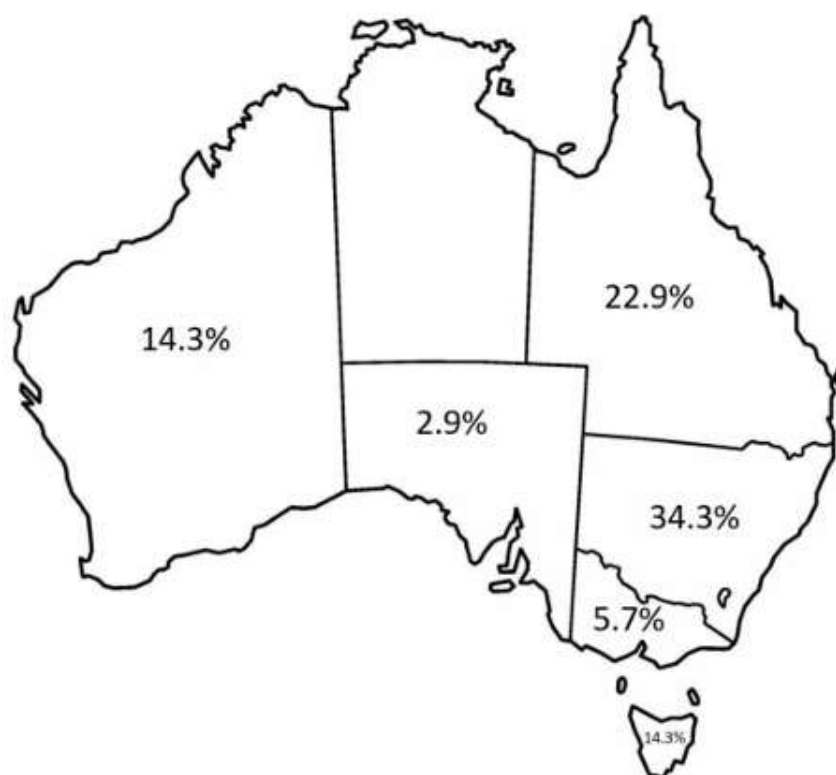
State/Territory	Breeders and producers (No.)	Total number of hives
New South Wales including ACT	22	396,494
Queensland	16	159,644
Victoria	10	130,227
Tasmania	4	32,117
SA including Kangaroo Island	6	86,000
Western Australia, Northern Territory	5	61,563
Total	63	866,045

Source: Plan Bee data (unpublished) and Clarke and Le Feuvre 2023

The population of queen suppliers approximately aligns with the size of the industry in each state. Chapman 2021 notes that more breeders locate in QLD and NSW than in other states due to the warmer conditions on offer and a longer breeding season.

There are 63 known queen breeders and producers in Australia. Frost and Chapman completed three surveys of this population and received 11 responses in 2020, 35 in 2021 and 33 in 2022. The location of 2022 survey respondent business is shown in Figure 1.

Figure 1. Location of queen bee breeders and producers 2022 (33 survey responders)



Source: Frost and Chapman 2023. NB: 5.7% of respondents did not disclose the state in which they breed queens.

Annual Queen Bee Sales

The actual number of queen bees sold each year in Australia is unknown. Almost 20% of beekeepers produce a small number of breeder queens from which they produce their own queens or allow some or all of their colonies to naturally replace their queen (Chapman and Frost 2022).

Benecke 2003, in CIE 2005, reported that few beekeepers purchased all their queen requirements (Table 5).

Table 5: Portion of queen bees purchased by beekeepers (%)

State/Territory	Purchased no queens	Purchased <50% of their requirement	Purchased >50% of their requirement	Purchased all of their requirement
New South Wales including ACT	48	21	18	13
Queensland	50	45	0	5
Victoria	0	85	0	15
Tasmania	unknown	unknown	unknown	Unknown
SA including Kangaroo Island	3	4	29	64
Western Australia	unknown	unknown	unknown	Unknown

Source: Benecke 2003

Frost and Chapman 2021 noted that 45% of all beekeepers don't regularly replace their queen bees (Table 6).

Table 6: Frequency of queen replacement - recreational and commercial beekeepers (%)

Queen replacement	Recreational, semi-commercial (< 200 hives)	Commercial (200-800 hives)	Large commercial (>800 hives)	Overall
As needed	51%	37%	35%	45%
1 year	11%	34%	57%	24%
2 years	30%	23%	8.1%	25%
3 years	4%	0	0	3%
Never	2%	0	0	2%
No response	2%	6%	0	2%
No. of responses	124	35	37	196

Source: Chapman and Frost 2021

A lack of data on own bred and non-replacement of queens has not stopped various studies estimating total queen sales.

Gibbs and Muirhead 1998 estimated total queen sales at around 200,000 per annum, assuming a total commercial hive population of 602,557. In 1997, these (production) queens were worth an estimated \$9 each, making a total value, excluding breeder sales, export sales and sales to recreational beekeepers, of \$1.8 million.

ABARES (Rodriguez *et al.* 2003) surveyed the beekeeping industry and estimated queen bee sales at \$3.3 million in the year 2000/01. Markets serviced were not identified in the study report.

Clarke & Le Feuvre 2020 using the same approach as Gibbs and Muirhead 1998 for 2018/19, estimated total queen purchases of 177,000 (based on 531,786 commercial hives, half

requiring purchased queens every 18 months). Average purchase price for production queens was estimated at \$30 per queen and sector value at \$5.5 million. Export sales and sales to the recreation sector were estimated at 50,000 queens per year (140,430 recreational hives requiring 46,000 queens plus 4,000 queens for export). The total value of queen sales for 2018/19 was estimated at \$6.8 million.

Banks *et al.* 2020 in progressing the implementation of genetic selection, estimated that the annual intake of new queens across the honey bee and pollination industries was likely to be about 250,000, assuming 500,000 commercial hives and queen life of two seasons.

Clarke & Le Feuvre 2023 updated their 2020 study for the year 2021/22. This time they estimated sales of 210,000 queens to commercial beekeepers, 78,000 to the recreational sector, and 4,000 queen bees exported.

The AQBBA provided an informal estimate of the value of queen bee sales to AHBIC in 2024 – 265,000 queens sold to the commercial sector plus 64,000 queens sold to the recreational sector with a total value of \$17.6 million. AQBBA cautioned that these numbers should be taken ‘with a grain of salt’ i.e., they are unreliable.

All study results are summarised in Table 7. When the more optimistic AQBBA estimate for 2024 is excluded, the queen sector has experienced steady but unspectacular growth over the twenty-five years since 1997.

Table 7: Value of queen bee sale (\$)

Study	Year of Estimate	Markets Assessed	Queens Sold (No)	Value of Sales (\$M)
Gibbs and Muirhead (1998)	1997	Commercial beekeepers	200,000	1.8
Rodriguez et al. (2003)	2001	Unknown	Unknown	3.3
Clarke & Le Feuvre (2020)	2019	Commercial beekeepers, recreational beekeepers, and export sales.	227,000	6.8
Banks et al. (2020)	2020	Commercial beekeepers	250,000	Unknown
Clarke & Le Feuvre (2023)	2022	Commercial beekeepers, recreational beekeepers, and export sales.	296,000	8.8
AQBBA (unpublished)	2024	Commercial beekeepers, recreational beekeepers.	329,000	17.6

Source: various.

Markets Supplied with Queen Bees

The above analysis shows that the queen sector is dominated by sales to commercial beekeepers with increasing opportunity for sales to recreational beekeepers and a small export sector.

CIE 2005 noted that Australia has had a long history of exporting queen bees to both Europe and North America (Canada and the USA till 2010 and Canada thereafter). Australian queen bees were required in the northern hemisphere spring which coincided with the end of the Australian breeding season (counter season supply). Exports of Australian queen bees to the USA ceased in 2010 when the USDA banned Australian live bee imports due to Slow Bee Paralysis Virus and possible links with Colony Collapse Disorder.

In the early 2000s, queens were shipped in wooden or plastic mailing cages packed into ventilated boxes, overnight express post bags or small queen bee banks (called Rightway queen

shippers). At the time, Australia Post was a widely used and effective way of shipping queens to export markets.

Packaged bee exports are focussed on sales to Canada. In 2014, Tasmania and Western Australia (WA) exported a total of 14 pallets (7,000 packages) of bees to Canada. These packages had an FOB value of \$110,000/pallet, a total industry value of \$1.54 million. In 2017, Tasmania and WA exported a total of 17 pallets valued at \$110,000/pallet, a total industry value of \$1.87 million (Clarke and Le Feuvre 2023).

