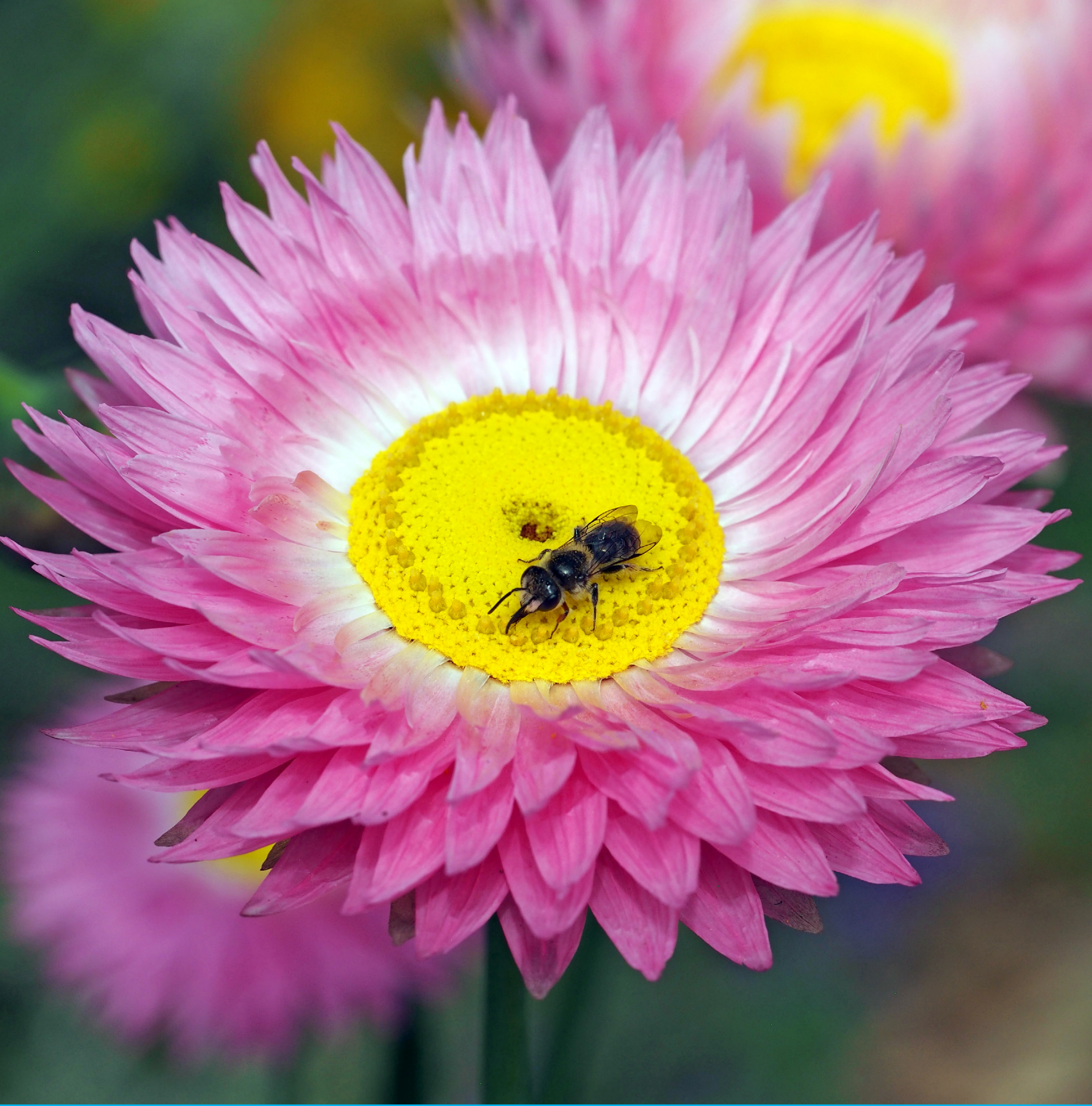

# Australian Native Bee Strategic RD&E Plan (2022-2027)

January 2022
by Olivia L. Reynolds and Michael Robinson

AgriFutures® Emerging Industries

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Australian Native Bee Strategic RD&E Plan

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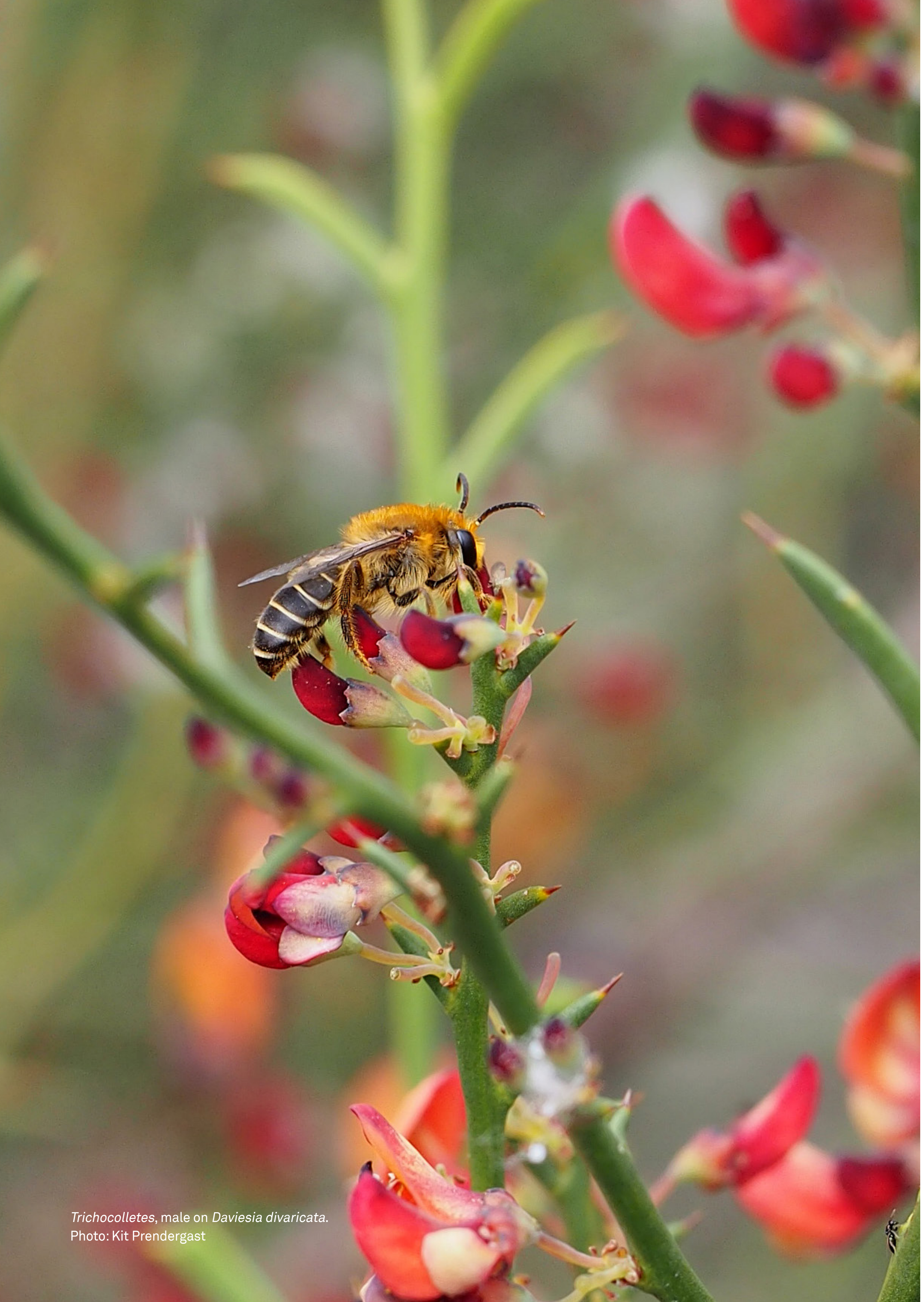
**Cover:** *Leioproctus* sp., female on *Rhodanthe chlorocephala.*
**Photo:** Kit Prendergast

*Xylocopa (koptortosoma) aruana*, female.
Photo: Kit Prendergast



*Trichocolletes*, male on *Daviesia divaricata*.
Photo: Kit Prendergast

# Foreword

Australia has approximately 1650 named native bee species. Most Australian native bees are classified as solitary or semi-social, however there are 11 described species of highly social stingless native bees. All species are valuable pollinators, with stingless bees also producing a highly valued honey with reported health benefits.