Frost and Chapman 2023 (quoting the relevant AgriFutures Australia RD&E Plan) note that there are growing global markets for Australian queen bees and packaged bees and that these markets are potentially lucrative. However, the market place is constrained by major risks, including freight costs and the threat of export bans. Respondents to the Frost and Chapman 2023 survey exported 2,664 queens in 2021/22. All exported queens originated in WA, with 99% exported to Canada and 1% to Fiji.

Economic Values Created by the Queen Sector

A conservative approach has been adopted by this study for the estimation of industry value and the AQBBA estimate for 2024 (\$17.6M) has been excluded. Value is currently estimated at \$8.8 million per annum.

3. Current Approaches to Queen Breeding

Genetic Traits and Information Sought by Buyers

Chapman and Frost surveyed beekeepers in 2020, 2021, and 2022 to determine the genetic traits they sought when purchasing queen bees. Survey results were analysed separately for recreational/semi-commercial beekeepers (<200 colonies), commercial beekeepers (200-800 colonies), and large commercial beekeepers (>800 colonies).

Survey response in all three years was dominated by recreational/semi-commercial beekeepers. Smaller beekeepers replace queens as needed; larger beekeepers are more likely to schedule queen purchase and replacement. Priorities across all three surveys were relatively uniform: 1) honey production, 2) hive health, and 3) a calm temperament. Results are shown in Table 8.

Table 8: Priority Genetic Selection Traits – All Surveyed Beekeepers 2020, 2021 and 2022

2020 (196 respondents)	2021 (79 respondents)	2022 (83 respondents)
Honey production	Honey production	Temperament
Brood pattern	Aggression	Honey production
Chalkbrood	Calmness	Brood pattern
Hygienic behaviour	Hygienic behaviour	Chalkbrood
European foulbrood	Brood pattern	Hygienic behaviour
Gentleness	Hive cleanliness	Pest and disease
Nosema	Swarm tendency	Pollen
Spring build-up	Small hive beetle	European Foulbrood
Longevity	Brood area	Colour
Hive cleanliness	Pollination	Swarming

Source: Chapman and Frost 2021, 2022 and 2023

Separate analysis of traits sought by large commercial beekeepers, the group most likely to purchase queens, showed that they prioritised: 1) honey production, 2) resistance to chalkbrood, 3) resistance to European foulbrood, 4) an even brood pattern, and 5) the ability of the bees to overwinter and be ready for spring pollination. There was some variation in traits required by state due to differences in climate and the presence or absence of a certain pest or disease.

A separate research project, noted that hygienic behaviour was a high priority for commercial beekeepers and can be effective against American Foulbrood (AFB), and chalkbrood, and may provide some protection against Varroa (Gerdtz 2020).

When commercial beekeepers purchased queens, they would like the breeder to provide information on (Chapman and Frost 2021):

1. Traits and performance – traits being selected, performance records, line traits, Estimated Breeding Values (EBVs)/selection indices, honey production, temperament, selection process employed, hygienic behaviour, vigour, brood pattern, small hive beetle (SHB) resistance, Varroa resistance, and use of a standard set of selection criteria.
2. Pedigree – genetics/line pedigree, breeder queen identification, subspecies verification.
3. Mating – age, AI or naturally mated, how long in the mating nuc, if banked for how long, drone numbers used, and the age of drones used.
4. Other – climate suitability, linkage with programs/experience of the breeder, an apiary disease report, antibiotic use, and who produced the queen if it was bought retail.

Information Provided by Queen Breeders

Chapman and Frost 2021 also surveyed queen breeders to determine the information they provide to their customers. Eleven breeders (4 NSW, 3 QLD, 3 WA, 1 VIC) who sold 21,300 queens responded to the survey 2020 survey. Their individual responses are summarised in Table 9.

Table 9: Information Breeders Provide on Queens Sold 2020 (sample size 11)

Breeder number	Information provided on sold queens
1	If queens are banked, how long and when they were caught, date caged and apiary from which they were sought, breeder queen mother, and mating nuc location. If queen was evaluated as superior this was also provided along with colour, race, traits, age.
2	Colour, traits.
5	Colour, race, traits selected for, age at caging.
6	Race, traits, age.
8	Race, line, traits, 21-day cycle.
9	Race.
10	Age and traits.
11	Colour and race, as requested by customer.

Source: Chapman and Frost 2021

Breeder priorities were then compared to buyer priorities, and the results are shown in Table 10.

Table 10: Breeder versus buyer priorities

Trait	Breeders selecting for trait (Percentage - %)	Beekeeper rating of trait (out of 10)
Colour	81.8	4.9
Gentleness	81.8	8.1
Honey production	81.8	8.5
Brood pattern	81.8	8.5
Hygienic behaviour	72.7	8.3
Chalkbrood	63.6	8.4
Race	63.6	5.2
Longevity	54.5	7.3
Spring build-up	45.5	7.4
Over-wintering	45.5	7.1
Swarm tendency	36.4	7.1
Hive cleanness	36.4	7.3
European Foulbrood	27.3	8.3
Small Hive Beetle	27.3	7.3
Nosema	27.3	7.9
Burr/brace comb	18.2	4.9
Wax production	18.2	5.6
Body size	9.1	5.8
Pollen production	9.1	7
No of respondents	11	196

Source: Chapman and Frost 2021

Colour and race were a high priority for breeders but a low priority for customers. It is likely that breeders use colour and race to differentiate between their breeding lines, or as a means of checking mate purity. That is, if resultant workers are a mix of colours, it is likely that the queens have mated with drones from a feral population, or from a surrounding beekeeping operation. Chapman and Frost 2021 note that breeders selecting for disease resistance, without sacrificing honey production and a calm temperament, could attract more customers.

Approximately half the large beekeepers responding to the Chapman and Frost survey in 2020 were satisfied with the quality of queens supplied by the breeder. When problems arise, they were most commonly associated with 1) inconsistent quality, 2) poorly mated queens, 3) poor brood pattern, 4) a drone laying queen, and 5) a lack of longevity with rapid supersedure of the purchased queen.

Queen breeders were asked about why they do not perform more selections on desirable traits, and they indicated that 1) beekeepers are satisfied with the queens they receive (36% of respondents), 2) breeders cannot charge enough to justify the additional investment (36%), and 3) they do not have sufficient time or staff resources to complete additional selections (27%). None of the breeders surveyed indicated that they weren't interested in performing additional selections or that there wasn't a market for queens selected for additional traits. Chapman and Frost 2021 concluded that both buyers and breeders are keen to embrace a coordinated program that makes use of modern genetic selection techniques. Some 73% of buyers and breeders indicated that modern breeding techniques would improve queen program success (Chapman and Frost 2022).

Oldroyd and Barron 2024 noted that breeding priorities post the Frost and Chapman surveys of 2020, 2021, and 2022, now need to include breeding for Varroa resistance.

Genetic Selection for Varroa Resistance

Breeding for Varroa resistance is an enormous task. Selection for Varroa resistant bees has been underway in North America, South America, and Europe since at least 2000 (Holmes *et al.* 2023). While claims of Varroa resistance are widely made, high-performing, Varroa resistant stock that are proven to be resistant to Varroa are not widely available. Furthermore, genetic selection for Varroa resistance needs to be mindful of other critical traits, including honey production, ability to manage disease, and a calm temperament (Holmes *et al.* 2023).

Breeding for Varroa resistance is difficult because:

1. Mechanisms used by honey bees to achieve Varroa resistance are numerous and variable. Individual mechanisms may have only a limited effect or genetics may have low influence. Successful breeding may need to select for multiple resistance traits alongside other critical traits (honey production, disease resistance, and a calm temperament).
2. Controlled mating is required to 'fix' resistance into the honey bee population. Resistance may be diluted when virgin queens mate with unmanaged drones or drones from other beekeeping operations. Noting that Varroa typically depletes wild colonies and the population of both managed and unmanaged drones.
3. The presence of traits for Varroa resistance (in the honey bee genetic pool) is expensive to identify. Methods used to quantify traits are varied and terms used to report traits identified are inconsistently applied. Initial research to identify traits for Varroa resistance in the Australian honey bee population via testing in the US did not identify useful genetic material (Oldroyd 2012).
4. Honey bees with claimed resistance to Varroa often have low performance in other essential traits (honey production, disease resistance, and a calm temperament). Bees with natural Varroa resistance may also be more prone to absconding.
5. While chemical controls for Varroa are working, queen breeders have limited incentive to incur the high costs associated with selecting for genetic resistance and beekeepers have low incentive to pay more for queens.
6. Breeding for Varroa resistance requires a long-term financial commitment. International honey bee breeding programs which focus on breeding for Varroa resistance have been constrained by short-term funding cycles. The same is true in Australia in relation to conventional queen bee breeding programs.