Australian native bee honey production is estimated to have an industry value of less than $1m. By 2030, this value is expected to increase to $3-5m, with native bee honey retailing for $200-450 per kilogram. The supply of colonies for beekeepers and the provision of pollination services for growers are where the highest returns in the value chain currently rest.

The development of a Strategic Research, Development and Extension (RD&E) Plan is a crucial first step in growth for an emerging industry. This Australian Native Bee Strategic RD&E Plan clearly identifies opportunities and barriers to industry growth, and subsequent RD&E priorities for the industry. Strategic RD&E Plans for emerging industries are resources that can be used by industry to help drive investment and growth within the industry.

This Strategic RD&E Plan is the result of extensive desktop research and stakeholder consultation across the Australian native bee industry, and pulls together specific recommendations for future investment to support the long-term growth and competitive advantage of the industry.

This Australian Native Bee Strategic RD&E Plan has been produced as part of AgriFutures Australia's Emerging Industries Program, which focuses on new and emerging industries with high growth potential. Emerging animal and plant industries play an important part in the Australian agricultural landscape. They contribute to the national economy and are key to meeting changing global food demands.

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**Michael Beer**

General Manager, Business Development
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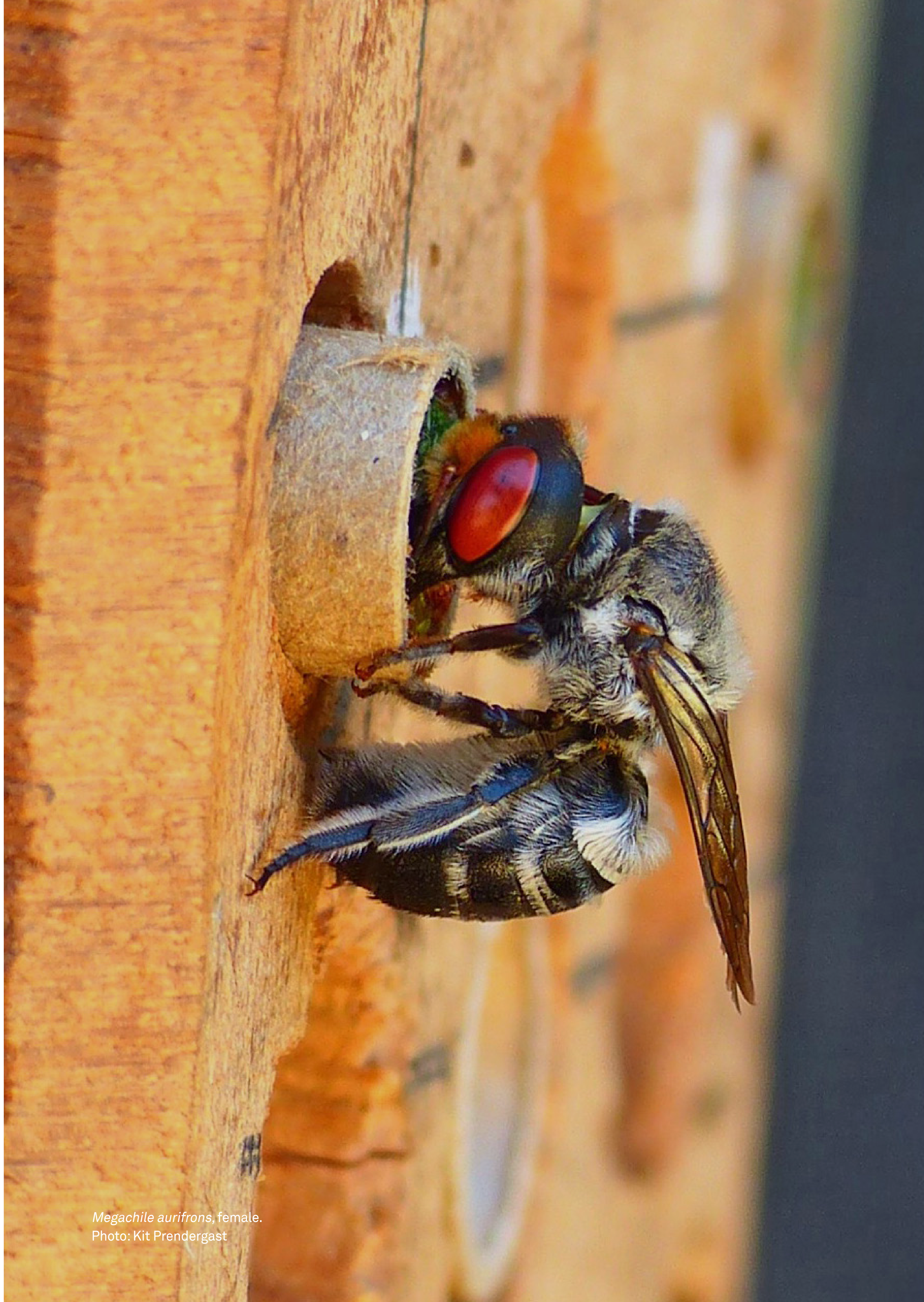
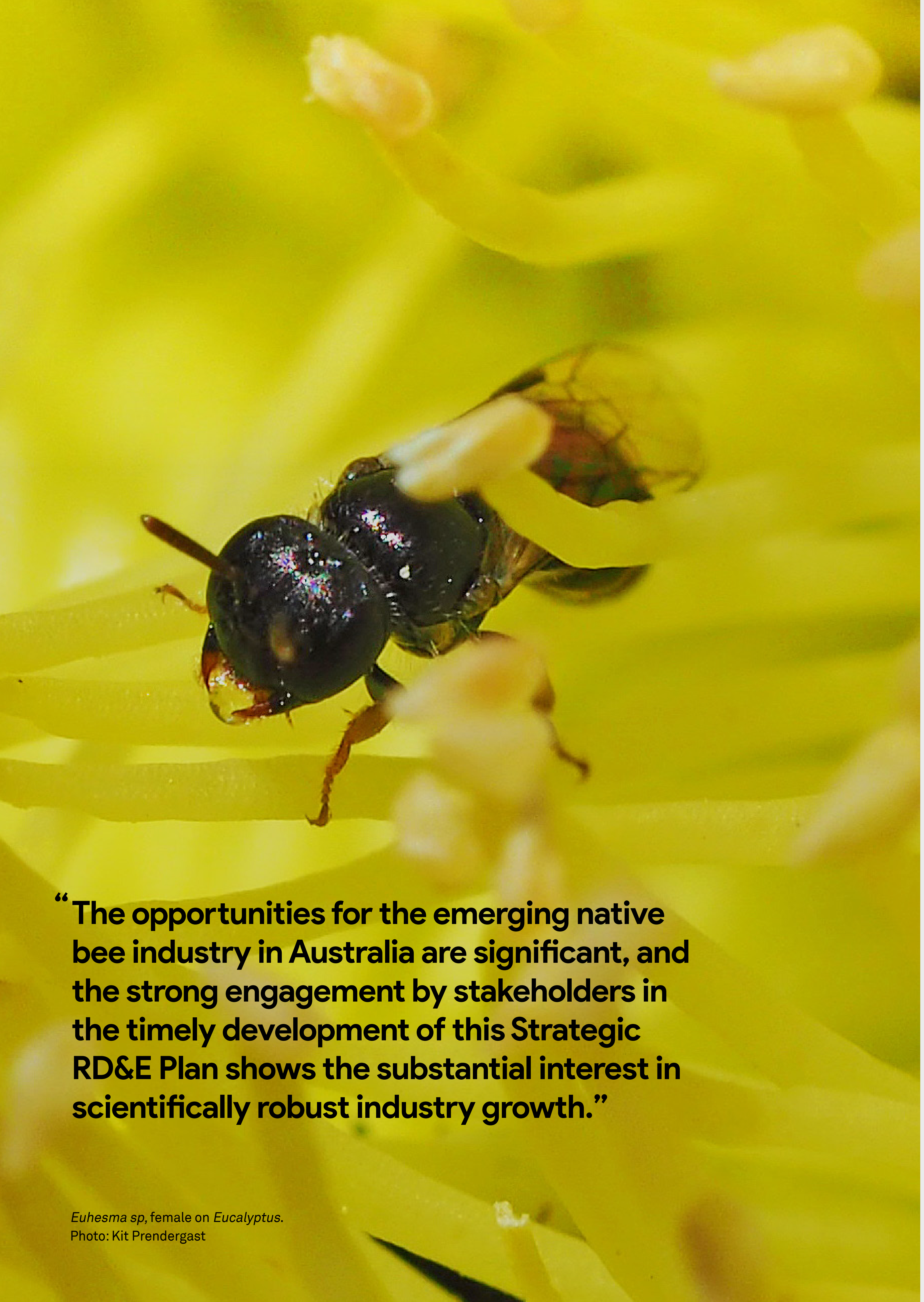


*Megachile aurifrons*, female.
Photo: Kit Prendergast



"The opportunities for the emerging native bee industry in Australia are significant, and the strong engagement by stakeholders in the timely development of this Strategic RD&E Plan shows the substantial interest in scientifically robust industry growth."

*Euhesma sp,* female on *Eucalyptus.*
Photo: Kit Prendergast



# Executive summary

Bees are essential to life, pollinating an estimated 80 per cent of all flowering plants, including agricultural crops, and are an important component of food security.

Australia has about 1650 named native bee species, which are found across all regions and climatic zones. The vast majority are solitary or semi-social, and include species within five of the seven globally known families. There are 11 described species of highly social (eusocial) stingless native bees, belonging to two genera, *Tetragonula* and *Austroplebeia* in the tribe Meliponini.

Stingless native bees live in perennial colonies and are valuable pollinators of native plants and a range of agricultural crops. Stingless bees also make small amounts of an aromatic native bee honey that is highly valued and has reported health benefits, and propolis, the nest-building material bees produce in abundance that has a range of uses.

The semi-social and solitary native bees are also critical to pollination of our native flora. Several groups of solitary and semi-social bees sonicate flower anthers to obtain pollen, i.e., they 'buzz' pollinate, a form of pollination required by some plant species, including certain crops.

The native bee industry in Australia is at the cusp of potential significant growth, largely due to wild and managed pollination by stingless, social and semi-social species. Industry growth is also likely to come from the high value of native bee honey, the potential uses and value of propolis, and increasing community interest in the value of having native bees in our environment and communities, and for societal wellbeing.

AgriFutures Australia commissioned the development of this Strategic Research, Development and Extension (RD&E) Plan to support the emerging Australian native bee industry. It was developed through consultation with a broad range of stakeholders, identified through the Australian Native Bee Association, AgriFutures Australia and suggestions from native bee stakeholders. Through a series of online meetings, the stakeholders have agreed a vision and mission, underpinned by goals and outcomes. The five goals are to be delivered by 22 strategies, with strategies to be implemented by a series of activities. Each of the 49 activities represent a potential RD&E investment area and have been prioritised as very high (6), high (14), medium (17) and low (12).

The opportunities for the emerging native bee industry in Australia are significant, and the strong engagement by stakeholders in the timely development of this Strategic RD&E Plan shows the substantial interest in scientifically robust industry growth. The development of a sustainable industry that prides itself on best environmental, social and ethical practices will be a valuable addition to Australia's economic, social and physical landscape.

## Vision

A highly valued and sustainable native bee industry that provides widespread pollination services, produces multiple premium products and services, and promotes conservation and biodiversity, based on best environmental, ethical and social practices.

## Mission statement

The Australian native bee industry will:

- Provide managed and support wild pollination of a broad range of agricultural crops and the environment.
- Produce high-quality, high-value native bee honey, propolis and other products for domestic and export markets.
- Be recognised as a best management practice industry (nationally and internationally) with regards to accepted product and service standards, and conservation of native bees to protect their welfare and role in the environment.
- Increase broad community awareness and knowledge, raise the profile, and support use and ownership of native bees.
- Engage with Aboriginal and Torres Strait Islander communities for mutual exchange of knowledge and development of opportunities.
- Secure investment and undertake collaborative and coordinated RD&E necessary to support the vision.



## Goals

- Pollination by native bees is widely recognised, valued and utilised across agroecosystems.
- Stingless bee products (native bee honey and propolis) are viably produced, widely recognised and highly valued.
- Native bee management is ethical and regenerative.
- The industry is cohesive and collaborative, and underpinned by enhanced awareness, knowledge, capacity and community support for native bees.
- Biodiversity and conservation of native bees is underpinning a regenerative and successful industry and healthy ecosystems.

## Outcomes

- Native bees are highly valued managed and wild pollinators of agricultural crops in Australia.
- Native bee honey and propolis are in high demand as valued products with significant health, social and environmental benefits.
- Knowledge of managed native bees and their environment is considerably enhanced to ensure their management is ethical and regenerative, and supports the sustainable development of pollination and native bee products.
- Knowledge of wild native bees and their habitat is significantly enhanced to support the conservation of bees and identify opportunities for enhanced ecosystem services and land restoration.
- Aboriginal and Torres Strait Islander enterprises are an integral and integrated component of the native bee industry.
- There is increased capability and capacity of skilled labour for the industry.
- Australian Native Bee Association (ANBA) is recognised as the peak industry body for managed and wild native bees, providing leadership, driving implementation of the RD&E Plan, and operating collaboratively across the industry.

# Industry situation analysis

## 1. Background

Globally, there are about 20,000 known bee species (Discover Life, 2021) that pollinate an estimated 80 per cent of all flowering plants (Michener, 2007). Australia has about 1650 named native bee species (AFD, 2021), but revisions are required (Ken Walker, pers. comm., 2021).

Although the majority of native bee species are solitary or semi-social, in Australia, there are 11 described species of highly eusocial stingless native bees, belonging to two genera, *Tetragonula* and *Austroplebeia* in the tribe Meliponini (Heard, 2016). Stingless bees live in perennial colonies and are valuable pollinators of crops such as macadamias, mangos, blueberries and lychees. They may also benefit strawberries, avocados and others. These social stingless native bees make and store small amounts of an aromatic native bee honey and propolis, which have a range of uses and reported medicinal benefits, including those that are culturally significant for Aboriginals and Torres Strait Islanders.