Potentially, honey bees may fight Varroa using a suite of biochemical, mechanical, and biological responses. Biochemical responses include honey bee larvae that don't produce the cues that trigger mite entry into the brood cell, pupae that don't produce the cues that trigger the mite to lay, and pupae that produce signals that they are unhealthy.

Mechanical means honey bees may use to resist Varroa include a brood cell silk lining that traps the mite and prevents it breeding in the cell¹, workers that respond to pupal signals that the pupae is unhealthy, and uncap and kill the infected brood, and worker bees that groom themselves or each other to dislodge, maim and kill mites.

¹ Dr Nadine Chaman (pers. comm., August 2025) notes that this is unlikely but there is some possibility that the mites might get caught when pupae move in the cell.

Biological means of resisting Varroa include a bee development time that is shorter than that required for mites to reproduce, bees that are resistant to mite spread viruses, and smaller brood areas or brood breaks that provide less opportunity for mites to breed. Smaller brood areas will have negative implications for the size and productivity of the resultant colony.

Mechanisms for Breeding Varroa Resistance

A summary of Varroa resistance traits that have been the subject of breeding programs overseas is provided in the table below.

Table 11: Varroa resistance traits used in overseas breeding programs

Trait	Features
Hygienic behaviour (<i>biochemical</i>)	- Nurse bees detect signals for dead/diseased brood and remove them from nest. - Can work for AFB and chalkbrood but doesn't confer chalkbrood resistance. - May help with Varroa (disrupts reproduction) but not as a standalone control. - Selecting for this trait does not suppress desirable attributes (honey, docility). - Test for presence of this trait via 1) freeze or pin kill brood, count cells emptied, 2) spray synthetic UBO (UbeeO) which mimics odour of unhealthy brood, count cells emptied. Cells 60% uncapped are considered hygienic and able to maintain a mite load below the chemical treatment threshold. - In some populations there is high correlation between low mite load and UbeeO response while in others there is not (Holmes <i>et al.</i> 2023).
Uncapping /recapping (<i>mechanical</i>)	- Uncapping changes the temperature and humidity of the cell, which can result in the death of immature Varroa mites and lower mite reproduction. - Different bees in the colony are responsible for detection and uncapping. - In some populations, the brood is not removed, and the wax is replaced. In these circumstances, the infected brood remains viable. The control is not effective. - Overseas, uncapping has a role in managing wax moth, SHB, and AFB.
Grooming (<i>mechanical</i>)	- Groomers and 'mite biters' care for themselves and other bees in the hive. Bees with this trait may continue to bite the mite after it has been dislodged from a nestmate, removing legs and reducing the mites reproductive capacity. Bees with this trait perform a unique dance to invite grooming by other bees. - Limits adult mites entering brood cells via their removal through grooming. - Does not set the colony back through the destruction of brood.
Short development time (<i>biological</i>)	- The African honey bee subspecies has a shorter development time than the subspecies used in Australia and other countries. The shorter development time can lead to fewer viable Varroa mite daughters in each brood cell. - However, reduction in brood development time of 2 days required for this control to be successful and this technique delivers a lesser duration (i.e. <2 days). - This breeding mechanism has fallen out of favour.
Virus suppression - Suppressed in ovo virus infection. - Virus tolerance. (<i>biological</i>)	- Reduces the prevalence of viruses (including DWV and CBPV), the main cause of colony death following a Varroa infestation. - Virus resistance in honey bees has only recently been investigated, with selection efforts focussing on transmission of viruses from queen to progeny. - Some queens infected with viruses are able to clear their infection and lay virus-free eggs. This is heritable and termed 'suppressed in ovo virus infection'. - Viruses can be present without colonies suffering ill effects and this control is termed 'virus tolerance'. Trait has been found in some European bee populations.
Varroa-sensitive hygiene - Suppressed mite reprod. - mite non-reproduction	- VSH to suppress mite reproduction occurs when 15-18 day old nurse bees respond to chemical cues produced by the developing bee or the reproductive mite or both. Workers remove wax cappings and parasitised pupae, and the immature mites die. - Suppressed mite reproduction/mite non-reproduction that stops mites reproducing may be due to the inability of mites to find brood of appropriate age due to changes in brood signalling, mite getting caught in cell silk lining, delay in

(<i>biochemical</i>)	mite egg development due to lack of cue from brood, death of the male resulting in production of unmated females, etc.
Low mite population and mite population growth	• Selecting colonies with low mite population and low mite population growth to breed from will result in decreased mite loads. Low mite loads have been strongly linked with increased colony survival. • Selecting for low infestation will promote all traits that keep Varroa populations low, even those that we do not know about.

Source: Homes *et al.* 2023

Current interest in selecting for Varroa resistant traits by Australian queen bee breeding groups is reviewed in the following chapter.

4. Queen Bee Breeding Groups and Varroa

Known queen bee breeding groups including those with an interest in incorporating Varroa resistance into their breeding programs are profiled in this chapter.

AQBBA VSH Collective

Stakeholders and their location

The AQBBA was formed in the mid-1980s to raise the standards of queen breeding in Australia. It provides a national focus for issues relating to queen bee breeding and queen rearing. The AQBBA is managed by a team of people elected each year at the Association's Annual General Meeting.

Purpose and products created

The AQBBA's purpose is to support members and the continuing enhancement of Australian honey bee stocks, safeguard and protect the biosecurity interests of the beekeeping industry, provide a forum for setting RD&E priorities, cooperate on disease related experimental work, increase demand/access to quality queen bees, promote best practice breeding, secure an appropriate financial return for quality queens, and provide a platform for training.

Planned approach to breeding for Varroa resistance

In July 2022 (immediately after Varroa was first detected in the Port of Newcastle), AQBBA had advanced plans to import Varroa Sensitive Hygiene (VSH) semen from New Zealand (NZ) for its breeding program. Importation was planned, progressed and funded by AQBBA. The first imports were due to occur in late 2022. Apiaries were identified and a one-year Australian Government import permit was in place. Importation was derailed when it was discovered that not enough semen was available from the NZ supplier to make the importation viable.

All efforts to import semen from NZ have been unsuccessful due to positive test results for DWV (Corrine Jordan, The Bee Lady Apiaries, 2 July 2025). Attempts to import from Europe have also been placed on hold until more is known about the risk of transmitting DWV to Australian colonies.

In 2024, AQBBA reported that it has been putting a sustained effort into the development and planning for VSH breeding in Australia (AQBBA President, AHBIC Annual Report 2024):

- In partnership with BeeGenetics (Corinne Jordan), queen bee breeders and participating beekeepers have undertaken a round of UbeeO based screening throughout NSW and QLD to identify an initial pool of high value queen stock that have demonstrated at least a mid-range response to testing. These high value queens have

been artificially inseminated and backcrossed with the semen of unrelated drones whose mothers have also demonstrated a favourable UbeeO response. These queens have been distributed to participating breeders for development in the 2024/25 season. Importantly, the screening has demonstrated that some of the desirable VSH genetics exist in honey bees in Australia and with the efforts of skilled breeders, it may be possible to accelerate the distribution of these traits more widely.

- AQBBA attended the AgriFutures Australia Varroa R&D workshop in April 2024. Workshop results were incorporated into the AQBBA's Breeding Plan. The AQBBA Breeding Plan is designed to be funded from within the limited resources of AQBBA and its membership. The Breeding Plan will only “get the ball rolling” but will build on already completed UbeeO screening work.

Varroa breeding challenges

AQBBA challenges with the introduction of Varroa resistance/suppression include:

- Uncertainty in relation to whether a suitable source of tested, virus-free semen can be found overseas for importation into Australia. Drone semen is a conduit for honey bee viruses (e.g., DWV, SBPV, and ABPV). In 2025, this challenge is being addressed by an AgriFutures Australia funded and CSIRO delivered research project. Project Principal Investigator is Dr John Roberts.
- High cost associated with queen bee imports through the full cost recovery PEQ Facility at Mickleham. There is also a lack of confidence in the facility's climatic suitability – imported queens are sourced from the northern hemisphere in summer/autumn and shut down when placed to a cold Victorian winter. Staff at the facility have limited experience in honey bee management.
- Limited funding to support Varroa resistance/suppression research and the introduction of such genetics into queen bee breeding operations. The queen bee R&D levy has been in long-term suspension –the cost of collecting the levy absorbed almost 40% of the revenues generated. The AgriFutures Australia Honey Bee & Pollination RD&E program has multiple priorities and limited funds for queen bee breeding.
- Access to scientific capacity that is skilled in assessing whether Varroa resistance/suppression is being delivered through selection efforts or whether the AQBBA VSH Collective is actually testing for Suppressed Mite Reproduction/Mite Non-reproduction. The CSIRO or the Plan Bee research team could assist with this challenge.