Australia's solitary and semi-social bees include five of the seven globally known families, including the family Halictidae, which display a wide range of social behaviours, and the solitary bee families Stenotritidae, Colletidae, Megachilidae and some Apidae (Heard, 2016; Houston, 2018). Several groups of solitary and semi-social bees, including the *Amegilla* (blue-banded/banded bees and teddy bear bees), *Xylocopa* (carpenter bees) and numerous halictids (sweat bees) such as *Lipotriches*, sonicate flower anthers to obtain pollen, i.e., they 'buzz' pollinate (Michener, 2007). Several crops require or benefit from sonification, including the Solanaceae, such as eggplants, chillies and tomatoes, and the Ericaceae, such as blueberries and cranberries. Further, 70 per cent of Australia's solitary bees are ground-nesting, with many capable of sonification, and are vital in the pollination and reproduction of key native plants (Megan Halcroft, pers. comm., 2021). The commercial European honey bee, *Apis mellifera*, the most commonly managed pollinator, cannot perform buzz pollination (Cooley and Vallejo-Marín 2021).

In Australia, several stingless bee species are currently managed, mainly for pollination and native bee honey production, including by hobbyists. Currently, there is no management of solitary and semi-social bees, but there is growing interest and investment in research.

Globally, growing evidence shows crop pollination by wild pollinators is comparable or higher than that by *A. mellifera* (Garibaldi *et al.*, 2013). In Australia, there is evidence that this varies for native bees between crop type and region (Hogendoorn *et al.*, 2021), and is likely due to multiple factors, including size (e.g. social stingless native bees are smaller than *A. mellifera*) and behaviour (e.g. solitary *Amegilla* (buzz pollinators) are excellent pollinators of greenhouse tomatoes (Hogendoorn *et al.*, 2006, 2007; Switzer *et al.*, 2016)).

## 2. Australian native bees

### 2.1 Australian native bee range

Native solitary and semi-social bees are found in all climates and regions of Australia. The social stingless bees are only found in warm regions of Australia, including the northern half of Western Australia, the Northern Territory, Queensland, and northern and coastal areas of New South Wales (Heard, 2016). An exception is *Tetragonula carbonaria* (Apidae), which has a natural range as far south as Bega NSW (36° 40') (Megan Halcroft, pers. comm., 2021). Hotter regions may be marginal for *A. mellifera* (Anon., 2018), therefore native bees can provide climatic resilience.

### 2.2 Size and industry standards

A recent formal survey of the stingless bee community showed that there are at least 1,158 beekeepers across Australia, managing approximately 11,971 nests or hives (Sunayana Sajith, pers. comm., August 2021), although the true numbers are likely to be much higher (Tobias Smith, pers. comm., September 2021).

The Australian Native Bee Association (ANBA) is in the process of applying to Food Standards Australia New Zealand (FSANZ) for the approval of honey from native stingless bees as a standardised food. The detailed application proposes a prescribed name for the honey, as well as a definition that includes compositional requirements relating to both sugar and water content. The proposed labelling requirement and definition are designed to distinguish native bee honey from the honey of *Apis* honey bees.

### 2.3 Industry value – now and in the future

#### 2.3.1 Stingless bees

A recent report commissioned by AgriFutures Australia identified Australian native stingless bees as a high-potential emerging industry (Wilkinson, Morris and Hughes, 2021). Stingless bees possess several key characteristics that enable this recognition, including that they are a native product, likely suitable under a changing climate, and have a range of value-add opportunities, including native bee honey (Wilkinson, Morris and Hughes, 2021).

Accurate estimates for the value of the entire Australian stingless bee industry do not yet exist. However, one estimate determined in May 2021 put the combined turnover of just 37 of the main commercial native beekeepers, from the production and provision of hives to hobbyists and farmers, pollination services, honey production, education workshops and other value-add products, at more than $2.5m annually (Tobias Smith, pers. comm., August 2021).

Australian native bee honey production is estimated to have an industry value of less than $1m (Wilkinson, Morris and Hughes, 2021), with widespread production of small quantities (Coriolis, 2020a). By 2030, this value is expected to increase to $3-5m. Native bee honey retails for $200-450 per kilogram (Mary Fletcher and Tobias Smith, pers. comms., August 2021).

#### 2.3.2 Solitary and semi-social bees

Solitary and semi-social bees are important pollinators, with about 200 species identified as potential pollinators of our food crops (Ken Walker, pers. comm., August 2021). There is no quantification of the value of Australian solitary and semi-social bees to agriculture or the environment, however their value for pollination is evident in several publications, e.g. Australia: Hogendoorn *et al.*, 2021 and globally: Garibaldi *et al.*, 2013.

## 3. Current uses and opportunities for Australian native bees

Australian native bees provide a range of services and products, and are of conservation interest, largely due to the important role they play as ecosystem service providers. While there are significant opportunities for native bee products, the supply of colonies for beekeepers (commercial and hobbyists) and the provision of pollination services for growers (Appendix 1) are where the highest returns in the value chain currently rest (Coriolis, 2020b).

### 3.1 Native bee services

#### 3.1.1 Pollination

Native bees

Native bees are important pollinators across the landscape, both in agricultural (Garibaldi *et al.*, 2011) and wild environments (Bawa, 1990; Corbet, Williams and Osborne, 1991; Houston, 2018; Prendergast and Ollerton 2021).

Native bees are generally accepted to forage no more than several hundred metres from the colony, or nest. The stingless bee *T. carbonaria* typically forages no more than about 700 m from the colony, while the mean range is about 300 m (Smith *et al.*, 2017). There has been no study on foraging distances of Australian solitary bees. However, a methodology has been developed to predict foraging distances for many bee species, based on a simple measurement of body size (Greenleaf *et al.*, 2007). Knowledge of this simple metric is valuable for land management practices, including plant conservation and crop pollination.

Pollination of natural vegetation, often unappreciated, is probably the most important activity of bees in terms of benefits to humans (Michener, 2007). Native bees play an important ecological role as pollinators of many wild plant species (Slaa *et al.*, 2006; Houston, 2018; Williams, 2021). Indeed it is likely that they are excellent pollinators of Australia's native 'bush tucker', including Kakadu plum, quandong, kutjera, muntries, riberry, finger limes, warrigal greens, yam and bush tomato as well as native wildflowers (Prendergast, 2021). A recent AgriFutures Australia initiative aims to develop a native bee pollination program with the Northern Australia Aboriginal Kakadu Plum Alliance (Northern Australia Aboriginal Kakadu Plum Alliance, 2021).

Pollination in agroecosystems, particularly in the developed world, is probably reliant upon one or several managed bee species, plus a depauperate native bee community, largely due to isolation from natural habitat/floral resources (Steffan-Dewenter and Tscharntke, 1999; Kremen, Williams and Thorp, 2002) and pesticide use (Kremen, Williams and Thorp, 2002). Restoring pollination services in areas of agricultural intensity would require both a review of the type and amount of pesticides used, and restoring native vegetation or providing surrogate vegetation to increase nesting habitats and floral resource availability. Although this may incur costs, it is likely that restoration strategies could be devised to achieve a net economic benefit (Kremen, Williams and Thorp, 2002). Factors such as how restoration would need to be distributed spatially requires economic and ecological research, and provides opportunities for producers to use ecologically sensitive approaches. Encouraging the ecosystem services of native bees, such as food, medicine, and pollination (Matias *et al.*, 2017), can in turn lead to better outcomes, including increased pollination, wild bee conservation and long-term sustainability. Further, using fewer pesticides provides an opportunity to develop the combined use of bees and biological control agents in urban, peri-urban and agricultural landscapes.

Ensuring reliance is not placed on a single pollinator species will enhance the resilience and quality of crop pollination, and provides a commercial opportunity for native bee producers. Incorporating both managed and wild species in our agricultural systems (Garibaldi *et al.*, 2013) is a genuine opportunity for Australian agricultural landholders. Relying on a single pollinator species for food production is risky (Winfree *et al.*, 2007). This dependence carries with it the risks associated with predator, parasite and pathogen development (Tscharntke *et al.*, 2005b; Winfree *et al.*, 2007; Potts *et al.*, 2010). Although honey bees are often considered a substitute for wild pollinators, they don't maximise pollination, or fully replace the contributions of diverse wild insect assemblages to fruit set for a wide range of crops, such as almond, blueberry and watermelon (Garibaldi *et al.*, 2013). Successful pollination of many crops (>40 grown globally) by wild insect pollinators is shown to consistently increase fruit set by twice that of when pollination is facilitated by honey bees (Garibaldi *et al.*, 2013).

### Stingless bees

Stingless bees are efficient pollinators (Heard, 1994) where they occur in the northern regions of Australia. The current main use for Australian stingless bees is as a commercial pollination service for fruit and nut growers, with macadamia nut (*Macadamia integrifolia*), native to eastern Australia, the most commonly pollinated commercial crop (Figure 1). While there are other crops that are under investigation (e.g. Hort Frontiers Pollination Fund project 'Stingless bees as effective managed pollinators for Australian horticulture' (PH16000)), or are known to be pollinated by stingless bees (Appendix 1), they are at the early research stage or are not known to be actively utilised, respectively.

Stingless beekeeping is known as meliponiculture. The main species used for crop pollination are *T. carbonaria* and *Tetragonula hockingsi* (Cortopassi-Laurino *et al.*, 2006; Heard, 2016). A recent article explored the emerging industry of stingless beekeeping, present largely in urban areas, and Aboriginal cultural heritage, which is based on traditional hunting and honey-gathering practices (Perichon *et al.*, 2020).

An important aspect of pollination services is the provision of quality bees and hives. Certifying commercial stingless bee apiarists as producers of high-quality hives, and establishing commercial standards and auditing procedures, will be an important aspect for the industry to lead.



**Table 1**

**Key crops that are pollinated or show potential for pollination at a commercial scale by Australia's native bees, and the native bees that pollinate/have potential to pollinate the crop**

| Fruit | Native bees |
|---|---|
| Avocado | *Lasioglossum (Chilalictus)* spp., *Meliponini* spp., *Tetragonula carbonaria*, *Xylocopa* sp. |
| Blueberry | *Exoneura* spp., *Lasioglossum* spp., *Meliponini* spp., *Tetragonula carbonaria* |
| Lychee | *Meliponini* spp., *Tetragonula* spp. |
| Macadamia | *Lasioglossum (Chilalictus) polygoni*, *Tetragonula carbonaria* |
| Mango | *Tetragonula* spp. |
| Strawberry | *Tetragonula carbonaria*, *Tetragonula hockingsi* |
| Tomato (greenhouse) | *Amegilla (Notomegilla) chlorocyanea*, *Amegilla (Zonamegilla) pulchra* (previously *A. homelsi*), *Xylocopa (Lestis) aerate*, *Xylocopa (Lestis) bombylans* |

See Appendix 1 for references.

#### Solitary and semi-social bees

Solitary 'buzz' pollinating bees, of which there are multiple species across 19 Australian bee genera (Smith and Saunders, 2019), are experiencing increasing interest from researchers and growers in Australia for their potential to pollinate crops grown in glasshouses. Blue-banded bees (*Amegilla*) are a favourable alternative to the introduction of the bumblebee (*Bombus terrestris*) for use as 'buzz' pollinators of glasshouse tomatoes (Appendix 1; Hogendoorn *et al.*, 2006, 2007; Switzer *et al.*, 2016), with more flavoursome fruit produced through bee (*Amegilla murrayensis*) pollination than a pollination wand (Hogendoorn *et al.*, 2010). A current Hort Frontiers project, 'Development of Blue-Banded Bees as Managed Buzz Pollinators' (PH19001), is investigating optimising breeding and management of disease in blue-banded bees.

In the United States of America (USA) and southern Canada, the solitary bee *Osmia lignaria* is being developed as an orchard (apple, prune and almond) pollinator (Bosch *et al.*, 2021; Kemp and Bosch, 2005). In eastern Australia, semi-social carpenter bees offer potential for orchard (pome) pollination (Brown, Barton and Cunningham, 2020). Several species of native bee, including *Amegilla*, leafcutter, resin and blue-banded bees, are pollinators of lucerne (Hogendoorn *et al.*, 2021).

Solitary and semi-social bees occur across all major horticultural production regions of Australia, and could provide a manageable alternative for pollination services, including in regions that stingless bees do not occur and/or in crops that stingless bees are not able to effectively pollinate. The enhancement of habitat for wild solitary/semi-social bees also shows promise (Brown, Barton and Cunningham, 2020; Prendergast *et al.*, 2021).

### 3.1.2 Biodiversity conservation

There is increasing evidence that growing crops near natural habitat increases abundance and diversity of flower-visiting insects, and that these crops have a higher yield than crops growing away from natural vegetation (Heard and Exley, 1994; Kremen, Williams and Thorp, 2002; Garibaldi *et al.*, 2011; Ricketts *et al.*, 2008). Further, as native bee species are often generalists that pollinate many native and crop plants (Heard, 2016), restoring pollination services for agriculture (Kremen, Williams and Thorp, 2002) through strategies such as carbon farming (Sardiñas *et al.*, 2021) and habitat management (Albrecht *et al.*, 2021) could also benefit native vegetation and thereby promote conservation of biodiversity across the agroecological landscape.

In order to conserve and encourage native bees, policies should include conservation or restoration of natural or semi-natural areas within agroecosystems, promotion of landscape heterogeneity, addition of diverse floral and nesting resources, and consideration of pollinator safety with regard to pesticide application (Kremen, Williams and Thorp, 2002; Tscharntke *et al.*, 2005; Greenleaf and Kremen, 2006; Klein *et al.*, 2007). Several of these recommendations entail financial and opportunity costs, however the benefits of implementing them include mitigation against soil erosion, improvements in pest control and pollination, nutrient cycling, and water-use efficiency (Wratten *et al.*, 2012).

There has been recent interest in reintroducing stingless bees into conservation areas (Cortopassi-Laurino *et al.*, 2006). Similarly, stingless, semi-social and solitary bees are being introduced or explored as an option for introduction into areas after bushfires (Kit Prendergast, pers. comm., July 2021; Ken Walker, pers. comm., August 2021). Aboriginal and Torres Strait Islander communities are also working to rescue and relocate to Country stingless bee colonies that are under threat or unwanted, e.g. Indigibee.

### 3.1.3 Hobbyists

In Australia, several stingless bee species are sold in hives for hobbyists. Stingless bees lack a functional stinger and the characteristic non-aggressive behaviour (unless disturbed or provoked) makes them an attractive option. Further, these traits lend themselves to urban environments, provided there are sufficient flowers available.

Solitary and semi-social bees do not use a hive but nest in soil and woody parts of plants. Offering homes, in the form of bee hotels, is gaining increasing attention globally, with such structures sold commercially, including in Australia (Heard, 2016; see the SWOT below for the pros and cons of these structures).

### 3.1.4 Education and awareness

Stingless bees are appealing for community-based education programs (Cortopassi-Laurino *et al.*, 2006; Heard 2016). Museums, exhibitions, gardens, early learning/childcare centres, schools and several businesses in Australia use social bee colonies to promote a range of nature-based topics. These include parasitism, pollination, sociality (Cortopassi-Laurino *et al.*, 2006) and sustainability. A recent example is the Gold Coast Regional Beekeepers group engaging with Bunnings at Nerang and a local Vietnam Veterans' Men's Shed to supply and build stingless bee hives respectively for a chain of early childhood learning centres on the Gold Coast. Formalising and broadening these opportunities for pre-school and school children, communities, corporates and tertiary institutions is a possibility.

## 3.2 Stingless bee products

Honey, propolis and pollen produced by stingless bees can be sold raw or processed into a variety of foods, cosmetics and toiletries.