National Honey Bee Genetic Improvement Program (Plan Bee)

Stakeholders and their location

Plan Bee was established in 2019 and Australian Government funding for Plan Bee concluded in 2024. The program was funded under the Rural R&D for Profit (RND4P) Program. A Plan Bee honey bee research population was domiciled at Tocal College in the NSW Hunter Valley. The program was developed as a model for a national approach in which breeding could be conducted by commercial queen breeders and evaluation could be performed by queen breeders or Plan Bee staff. Genomic, extension and statistical support was provided. The Plan Bee project was a collaboration between Better Bees WA, the Wheen Bee Foundation, NSW DPIRD, the University of Sydney, the University of New England Animal Genetics and Breeding Unit (UNE AGBU) and was supported by the AQBBA who provided practical expertise.

Purpose and products created

Bushfires, drought, flood, COVID19, and then the 2022 Varroa incursion played havoc with the project and most of its research colonies were destroyed as part of the attempt to eradicate Varroa. However, the project did deliver the first honey bee trait definition and selection manual (now in its second edition) and calculate honey bee estimated breeding values (EBVs) for Australian stock.

The Plan Bee genetic evaluation program included a reference population of hives in Tocal NSW. Phenotypes and genotypes were collected from QLD, VIC, TAS, SA, NSW, and WA which delivered colony performance data in diverse environments. NSW DPIRD staff based at Tocal College had skills in bioinformatic, genomic and statistical analysis. Genetic evaluation and data analysis capacity was supplied by UNE AGBU in Armidale.

AgEconPlus 2022 noted a high level of industry satisfaction with the performance of the stock provided. Oldroyd and Barron 2024 concluded that Plan Bee provided a nexus of expertise and physical resources that could be used to support a future national breeding strategy.

Planned approach to breeding for Varroa resistance

Plan Bee priorities were those of participating commercial queen bee breeders. Plan Bee simply provided the genetic information to support, and more rapidly advance, those commercial priorities. In 2025, the Plan Bee RND4P grant is complete.

Varroa breeding challenges

Plan Bee challenges with breeding for Varroa resistance include:

- A lack of funding continuity – AQBBA supports Plan Bee participation in its VSH breeding efforts. AQBBA has sought funding support for breeding Varroa resistant queens from AgriFutures Australia Honey Bee & Pollination RD&E program. Approaches for funding support have also been made to DPIs in NSW and at least one other state. Funding is needed before key Plan Bee staff are permanently lost to other roles.
- If Plan Bee is to be revived with public money, care will be needed to ensure that its outputs (e.g., breeder queens) do not compete unfairly with those supplied by private sector queen breeders.

The Bee Lady Apiaries – Bee Genetics (Corinne Jordan)

Stakeholders, foundation and location

The Bee Lady Apiaries was founded by Corinne Jordan in 2008 and is located in Carbrook, QLD. Corinne is also active in BeeGenetics (<https://beegenetics.com.au/about-us>).

Purpose and products created

The Bee Lady Apiaries specialises in breeding docile, productive, and hygienic Italian Queen Bees. The business supplies Italian breeder queens, nucleus hives suitable for hobbyists and semi-commercial beekeepers, mentoring and advice. Staff provide Instrumental Insemination (AI) services to support individual beekeeping business breeding objectives.

Breeding priorities including Varroa resistance

The Bee Lady Apiaries breeding priorities are docility, honey production, and disease resistance. The business is breeding Varroa resistance with a strong focus on UbeeO testing. Care is needed to ensure heavy selection for UbeeO is not at the expense of other desirable traits (i.e., honey production and docility). The Bee Lady Apiaries works in close partnership with the AQBBA VSH Collective.

Varroa breeding challenges

The Bee Lady Apiaries reports the following challenges with respect to breeding for Varroa resistance:

Technical assistance:

- Research collaboration – it is crucial to partner with research institutions like CSIRO and the Plan Bee team to investigate the genetics and mechanisms behind Varroa resistance. CSIRO has been approached via AQBBA, but external funding support is needed.
- Advanced breeding techniques – utilising cutting-edge technologies such as genomic and marker-assisted selection to significantly improve breeding efficiency. With appropriate funding support, CSIRO is capable of assisting with this endeavour.
- Data collection and analysis – effective monitoring and analysis tools enhance the understanding of bee health, Varroa mite levels, and the impact of environmental factors. Commercial sensor technology (e.g., Beestar) is suitable, a tech transfer team or field researchers would also be required.
- Training and education – workshops on advanced breeding and Varroa management techniques are needed. Tocal College recently delivered this type of training but broader geographic coverage beyond NSW is needed. Arista in the Netherlands provides appropriate workshops and funding is needed to deliver these workshops in Australia.

Access to overseas genetics:

- Importing overseas genetics would significantly reduce the time required to establish Varroa-resistant honey bee populations. Importation of overseas genetics would be financially feasible for individual queen bee breeders and less costly than establishing an Australian breeding improvement program.
- Semen – all efforts over the last four years to obtain VSH semen from NZ have been unsuccessful due to the product testing positive for DWV.
- Queens – sourcing Varroa-resistant lines such as the USDA Pol line or similar strains from Hawaii is constrained by both stringent quarantine requirements and a PEQ Facility at Mickleham Victoria that has a climate too cold to accommodate queens bred in the northern hemisphere summer.

Financial viability of breeding Varroa-resistant queens:

- Breeding Varroa-resistant queens entails significant costs including research, investment in technology, and labour associated with selective breeding techniques.
- Breeding improvement programs are expensive but offer benefits for the entire industry.
- Consequently, it is important that funding for these initiatives comes from all industry stakeholders who stand to gain from the advancements. Care is needed to ensure public money is not used to generate private benefit.
- Individual queen bee breeders cannot bear the cost of a breeding program on their own due to the delay in achieving quantifiable results, with an estimated cost of \$700k per annum and a timeline of up to 10 years to breed resistance into the domestic bee population.
- High-testing UbeeO production queens produced by The Bee Lady Apiaries are currently priced at \$50 to \$70 each. High-testing UbeeO breeder queens are yet to reach the market.

- Government or industry subsidies may be needed to offset initial breeding costs and encourage widespread adoption of Varroa-resistant queens.

Bee Scientifics (Dr Jody Gerdts)

Stakeholders and their location

Bee Scientifics was founded by Dr Jody Gerdts in 2014 and is located in Benalla, Victoria. Commercial beekeeper David Briggs works on an *ad hoc* basis with the business. Bee Scientifics also works on queen breeding projects with Mick Palmer of Tasmania Pollination Services.

Purpose and products created

Bee Scientifics operates a bee breeding program, undertakes original research, and provides education services. Training is provided to queen bee breeders and beekeepers including those new to beekeeping. Breeding lines are maintained through AI and the business offers a contract AI service to other breeders and researchers. Products include AI mated breeder queens, mated queen bees, queen cells, 5 frame nucs, and queen breeding and rearing workshops.

Planned approach to breeding for Varroa resistance

Bee Scientifics bee breeding program maintains Italian and Caucasian X Carniolan breeding lines and selects for honey production, temperament, and pest and disease resistance. With the establishment of Varroa on the Australian East Coast, Bee Scientifics is dedicated to developing commercial quality Varroa resistant stock.

Bee Scientifics received progenies from Varroa resistant stock imported from Arista in the Netherlands in 2021. Industry reports that:

- There are no major issues with this stock. The stock show good commercial traits but may lack adaptations to local pests (Small Hive Beetle) when compared to domestic stock.

Better Bees WA (Tiffane Bates)

Stakeholders and their location

The activities of Better Bees WA stretch back to 1979 when a ban was placed on interstate and international importation of honey bees into WA. Better Bees WA is operated by a group of 12 commercial apiarists.

Purpose and products created

Better Bees WA use the isolated mating technique with drone hives and grafted breeding nucs annually relocated to Rottnest Island in spring for mating. Approximately 800 nucs are mated each year. Resultant queens are marked, their wings clipped and inserted into production hives for assessment. Commercial beekeepers participating in the program collect, record, and share objective data. Better Bees WA only sell small quantities of breeding stock.

Planned approach to breeding for Varroa resistance

Better Bees WA were part of Plan Bee, and it is noted that Rottnest Island stock does not show any resistance to Varroa. Better Bees WA stock was tested in the United States and like all Australian stock tested in the US it did not perform well when challenged with Varroa. Consequently, the longest running queen bee breeding program in Australia is vulnerable to Varroa in the absence of miticide (Dr Rob Manning, pers. comm., May 2025).

Additional Queen Bee Breeding Stakeholders

Additional queen bee breeders and industry stakeholders contributed the following insights and possible recommendations (see table below).

Table 12: Other bee breeding stakeholders – challenges and possible recommendations

Stakeholder	Queen breeding challenges and possible recommendations
David Briggs Fifteen Mile Apiaries (breeder)	- Fifteen Mile Apiaries intends to select for Varroa resistance on the basis of low mite population in the hive once Varroa reaches David's Victoria-based apiaries. - Varroa resistance is just another trait (like honey production and temperament), but the fact that it is hard to 'fix' in improved stock and in commercial beekeeping operations means that breeding efforts must be much more rigorous and sustained than we typically have capacity for in Australia. - Currently David is not using surrogate selection measures such as UbeeO. - David maintains a line of bees from the 2021 Varroa-resistant queens imported from the Netherlands. He notes "they are good bees but there has been no VSH selection pressure on this line in 6 or 7 generations". - Drones are very important when breeding for VSH. For VSH a high proportion of drones need to be carrying the genes for VSH otherwise resistance will not be 'fixed' in the commercial bee population. Because of multiple matings, recessive traits turn up in individuals but are not necessarily expressed in subsequent generations. - Of the many drones that a virgin queen (that may be reared from a high VSH expressing mother) mates with, only one may have been carrying genes for VSH. Only daughters reared from the sperm from that one drone will have a chance of expressing those genes. It is not until a recessive trait is built up across the entire population that that trait is expressed reliably in all progeny. It is the drones that circulate the genetics of a queen through the breeding population. - The greatest impediment to breeding for Varroa resistance is viable selection methods that can be applied at scale across the industry. Australia cannot ignore US and European experience where development of highly hygienic lines using AI queens has not translated into widely used commercial stock. There are biological, economic and cultural reasons why this is the case. - Leading US researcher Dr Randy Oliver is on the right track with breeding for Varroa resistance – commercial beekeeping operation, <i>no chemical treatment for colonies identified as resistant to Varroa</i>. Dr Oliver treats all hives normally once the potential breeders have been identified. Colonies selected for breeding are not treated for Varroa unless they start to fail. Intensive selection pressure is placed on the commercial bee population and queens as well as drones are bred from the selected stock. Mass selection for Varroa resistance in commercial beekeeper stock is yielding slow but positive progress. - Recommendation: A scale based Varroa-resistance breeding program where all commercial stock in a quarantinable area is subject to selection pressure. That is, selection by the beekeeper controlling the breeding population and Mother Nature applying her own selection pressure to unmanaged bees. This could be extended to the recreational sector if beekeepers are willing to collaborate. Breeders target VSH in both queens and drones. Measures are taken to minimise non-VSH drones and flood the area with VSH drones. VSH stock supplied to commercial beekeepers. Program funding used to employ a technician to collect performance/trait data from commercial apiaries and inform queen breeder selection decisions. Technician funding required as neither breeder or commercial beekeeper has resources available to collect data during spring and summer. Furthermore, a technician would not generate a financial return for breeder or beekeeper but might be shared across multiple

	commercial apiaries. Tech transfer program would help to ensure that Plan Bee/AGBU developed a valuable database and eventually EBVs with a reliable source of data. David suggests access to a US-style tech transfer team would be contingent on data being contributed to Plan Bee – assuming data IP rights/security could be addressed (a sticking point with Plan Bee). If public funds are used, the breeding program must not sell queens and compete with commercial queen breeders (likewise public money cannot be sequestered for private gain). The public/industry benefit would accrue from an improved capacity to work towards better stock (not just VSH but across all traits) and a decreased reliance on chemical miticides. Improved pollination security would be a further, long run benefit. Access to imported VSH stock (queens plus semen) would speed up breeding program progress.
Fiona Chambers, CEO, When Bee Foundation.	• The Plan Bee evaluation program is critical to the queen sector and hence the Australian honey bee industry. Scientific evaluation permits selection for VSH, or any other trait required by beekeepers. Plan Bee is trait selection technology. • Plan Bee is more important to the industry's future than a breeding program. • PEQ Mickleham had some genuine difficulties with a cold location and staff that did not have colony management skills. However, most of these difficulties were worked through as part of Hort Innovation research project MT18019. • Resentments arose through Plan Bee (products competing with breeders) and MT18019 (distribution of imported genetics), and IP and industry leadership investment is required for the smooth running of future projects. • There is a real need for investment in capacity building for people working in the queen sector. Breeders work alone and are highly competitive. Skills are needed to facilitate the delivery of collective endeavours. There is value in a queen sector leadership program, and a public good program could be supported by the When Bee Foundation. • A queen sector leadership program might include 1) working with people / working in groups, 2) managing change, and 3) understanding governance. • Queen breeders would benefit from additional skills in business management, pricing and marketing. In time investment in this space might create sufficient trust for a business benchmarking project. • Recommendation: 1) long-term secure funding for Plan Bee, 2) a queen sector leadership program, 3) clear understanding of IP and ownership of genetics prior to commencement of queen breeding projects, 4) financial and business literacy training for queen breeders.
Dr Nadine Chapman, National Varroa Management and Training Coordinator (previously Plan Bee co-lead, University of Sydney)	• Barriers to Australian queen bee sector growth include a lack of funding for breeding initiatives, division within the sector, confusion caused by an absence of standard terms and measurements for traits, and a loss of belief in Plan Bees objectives. • There is a lack of knowledge on effective Varroa control under Australian conditions for queen production and breeding. • Breeding for Varroa resistance is a long-term investment, with no short-term financial return. Return on investment (ROI) may not happen for breeders for a long time, or ever, but ROI can be realised at the industry level. • Until mite infestation levels stabilise, we must be open to treating with miticides to protect the genetic diversity in our stock. If mite reinfestation is high, resulting in multiple infestations of brood then hives will eventually be overwhelmed regardless of their genetics (having multiple foundresses during development means a worker will not be a fully functional member of society, having too many workers in this state can result in colony death). Genetic variation was lost with Varroa overseas and quality Australian stock has been lost here through the eradication attempt. • The best selection strategy for Varroa resistance is mite load and this can be monitored via routine alcohol washes. It is a low input trait to phenotype and has been consistently correlated with colony survival.

	- Breeders are enthusiastic and want to jump straight into trait selection for Varroa resistance, but caution is needed. Systems are needed (including within the breeder's apiary e.g. record keeping, unique hive and queen IDs) before real progress can be made. It will be difficult to achieve under high reinfestation pressure as this varies between colonies for reasons other than the bees themselves. Looking for hives that have the same mite load as others but are not showing the same level of distress could be useful, but a system for scoring these signs will be needed. - Any revival of a national breeding program like Plan Bee will need to be more broadly funded – the cost of a national program cannot be mostly borne by one state; involving more state departments will be essential. - Effort is needed to educate beekeepers on the benefit of genetically superior queens and why it is worth spending more for this type of stock. - Recommendation: to move the sector forward a five-step strategy is suggested: 1) breeding stations to review stock in a range of locations and climates, 2) technical support for bee breeders for colony labelling, record keeping, phenotyping and sampling, 3) genetic analysis at UNE AGBU, 4) bee breeders selecting on the basis of known traits/EBVs that are a priority for them and their beekeeping customers, and 5) transparency for beekeepers when choosing stock to buy.
Elizabeth Frost, Technical Specialist Bees, NSW DPIRD (previously co-lead on Plan Bee)	- Plan Bee has provided a valuable foundation for strengthening the Australian queen breeding sector. The Breeding Manual Second Edition 2025 details key breeding concepts including selection for Varroa tolerance traits. - Effective breeding that “fixes” Varroa tolerance in the honey bee population requires application of the Plan Bee scientific principles including unique hive identification, the accurate recording of pedigree details, use of the Plan Bee trait selection manual. The Plan Bee database, and more reliable access to genotype analysis in future will speed progress toward EBVs for queen bees. EBVs have transformed Australia's cattle and sheep industries for the better. - Plan Bee products provide a ‘head start’ with selection for Varroa resistance and other traits that are important to breeders/beekeepers. - If breeders are not making use of Plan Bee resources, they risk selecting on the basis of indicators that are not heritable or accurate. - There was a shortage of queens and genuine queen breeders, who focus on genetic improvement, prior to Varroa. This shortage is expected to get worse as breeding (and beekeeping) gets harder post Varroa and key individuals retire. - One barrier to importing VSH genetics is lack of access to virus and Africanised gene testing for semen in Australia. NSW DPIRD is planning to launch a virus testing service that will soon be available to the public on a fee-for-service basis. - The T2M funded Varroa Trait Queen Breeding Workshop held at Tocal in June 2025 was encouraging. Breeders came together and developed a better understanding of how Plan Bee selection methods and genotyping could delivery their breeding goals. - In 2025, skills are needed right through the queen sector and span the simple stuff like tips on rearing queens through to executing a breed plan. Breeding and purchase of cattle and sheep on the basis of EBVs took 40 years in Australia. A similar development period can be anticipated for honey bees.
Jon Lockwood, MD, Goldfields Honey Aust (breeder)	- Queen bee breeding for Varroa resistance in Australia is constrained by the financial capacity of breeders. Engaging in a committed full time breeding program is extremely costly with no visible short-term benefits to cover costs. Poor financial returns from VSH breeding are further exacerbated by the lack of profitability in commercial beekeeping at the current time. - Australia must engage in breeding for VSH despite limited commercial uptake of VSH queens in the US and Europe. Australian breeders can learn from overseas experience. The main lesson to be learnt is not to become too