### 3.2.1 Native bee honey

Native bee honey is produced by stingless bees, from collected and dehydrated floral nectar. Many native bee honeys are considered to have a tangier flavour than *A. mellifera* honey due to the small resin pots in which the honey is stored (Heard, 2016; Haley, 2021) and are well regarded by connoisseurs for their depth of flavour (Fletcher *et al.*, 2021). Native bee honey is highly valued by Aboriginals and Torres Strait Islanders, who collect it from wild nests – real bush tucker! Among Aboriginals and Torres Strait Islanders, there are significant traditional values, beliefs and cultural practices associated with stingless bees. A recent article explores the emerging industry of stingless beekeeping, present largely in urban areas, and Aboriginal cultural heritage, which is based on traditional hunting and honey-gathering practices (Perichon *et al.*, 2020).

Stingless bees have a range of nesting habits, mainly in tree hollows, so special methods and a range of hive designs have been developed to house them and harvest moderate amounts of native bee honey without harm (Cortopassi-Laurino *et al.*, 2006). Stingless bees produce small amounts of native bee honey, typically up to 1 kg per hive per annum (*A. mellifera* produce up to 59.5 kg/hive/annum). Only in warm areas of Australia, such as in Queensland and northern New South Wales, can they produce more native bee honey than what they require for their survival. The main stingless bee honey production period is from late spring to summer and is dependent upon the region and floral resources. Scaling up hive production, including through automation, is an opportunity for the industry. Industry standard(s) for hive design would benefit colony health and potentially increase hive productivity.

Australian native bee honey has antioxidant (Persano Oddo *et al.*, 2008) and *in vitro* antimicrobial properties (Irish *et al.*, 2008; Boorn *et al.*, 2010; Massaro *et al.*, 2015). Several species of native stingless bees in Australia (and elsewhere) produce honey that contains the beneficial disaccharide trehalulose, which is not dominant in any other foods, rather than glucose and fructose found in the honey of other bees (Fletcher *et al.*, 2020). Trehalulose has a low glycaemic index (GI) (Hungerford *et al.*, 2021). This property makes it appealing to consumers; it does not cause tooth decay (Fletcher *et al.*, 2020) and a low GI diet has a number of health benefits, including reducing blood sugar levels, aiding weight loss and lowering the risk of heart disease and type 2 diabetes. Research supports the long-standing claims of Aboriginals and Torres Strait Islanders that native bee honey is beneficial for human health. Further, as trehalulose is produced by stingless bees from sucrose (Hungerford *et al.*, 2021), positioning hives near plants with sucrose-rich nectar has potential to alter trehalulose content of honey (Mary Fletcher, pers. comm., August 2021). Attempts by stingless beekeepers to feed bees sucrose will produce honey high in trehalulose, but the C4 signature of the honey will show it is adulterated (Hungerford *et al.*, 2021).

*Tetragonula carbonaria* brood.
Photo: Tim Heard

### 3.2.2 Propolis

Propolis is the nest-building material that stingless bees produce in abundance. Aboriginals and Torres Strait Islanders collect it from nests for a range of traditional uses, including making didgeridoo mouthpieces (Heard 2006), waterproofing vessels, securing tool heads to handles, protecting rock art, and making personal adornments (Megan Halcroft, pers. comm., 2021). Australian stingless bee propolis has antioxidant (Massaro et al., 2011) and antimicrobial (Massaro et al., 2014) activity, and may have therapeutic application for conditions in which vascular supply is compromised (Massaro et al., 2013), but this requires further research.

### 3.2.3 Pollen

Pollen is abundant in hives, with about 1 kg produced per year per hive (Tim Heard, pers. comm., July 2021). There is little scientific evidence to support the benefits of this product, however pollen supers may be an opportunity to exploit this resource (Ian Driver, pers. comm., July 2021) if deemed valuable.

## 4. Stingless bee investment

The key areas for stingless bee investment as identified by Coriolis, 2020b are:

1. Increasing native bee honey yields and reducing costs, including through automation
2. Marketing and messaging to target consumers, not beekeepers as is currently the case
3. Value-added products that contain small amounts of raw native bee honey or propolis

### 4.1 High-potential customers and commercial partners

The highest-potential customers and commercial partners for Australian stingless bee products include a range of multinational companies in the cosmetics; skin, hair and personal care; hospitality; medicine and personal heath sectors (Coriolis, 2020b). However, while the industry is still young, it is expected that the supply of stingless bee products will likely provision smaller niche brands (Richard Ray, pers. comm., July 2021).

## 5. Advantages of Australian stingless bee products

### 5.1 Authenticity and provenance

Aboriginals and Torres Strait Islanders have long harvested native bee honey from stingless bees and have an extensive knowledge base. Stingless bees are woven into culture and art, which provides a unique opportunity for Aboriginal and Torres Strait Islander stingless bee enterprises. A long-term example of this is the work of Russell and Janine Zabel, who have linked with the Aboriginal community of Aurukun in Far North Queensland to develop a stingless bee industry, mostly comprising *T. hockingsi* (Cortopassi-Laurino *et al.*, 2006).

Fraudulent or adulterated native bee honey is a real issue. This can occur in two ways: i) addition of sugar or feeding of sugar solution to bees, or ii) blending honey bee honey (which is less expensive) with native bee honey (Haley, 2021). Thus, a food standard or certification that enables the establishment of authentic, unadulterated products is required. A method to identify honey from the DNA of bees present in the honey has been developed (Peng Kek *et al.*, 2017). There is also a C4 isotope test (isotope ratio – mass spectrometry), which will readily show if the addition of sugar/corn syrup or feeding of sugar has occurred (Hungerford *et al.*, 2021). Recent advances in Australia have resulted in the identification of a unique bioactive marker, trehalulose, for authentication of native bee honey in associated food standards (Fletcher *et al.*, 2020). A current initiative that seeks to develop a 'honey library' for *Apis* honey to increase supply chain transparency (Hayes, 2020) could also be explored for native bee honey. In addition, work is underway to develop methods to DNA profile stingless bees, the botanical/floral sources and the microbial profile of products (James Hereward, pers. comm., July 2021).



### 5.2 Australian branding

In export markets, Australian stingless bee products provide another point of difference for "Brand Australia" (Wilkinson, Morris and Hughes, 2021).

## 6. Current challenges and barriers for the Australian native bee industry

### 6.1 Stingless bee value chain

The stingless bee value chain is in its infancy in Australia (Wilkinson, Morris and Hughes, 2021). The main barriers include a lack of consumer awareness of the services stingless bees provide, inconsistent supply of native bee honey and associated products, distribution logistics, and scalability in the supply chain (Wilkinson, Morris and Hughes, 2021).

### 6.2 Native bee threats

The main threats to Australian native bees are the removal of nesting and foraging resources through land clearing and agriculture, the spread of exotic plant species, and the consequences of a changing climate (Slaa *et al.*, 2006; Michener, 2007; Batley and Hogendoorn, 2009; Heard, 2016; Winfree 2010). Pesticides and biosecurity are further concerns. These threats are in line with the evidence of global declines in both wild and domesticated pollinators, and parallel declines in the plants that rely upon them (Potts *et al.*, 2010). Further, the increase in demand for native bees and 'spotter fees' will see an increase in robbing, or removing of native bee colonies from the bush, as well as theft of commercial and hobbyist hives if not managed.

Land clearing and habitat destruction removes adequate nesting sites and food resources/floral diversity for native bees (Kline and Joshi, 2020). In agroecosystems, large monocultures with intensive production systems often cannot support populations of wild bees required for effective pollination of crops (Kline and Joshi, 2020). These vast monocultures of agricultural crops are likely having an impact because of the absence of flowers for much of the year (Batley and Hogendoorn, 2009).