	focussed on VSH and to ensure that it is incorporated alongside other beneficial traits. The US and Europe have limited treatment options due to chemical resistance; this can be seen when reviewing northern hemisphere colony loss numbers. Breeding is the only long-term sustainable solution to Varroa. • Jon has witnessed bees that can handle pests and diseases better than others (e.g., WA bees are renowned for being susceptible to EFB when introduced to the eastern states, WA does not have EFB). Jon believes Australia can produce bees that can 'handle' Varroa better via breeding. • Recommendations: breeders need remuneration to encourage investment into improving Australia's bee genetics. It is currently a 'chicken and egg' scenario, industry is reluctant to invest as there is currently no great need for VSH stock, and it will take a 'big hit' in Australian bee stocks before the need for superior genetics is truly recognised by the broader beekeeping community. Australia has a bad track record when it comes to maintaining a national bee breeding program. Caution should be taken to avoid repeating this unfortunate history.
Dr Rob Manning, Research Scientist, Bee Breeder and Exporter, WA	• Rob has been closely associated with Better Bees WA for a long time. He notes the productivity of the program's queens and their vulnerability to Varroa. • Barriers to queen sector growth include unnecessary "red tape" associated with interstate health certificates. These are a waste of time and money especially for queens sourced from low pest environments such as WA. WA does not have many of the pests and diseases present in other Australian states (i.e., Nosema cerana, European foulbrood, and Varroa). The cost and inconvenience of health certificates is particularly galling when it is understood that there is little checking of compliance in a highly automated postal system.
Prof. Sasha (Alexander) Mikheyev, Evolutionary Biologist/Social Insects, ANU	• Before Varroa as a selection pressure, there was an over-reliance on resistance proxies, such as hygienic behaviour, UbeeO, etc. These proxies explain part of resistance story, but whether they are sufficient remains unclear, making an all-out investment into one of them is risky. Selection at the hive level for mite count is a better long-term strategy. • Science still doesn't have a good grasp of the genetics underlying Varroa resistance and why local adaptation by bees seems to play such a key role. Most successes have been reported by local breeders on fairly small scales, and not massive queen breeding operations. I think in Australia it makes sense to do small-scale breeding and then see where it fails and work on that. • I think a knowledge sharing and a strategy would be most effective. This is difficult to achieve, as everyone will have their own ideas, but I think all breeding programs have to be rooted in scientific data, which might provide some common ground. For example, if the industry adopts standardised protocols and reporting infrastructure, keeps samples for genetic analysis that will pay off in the long term. A consortium with a common goal would be the best approach in my mind, especially since it is unlikely that a single operator will be able to create a "magic bee" in the short term and corner the market.
Dr Cooper Schouten, SCU Bee Research and Extension Lab (<i>applied research and extension</i>)	• Scale of businesses involved in the breeding and rearing sector, and their incentive structures (degree of for-profit vs passion) is critical to driving genetic improvement programs at a scale that will impact industry outcomes. • There has been limited whole of value chain investment in RD&E (queen breeders, queen producers and commercial beekeepers) – the bar needs to be raised with 'win-wins' for all players simultaneously. • Incremental changes, focused on core traits that can be demonstrated to make money, using skills and technology available to match current business/sector maturity, are needed. Aim to reach the people, not the moon. • Existing research (e.g. Rhodes and Somerville, 2003), among others, demonstrate practices (i.e. age of catching queens) that can result in significant economic returns on investment, and which are 'low hanging fruits' to market. Are queens that are significantly more likely to be accepted initially

	and not superseded in time priced higher? Will a VSH queen be worth more to justify the increase in cost of production? The root cause issues and clear identification and articulation of chain upgrading strategies, margins and willingness to pay/evaluate return on investment across actors, haven't been properly evaluated. Peer-peer extension across the chain targeting product understanding, marketing and business development, and business decision making tools may be of value. • Peer-peer extension is more likely to result in practice change and needs to be based on tailored solutions that are informed by an understanding of the businesses level of maturity ("fit for purpose" and not necessarily "cutting edge"). Funding continuity will always be an issue, so evaluate other breeding program models and embed within existing businesses. Caution investing in activities that are external to business operations, beyond risk appetite, without deep understanding of end user perceived benefit and return on investment for change in practice - take up will be short-lived. • Beekeepers will mostly respond to outputs that increase their profitability, but need the systems in place to evaluate this, and the systems themselves need to be easy to integrate and cost effective. Varroa traits can be added as a secondary benefit to profitable queens that focus on honey production (or spring colony strength for pollination services/ relevant to business model). • Recommendations: the queen breeding sector needs strong and impartial leadership, an agribusiness focus emphasising product and market development, and evaluation of a (proven) model similar to that employed by Better Bees WA. Dr Rob Manning was able to demonstrate that queens from Better Bees WA made the beekeeper more money. In the first instance, effort is needed in relation to extension and maximising the productivity of the queens, including science we already have.
Colin Wilson, Hunter Valley NSW (<i>breeder</i>)	• Col is a long-term member of the AQBBA, a former president but is not currently involved with the AQBBA's UbeeO-based breeding efforts. He was a major exporter of Australian queen bees for many years. • Col was required to euthanise hives in the early part of the Varroa response. The NSW Hunter Valley was where Varroa was first detected in 2022. • Col was permitted to save a small number of breeder queens from his operation. These breeder queens were previously selected for disease resistance have been exposed to Varroa longer than any other Australian stock (but still only one full season). • Col is noting encouraging signs of suppressed mite reproduction in his stock. He is now selecting breeder queens for low mite levels. All stock is selected for honey production and a docile temperament. • His AI breeder queens sell for \$2,000 each. In 2025, he is producing fewer queens than in the past (he is semi-retired) and is concerned about critically low levels of profitability in the industry (poor honey and wax prices as well as additional costs associated with Varroa treatment).

5. Importation of Improved Genetics

Historically, Australia imported most of its breeding stock from the United States (US) and more recently from the European Union (EU). In the early 2000s, imports from the EU were driven by the need to create quality Australian queen bees for counter-season supply to Canada (CIE 2005).

In 2006, the Australian Government suspended queen bee imports from the US due to the inability of suppliers to determine the presence of genes from the aggressive, Africanised honey bee. In 2008, importation of queen bees from all sources was suspended due to concerns

about the international spread of Colony Collapse Disorder (Department of Agriculture, Fisheries and Forestry (DAFF) 2012).

Importation of Queen Honey Bees

In 2012, DAFF completed a review of queen bee import arrangements. As part of this review all disease, agents, pests, and species of concern were assessed and risk management measures identified to reduce risks to a level consistent with Australia's Appropriate Level Of Protection (ALOP).

The review recommended that queen bee imports be restricted to those countries that can provide certified assurance of meeting Australian biosecurity requirements. These countries were Canada, the EU, Japan, New Zealand (NZ), and the US.

However, the review concluded that importation from these countries does not achieve Australian ALOP for key pests, i.e., Africanised bees, varroosis (Varroa), acarapisosis (tracheal mite), and Tropilaelaps. For these hazards, additional risk management measures are required, and depending on the disease agent, multiple measures are needed.

Commercial queen bee imports have not resumed since the review was completed (NB: a small number of queens were imported in 2020 as part of a research project to test the viability of a new import protocol – see Roberts 2021).

Honey Bee Semen Imports

In 2016, the Department of Agriculture and Water Resources (DAWR, previously DAFF) reviewed the importation of honey bee semen and concluded that imports be restricted to those countries approved for queen bee imports i.e., Canada, the EU, Japan, NZ, and the US.

Submissions to the DAWR review expressed concern that harmful viruses might be transferred through honey bee semen and referenced Anderson 2015 which reviewed the disease status of Australian honey bees. Anderson 2015 confirmed that Deformed Wing Virus (DWV) and Slow Bee Paralysis Virus (SBPV) are not present in Australia. DAWR subsequently concluded that the biosecurity risk associated with SBPV was not sufficient to warrant risk management measures and that DWV was not an issue until Varroa was present in Australia.

Anderson 2015 also showed that the presence of *Nosema ceranae* in Australia had implications for honey bee semen imports. Anderson 2015 found that *N. ceranae* was present in all parts of Australia except Western Australia (WA). Consequently, imported semen should not be permitted to enter WA directly unless it was sourced from a country or zone accepted by DAWR as free of the disease.

In addition, the DAWR review concluded that the importation of semen from approved countries does not achieve Australia's ALOP with respect to Africanised honey bees and Cape honey bee. Cape honey bee is an exotic that exhibits social parasitism and worker bee laying that would adversely affect beekeeping in Australia. For both these subspecies, additional risk management measures are required, and measures are described depending on the status of the exporting countries. For various reasons, including a shortage of supply, drone semen has not been imported since the DAWR review was completed.

Importation Protocols

The DAFF website, as of April 2025, indicates that the findings from both the review of Importation of Queen Honey Bees (DAFF 2012) and the review of Importation of Honey Bee Semen (DAWR 2016) reflect current Australian biosecurity requirements.

If requirements are to be met, importation of queen bees needs to be via the Australian Government approved Post Entry Quarantine (PEQ) Facility at Mickleham in Victoria. Colonies derived from imported queens are propagated at the PEQ and only larvae grafted from those colonies are released to the Australian industry.

In principle, honey bee semen can be imported from approved countries with relevant test results. Imported semen that has been tested for viruses in its country of origin can be imported directly and bypass PEQ Mickleham.

Opportunities to Import Varroa Resistant Stock

Briggs and Revell 2023 note that two current pathways exist for the introduction of new honey bee germplasm into Australia:

- 1) Grafted larvae from live queens contained in the PEQ Facility at Mickleham.
- 2) Drone semen.

Commercial importation of honey bee germplasm through live queens has not occurred in Australia since the PEQ at Mickleham was constructed in 2015. This is because industry lacks confidence in the suitability of Mickleham PEQ's "climate and staff capacity to enable successful queen importations". Similarly, no bee semen importation had been conducted since the implementation of importation protocols in 2016.

Consequently, there was a need to trial queen importations through the new quarantine facility and evaluate the bee semen importation protocol for practicality and biosecurity integrity. To this end, a Hort Innovation RD&E project (MT18019/Roberts 2021) was conceived and delivered between June 2019 and December 2021. The project's aim was to assess import protocols and procedures and determine whether they could be used to successfully import Varroa resistant genetic material.

While the project delivered a successful trial importation of bee semen and live queen bees, validated a workable protocol and (successfully) tested the PEQ Facility for honey bee germplasm imports, further work is required to deliver a commercial outcome (Briggs and Revell 2023).

Project researcher Dr John Roberts CSIRO noted that the main impediment to leveraging the import protocols established through the project was identifying a reliable source of germplasm that is both Varroa-resistant and commercially viable. Since project MT18019, attempts to import (Varroa resistant) bee semen from NZ have been unsuccessful, due to DWV being detected in source semen. PCR testing is able to determine whether DWV is present but not whether the virus is viable.

In 2024, a new research project led by Dr John Roberts CSIRO (PRO-01749 - 'Transmission of DWV through Imported Semen') was commissioned by AgriFutures Australia and is due for completion in December 2025. This project is investigating whether DWV is transmitted from queens to offspring when inseminated with DWV-infected semen. The project will also explore the feasibility of using anti-viral treatments on imported semen.

Dr John Roberts, CSIRO (pers. comm., July 2025) reports:

- There are already studies that show DWV can be passed through semen to infect a queen and her progeny. However, it is not clear how frequently this occurs, particularly in the context of imported semen. This is part of what is being studied in the current AgriFutures Australia project. CSIRO's preliminary results show lower frequency of transmission than reported in previous studies. Regardless, virus testing for DWV and other viruses not found in Australia (SBPV, ABPV) is needed to mitigate the risk of virus introductions².
- In 2020, the research project (MT18019 – 'Developing and Implementing a Protocol to Enable Importation of Improved Honey Bee Genetics to Australia') was able to successfully bring imported grafted stock through the PEQ Mickleham but it was challenging. Recommendations were made to DAFF on how the process could be improved including changes to the 'too cold' PEQ Mickleham environment. Dr Roberts notes that while PEQ staff are good, they are not queen bee breeding specialists. Queen breeders Dr Jody Gerdt and David Briggs, who participated in the project, were permitted to complete their own grafting and colony management under the supervision of PEQ staff.

Research Project Recommendations (Roberts 2021/MT18019)

MT18019 recommendations to improve the operation of PEQ Mickleham in relation to live queen import included:

- Administrative changes in relation to notification requirements for health certificates, licensing to allow release of material from the PEQ, virus testing, and industry participation in the PEQ process.
- Changes to the PEQ protocol in relation to incubation period upon arrival to reduce stress on imported queens and special use permits to facilitate acaricide use.
- PEQ improvements – changes to temperature control facilities, light levels, wash up facilities, the inhospitable flight cage environment, colony housing and location, improvements in field conditions, and sterilisation of equipment.
- Nucleus and support colony management including changes to nucleus colonies destined for flight cages and the movement of brood above the excluder of a strong double hive.
- Export country colony management – stock sourced in northern hemisphere spring, low starting levels of mite, colony pre-testing for viruses and Africanisation where this is relevant.
- Consideration of policy changes in relation to tracheal mites and for miticide treatment of nucleus colonies.

MT18019 recommendations to improve the importation of drone semen included:

- Administrative changes similar to live queens i.e. notification requirements for health certificates and export preparation plus DAFF confirmation of the definition of what constitutes a representative semen sample for virus testing.

² DAFF (pers. comm., June 2025) note that while DWV is widely spread there will be areas in infected countries, even in individual hives in apiaries, where the virus is not present and clean semen can be sourced.

- Research to address knowledge gaps in relation to developing country of origin best practice colony management protocols, standardised semen collection, storage and packaging protocols, and improved virus testing procedures.

Additional MT18019 recommendations requiring research were:

- Importation pathways for honey bee eggs – eggs are known as an effective way of conveying genetic material. R&D is needed to determine if this is effective and the risk associated with this pathway.
- Semen treatment with anti-viral agents – research is currently being completed as part of PRO-01749 - ‘Transmission of DWV through Imported Semen’.

Recommendations to Facilitate Imported Genetics

Consultation and analysis have identified outstanding stakeholder concerns in relation to importation of improved genetic material. The following suggestions were made:

- Implementation of MT18019 recommendations (Roberts 2021) to improve the operation of PEQ Mickleham including queens, semen, and the research questions listed above.
- Investigate measures to address the high level of investment needed to secure imported genetics. Investment includes in-country testing costs, investment of time for management and advanced technical assistance (e.g., introduction of queens to a colony and production of grafted larvae). The cost is estimated at \$20,000 per consignment and this cost is a barrier for commercial breeding groups (even if queen breeding labour is supplied by the breeding group).
- If public funding is secured (or PEQ fees waved), care is needed to ensure a public benefit is not sequestered for private gain. A return on investment for the public funder needs to be agreed prior to importation (or equitable access to products provided to all queen breeders). Possible public funding sources include a Commonwealth grant, via a DPI program, or a levy-funded R&D project (AgriFutures, Hort Innovation, or GRDC).
- Systems are needed to manage imported semen including source country testing, maintenance of its viability during transit, prompt release in Australia, local storage, dissemination, and access to insemination technology.
- Queen sector support is needed to ensure that the current NSW DPIRD Elizabeth Macarthur Agricultural Institute proposal to offer virus and Africanised gene testing in Australia for imported genetics is advanced. This fee-for-service proposal would provide confidence and discourage illegal imports.
- Consideration should be given to the simultaneous importation of queens and semen – queens could then be mated with imported semen and gene dilution avoided. Dilution occurs when local drones (even those selected for some measure of VSH) are used to inseminate imported queens.
- Determine whether current barriers to the importation of genetic material from Hawaii and the US put in place to manage Africanised genes, particularly VSH genetics developed by the USDA at Baton Rouge, can be overcome without risking damage to the Australian honey bee industry. It is noted that Africanised honey bees are climatically well suited to Australian conditions.