The impact of *B. terrestris* (in Tasmania) and *A. mellifera* on native bees is thought to be predominantly indirect through propagation of exotic weeds at the cost of native vegetation (Batley and Hogendoorn, 2009 and references therein).

The increase in the frequency and severity of climatic events, particularly bushfires, and increases in temperatures due to climate change are likely to impact native bees through loss of their native habitat (Batley and Hogendoorn, 2009). Bushfires in 2007 reduced the nesting substrate of the last remaining South Australian population of the green carpenter bee, *Xylocopa aerata* (Hogendoorn, Glatz and Leijs, 2021). However, recently, a conservation effort showed that artificial nesting substrates could substantially improve the breeding capacity of a threatened population of these endemic bees in their natural habitat (Hogendoorn, Glatz and Leijs, 2021).

The impact of pesticides on bees is well recognised. Although most studies have focused on *A. mellifera*, smaller-bodied stingless bees are probably more susceptible than honey bees due to their high surface area-to-volume ratio (Slaa *et al.*, 2006). For example, sulfoxaflor was shown to have a greater impact on the solitary bee *Osmia bicornis* than *A. mellifera* and the bumblebee *Bombus terrestris* (Azpiazu *et al.*, 2019). The development of protocols that detect sublethal effects of pesticides in native bees is deemed an urgent priority, in order to improve understanding of the effects of pesticide exposure on the dynamics of bee populations in agroecosystems (Azpiazu *et al.*, 2019; Sgolastra *et al.*, 2019).

The threat of exotic pests and disease is a long-term concern for industry. A recent initiative funded by the Department of Agriculture, Water and the Environment (DAWE) (through the Chief Environmental Biosecurity Office; CEBO), titled 'Environmental Risk Mitigation Plan for the Australian Native Bee Industry', aims to better understand the biosecurity risks and provide recommendations for priority actions to improve biosecurity preparedness and management for Australian native bees. The Plan will include a stakeholder map, list of pest risks, identification of pest entry pathway intervention points, and identification of knowledge gaps and future research goals for investment.

### 6.3 Conservation and biodiversity

Early steps to conserve native bee fauna include commercial applications, the raising of public awareness and preservation of natural habitat. However, these actions are severely hampered by a lack of both identification keys and taxonomic expertise (Batley and Hogendoorn, 2009) and, in some instances, poor survey methods and taxonomic practices (Prendergast and Hogendoorn 2021).

Conservation of many habitats depends upon preservation of bee populations, due to the reliance of many of the world's plants on bees for reproduction (Michener, 2007). Certain habitats are extremely rich in bee-pollinated plants, and their preservation and reproduction may be essential in preventing erosion and other problems, and in providing food and cover for wildlife (Michener, 2007).

Conservation could be affected by the commercial use of stingless bee colonies for pollination services. Ensuring that colonies for such services are mainly obtained from breeding programs, instead of from nature, will ensure commercial use of stingless bees does not negatively impact on the wild population, and may also contribute to their conservation. Several recent publications provide evidence-based methods to conserve our native bees (Prendergast and Ollerton, 2021; Anon., 2016; Smith and Heard, 2016).

Particular conservation consideration needs to be given to species that may occur in low numbers or within limited areas. For example, although solitary carpenter bees (Xylocopa) are suitable pollinators of tomato (Hogendoorn, Steen and Schwarz, 2000), they are relatively rare in Australia and nearly extinct in southern areas (Leys, 2000). Therefore, large-scale harvesting to establish a breeding population for commercial pollination is not feasible (Hogendoorn et al., 2007). However, blue-banded bees (Amegilla) are a feasible alternative (Bell, Spooner-Hart and Haigh, 2006; Hogendoorn et al., 2006; Hogendoorn, Coventry and Keller, 2007).

### 6.4 Managed bee challenges

Challenges, particularly for stingless bee management, include domestication, mass rearing and colony reproduction, pollination conditions, pests and disease, migratory hives and environmental contaminants in native bee honey.

#### 6.4.1 Domestication

To use stingless bees for commercial pollination purposes, management of colonies in hives is of vital importance (Slaa *et al.*, 2006).

There are many different species of stingless bees that have been kept in hives (Cortopassi-Laurino *et al.*, 2006; Grüter 2020), including in Australia. And despite several species being domesticated since ancient times, management of stingless bee colonies is not as advanced as management of honey bee colonies (Cortopassi-Laurino *et al.*, 2006). In addition, stingless bee management practices have been developed principally for the harvest of hive products, mainly native bee honey.

Using colonies for commercial pollination services has different management requirements. Colonies used for pollination services are much more disturbed than colonies used for native bee honey production (Slaa *et al.*, 2006). Transportation to and from the crop, and the limited diet offered by the crop (many crops offer no nectar), are challenges that must be considered (Slaa *et al.*, 2006).

#### 6.4.2 Mass rearing and colony reproduction

Colonies used for pollination services and commercial-scale native bee honey production need to be available in large numbers.

Colonies can be propagated by splitting, brood transfer or eduction (budding) of the hive population (adult bees and brood), resulting in a new colony (Cortopassi-Laurino *et al.*, 2006; Drew Maywald, pers. comm., July 2021). While native beekeepers have developed methods to overcome the challenges of rearing and reproduction, there remains room for efficiencies and standards for these practices.

Although artificial insemination has not been developed for stingless bees, this is an alternative to natural mating (Slaa *et al.*, 2006) and is an opportunity for colony reproduction on a commercial scale. Recently in Australia, the Gloag lab at The University of Sydney successfully hatched virgin stingless bee queens in petri dishes and performed controlled matings in which queens were inseminated with target males. Regardless, the limiting factors for colony growth and reproduction are largely unknown, and further research is warranted to advance this area.

#### 6.4.3 Pollination conditions

In Australia there are several native bee species that are utilised or currently being researched for crop pollination (Appendix 1), however there are gaps in research and knowledge of other potential bee species, including foraging capabilities. Knowing the factors that contribute to the successful foraging of native bees, particularly in confined environments such as greenhouses, is key to understanding their effectiveness as pollinators, in addition to the number required and the costs to breed adequate numbers.

Under confined conditions, there are several challenges for successful pollination. Bees may mass in the top of the enclosure (especially during the first days after release), which can lead to death (Amano, 2004). Further, a lack of foraging may occur due to suboptimal foraging conditions, a low attractiveness to the crop, and/or a reluctance to forage under confined conditions, suggesting they may be unsuitable for greenhouse pollination (Slaa *et al.*, 2006). An important consideration for solitary bees is ensuring they can be reared in the numbers required at the time of crop flowering, as they typically have a short lifecycle, spending 2-6 weeks as an adult, with the remainder spent in nests underground or in plant material as pre-pupae and pupae (Ken Walker, pers. comm., July 2021).

Stingless beekeeping on a large scale may face problems with species that show aggressive nest defence and/or intra-species territorial behaviour, when hives are situated in close proximity (Slaa *et al.*, 2006). This behaviour has been displayed in some species of Australian *Tetragonula* (Gloag *et al.*, 2008; Cunningham *et al.*, 2014). Conversely, a study of *T. carbonaria* showed foreign intruders were accepted among artificially aggregated colonies, probably because under these conditions the cues available for successful discrimination between nestmates and non-nestmates are reduced (Stephens, Beekman and Gloag, 2017). This behaviour prevents colonies from launching costly defensive swarms in response to harmless drifters, and is a benefit under artificial scenarios.

#### 6.4.4 Migratory hives

The increase in demand for hives, for commercial and hobbyist purposes, is causing greater movement of these hives throughout Australia, and is therefore raising concerns about management of migratory hives, disease transmission, weakening of genetics, movement of species to non-endemic ranges, and associated ethical care standards. For example, there is concern that movement of *T. hockingsi* hives will accelerate the observed invasive wave of this species moving south.