6. SCOT Analysis and Additional Recommendations

Queen Bee Breeding SCOT Analysis

A Strengths, Challenges, Opportunities, and Threats (SCOT) analysis was prepared by Dr Nadine Chapman in 2021 to inform the Plan Bee project. A summary of the analysis combined with the findings from project consultation is reproduced in the table below.

Table 13: SCOT analysis Australian queen bee sector

Strengths • Improved stock from 50 years of breeding programs and individual endeavours. • No evidence of inbreeding in either heartland (NSW/QLD) or isolated populations (WA, Kangaroo Island, or Norfolk Island). • Australian expertise in bee breeding and livestock breeding programs. • Accredited queen bee breeding and AI courses (TAFE Cert III). • Knowledge of inheritable traits (but more work required on Varroa-resistance traits). • Some support from pollination dependent industries and government.	Opportunities • There is an undersupply of quality queens and ample demand for the product. • Market growth – insufficient drones for self-replacing stock, pollination services post loss of unmanaged bees, potential growth in export markets, a large rec. beekeeping sector. • Imported genetic material is a potential ‘head start’ on breeding for Varroa-resistance. • Beekeepers interested in receiving more information about the queens they purchase. • Cutting edge genomics and marker-assisted selection can rapidly increase productivity. • Establish a register of queen breeders and producers to improve information flow (including information on traits selected and climatic suitability of products). • Establish more broadly based collaborative breeding program.
Challenges • Capacity building needed in breeding groups – leadership and technical. • Sector lacks a funding base to support R&D or a breeding program (levy on hold). • Breeding programs have a long history of stop/start funding, industry is sceptical. • Breeding for Varroa-resistance is unlikely to be profitable for individual breeders. • Beekeeping currently unprofitable. • Importation of improved genetics constrained by viruses, African genes. • Breeders and beekeepers in a never ending battle to prevent dilution of desirable genes (this is particularly true when breeding for Varroa-resistance). • Staff to undertake queen breeding tasks are in short supply and expensive. • Interstate health certificate constrains market growth (especially low-risk WA). • Most Australian bee breeding groups lack enough scale for their products (queens) to influence industry outcomes.	Threats • Beekeepers who are unwilling, or do not have the capacity, to pay for quality queens (low or no industry profit in 2025). • Potential loss of lines that have been bred specifically for Australian conditions following the introduction of Varroa. • Loss of breeding capacity as key breeders retire and scientific expertise lost to other industries. • Breeding for Varroa-resistance unprofitable while chemical miticides are working and Varroa is not in all jurisdictions. • Agricultural chemicals (especially miticides) negatively impact drones and the production of queen pheromone – apiary sites with low chemical exposure need identifying/protecting. • Breeding for Varroa-resistance has not delivered commercial outcomes in US or EU. • Inadvertently importing unwanted viruses. • Use of publicly collected funds being perceived as generating private gains. • The long time it takes to fix Varroa suppression in the bee population.

Source: Chapman 2021 and project consultation

After considering the SCOT analysis the following additional recommendations are made for the queen sector.

Plan Bee Type Technical Support

Small-scale queen bee breeding groups do not have the resources (money, skills) to make scientifically informed selections for Varroa resistance. External capacity that can potentially service all current and emerging breeding groups is needed. This capacity needs to be funded by multiple organisations e.g., more than one state-based DPI.

Capacity needed by small-scale queen bee breeding groups will include resources to assist with phenotyping, pedigree recording, hive marking, scoring for mite suppression, genomics and marker assisted selections. Private breeding groups cannot afford technicians for data collection and accurate data is needed if genetic progress is to be made. Support is also needed from the UNE AGBU to record and analyse trait information, assist with breeding program design and allow progress toward honey bee EBVs.

Capacity Building for Queen Bee Breeding Groups

To ensure the smooth running of future breeding projects benefiting from Plan Bee type technical support, this study recommends capacity building for representatives from existing breeding groups. Queen bee breeders work alone and are highly competitive. Skills are needed to facilitate the delivery of collective endeavours. There is value in a queen sector leadership program, and a public good program might be supported by the Queen Bee Foundation.

A queen sector leadership program might include 1) working with people / working in groups, 2) managing change, 3) understanding and managing IP, and 4) corporate governance. Queen breeders would benefit from additional skills in business management, pricing and marketing. In time, investment in this space might create sufficient trust for a business and performance benchmarking project. Queen sector benchmarking was unsuccessful in the past.

A queen sector leadership program might also embrace national workshops on advanced breeding techniques. A 2025 T2M funded Varroa Trait Queen Breeding Workshop at Tocal College in the NSW Hunter Valley was well regarded by attendees. Post completion of the Varroa T2M program, follow up workshops in NSW and other states are suggested as part of this recommendation. Skills are needed from the simple stuff like tips on rearing queens through to executing a breed plan.

Queen Sector Information Dissemination

Chapman and Frost 2023 note that an official register of Australian queen breeders and producers would assist domestic market participants with locating production or breeder queens to purchase. A register would help sustain queen breeder and producer businesses, while also connecting queen breeders and queen producers to potential new markets.

A register would clearly differentiate between breeders and producers, identify traits and the climate that a supplier is selecting for. The register may assist breeders in securing a return on the effort they put in to their genetically selected queens. The register might also include information directed at educating beekeepers on the benefits of genetically superior queens and why it is worth spending more on this type of stock.

Queen Bee Extension Program for Beekeepers

An extension program would address the value of genetically selected queens and educate beekeepers on how to get the most out of their current queens. For example, if young, mated queens are left to lay eggs in the breeder's nuc for 21 days – the queen is less likely to fail when introduced to a commercial hive. Beekeepers need to recognise this advantage, and breeders need to charge accordingly. All queens sold should be marked when purchased to ease the monitoring of their performance (Schouten, pers. comm., July 2025). Beekeepers need to better understand how to requeen for maximum acceptance rates, disease prevention, productivity, and management (Chapman and Frost 2021).

'Seedbank' for Valuable Australian Genetics

Valuable honey bee genetic variation was lost when the Varroa mite became established overseas. Quality Australian stock was lost in 2022 and 2023 with the attempt at Varroa mite eradication in this country. Beekeeper inexperience with Varroa and high environmental mite loads are resulting in further losses. The introduction of viruses associated with Varroa could further exacerbate the situation.

A research project is needed to test the feasibility, cost and benefit of identifying and preserving the genetic diversity of Australian honey bees. It may be feasible to establish a "seedbank" before more valuable Australian stock is destroyed by Varroa.

Publicly Funded Breeding Program - Not Supported

Investment in a publicly funded breeding program that produces and sells queen bees is not recommended by this study. Publicly funded breeding programs have a long stop/start history with governments withdrawing funding before goals are met, leading to industry cynicism. Breeders are used to working on their own or in small groups, a national program would need broad based support, and this is not likely to be secured from individuals who are competitive and focussed on their own breeding priorities.

Honey bee breeding programs require continual investment if genetic drift/dilution is to be avoided. Public programs, that sell queen bees, risk the "crowding out" of private sector breeders and the industry has insufficient resources to fund a national breeding program on its own. Industry estimates that a minimum of \$700k pa for ten years would be needed to "fix" Varroa suppression in the Australian population, industry does not have these resources, and public funds would be better allocated to Plan Bee type technical support for individual breeder priorities.

7. Study Conclusions

This study has provided a profile of the Australian queen sector, identified barriers to its growth, and delivered actionable recommendations. The sector has access to improved stock from fifty years of breeding programs, is well supported with breeding expertise and has data available on heritable traits. More work is needed on traits for Varroa mite suppression. There is opportunity to strengthen the queen bee sector, which in turn will strengthen the Australian honey bee industry and the production of pollination dependent crops. Study recommendations address imported genetics, Plan Bee type technical support, capacity building, queen sector information dissemination, and a genetic "seedbank". The study does not support a national breeding program.

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