In Australia, there are restrictions on the movement of plants and animals of agricultural and environmental significance, both living and dead, between states. These are managed by the Subcommittee for Domestic Quarantine and Market Access (SDQMA; https://www.interstatequarantine.org.au/).

Each state and territory has its own specific regulations with regard to the movement of plants and animals (including bees), and these need to be considered when movement of stingless bee hives/native bee hotels and/or bees across state and territory borders is planned.

#### 6.4.5 Pests and disease

Native bees are susceptible to several pests and diseases, such as Shanks brood disease (Shanks *et al.*, 2017), small hive beetle, native pollen beetle, syrphid fly and phorid fly. There is also evidence that viruses may be transmitted from *A. mellifera* (Mary Fletcher, pers. comm., July 2021), and that such spillover may be harmful (Congedi, 2021). This susceptibility increases when the bees are mass-reared in large numbers.

#### 6.4.6 Environmental contaminants in native bee honey

Stingless bees are environmental monitors and have the potential to transfer environmental contaminants, if present, to their honey (Hungerford *et al.*, 2019). However, a recent study showed that there was low or negligible pesticide, herbicide and polycyclic aromatic hydrocarbon (PAH) contamination in native bee honey from Queensland and Malaysia, regardless of whether the origin of the honey was urban or rural (Hungerford *et al.*, 2019).

# Strengths, weaknesses, opportunities, threats

## Strengths

### Native bees

- Engaged research capacity across universities and scientific disciplines, with established links with industry
- Stingless bees and some solitary bees play an important role in crop pollination
- The use or conservation of native bees for pollination supports adaptation to a changing climate
- Protecting and promoting native flora and fauna through pollination by native bees safeguards future pollination needs
- Diversity of most native bee species means that there is potential to pollinate a range of crops
- Diversity of pollinators in field and protected cropping leads to improved pollination
- The industry organisation is established and has a large membership base (>600 members), as well as a website, social media, newsletter, events calendar and regular industry conferences
- There is cooperative research across multiple research institutions and business enterprises

### Stingless bees

- Several species are known to deliver a valuable pollination service to agricultural crop farmers in their endemic range
- Endemic native bees are able to flourish in hotter regions that may be marginal for European honey bees, providing climatic resilience for crop pollination services
- Honey contains healthy rare sugars that are up to 85 per cent trehalulose (low GI and does not cause tooth decay), along with other components known to provide health benefits such as polyphenols and organic acids
- Readily kept in hives. Hives are cheaper to make and maintain than honey bee hives
- Unique Australian native bee honey products can satisfy a drive beyond manuka and jarrah honey
- Free from several devastating pests and diseases that occur internationally
- Suffer from fewer diseases, pests and parasites than European honey bees, thus simplifying colony management
- Well suited to growing consumer demand for authentic, local foods with a good provenance story
- Can be maintained indoors in colder climates using temperature-controlled rooms and/or hives
- Colonies don't die after reproducing (like bumble bee colonies, for example) and are long-lived (hives can be kept for up to 60 years)
- Lack a functional sting and are not aggressive, making them especially suitable for pollination of crops in inhabited areas and in enclosed spaces, e.g. greenhouses, and for hobbyists (protected cropping is an emerging area of industry interest to which stingless bees are well suited)
- Forage year-round under suitable climatic conditions, making them suitable for pollination of off-season crops in greenhouses
- Foraging distance means they will pollinate within the area the hive is situated
- Less specialist knowledge required as compared with *Apis* beekeeping
- Food Standards Australia New Zealand and other legislation governs food handling, labelling etc. of native bee honey and other native bee products
- Stingless bees fed sucrose will produce honey high in trehalulose, however the C4 signature of native bee honey will show it is adulterated
- Australian propolis has unique attributes that distinguish it from other forms internationally

### Semi-social and solitary bees

- Present in variable numbers in many agroecosystems and provide free pollination services
- Occur in many areas where stingless bees are typically unable to persist, including southern NSW, Victoria, South Australia and most cropping areas in Western Australia
- Pollinate a range of crops that are not pollinated by stingless bees (e.g. buzz-pollinated tomato, bush tomato, lucerne and carrot seed)
- Often larger than stingless bees, and hence visit more flowers per foraging bout

## Weaknesses

### Native bees

- Lack of knowledge or understanding about the importance and application of RD&E for native bees by some in the industry and the community
- Unconfirmed whether some bees pollinate crops effectively, rather than just visiting, which is required before releasing for pollination

### Stingless bees

- Current native bee honey yields are very low (approximately 1 kg/hive/annum) when compared with honey from introduced European honey bees (up to 59.5 kg/hive/annum)
- Consumer awareness of the benefits of native bee honey is low, largely because we are only just beginning to research this aspect. There is much greater consumer awareness internationally, e.g. in Malaysia and Brazil, presumably because of a greater focus on honey research in these countries
- Product is not consistently available
- Skilled labour force is required to increase production
- Scalability across the supply chain remains unknown
- Distribution logistics are yet to be established
- Removal of colonies from the wild poses a threat to conservation
- Stingless bee domestication, colony reproduction and mass rearing for commercialisation not established
- Small size may make them less efficient pollinators than *A. mellifera* in some instances, as they would visit fewer flowers and/or not make contact with the stigma of larger flowered crops (e.g. passionfruit, watermelon, zucchini)
- Cannot be used in southern regions for pollination
- Susceptible to several pests and diseases, including viruses transmitted from *Apis*, such as Shanks brood disease, small hive beetle, native pollen beetle, syrphid fly and phorid fly
- Negative impact of monoculture crops during pollination on bee health
- Theft – hives can be readily removed/taken
- Stingless bee hives are not registered or regulated in the same way that *Apis* hives are
- Cannot make claims about the therapeutic properties of bee products unless organisations that are making these claims have registered products with the Therapeutic Good Administration (TGA)
- Regulations in some regions constrain and do not account for mobility of hives

### Semi-social and solitary bees

- Very few remaining taxonomic experts
- Lack of taxonomic keys for many species
- Further research required to develop understanding of the taxonomy, biology, ecology and conservation status of a minority of species (approximately 300-400)

# Strengths, weaknesses, opportunities, threats

## Opportunities

### Native bees

- Defined and realised values for the industry
- Recognition and incorporation of Aboriginal and Torres Strait Islander knowledge and cultural ownership can lay the foundations for social licence for the industry
- Development of a single source of robust, evidence-based information about native bees
- Reliable, scientific-based RD&E that yields robust outputs and outcomes, achieved via collaborative research and publication in both industry and scientific literature
- Development of a peak industry body (PIB)
- Increased knowledge and recognition from the general public and producers of the role of native bees in our native environments and agriculture
- Incorporation of native bees into community and school education programs
- Better understanding of the contribution of natural vegetation near crops to wild insect pollinators and thus pollination and yield
- Better understanding of native bees' potential role in pollination across multiple industries, including wildflowers, horticulture (field and protected cropping), pasture, seed production (e.g. sunflower)
- Promotion of an operating environment for investment that is the strongest it has been for pollination (strongly weighted) in particular
- Use of native bees and biological control agents together in crop management
- Development of optimal spraying practices to minimise impact of pesticides on native bees
- Development of a certificate in managed native bee husbandry
- Industry-driven regulation (be on the front foot) for harvest and propagation of bees, development and sale of bee products, and hive movement
- Use of native bees for therapy (mental health and well-being)
- Development of interstate quarantine standards for movement of bees

### Stingless bees

- Native bee honey and propolis can be sold raw or processed into a variety of true luxury, super-premium products, including foods, cosmetics and toiletries
- Development of a native bee honey standard that meets quality and health requirements and provides increased consumer confidence
- There are great commercial prospects for Aboriginal and Torres Strait Islander communities given the narrative, provenance and art of native bees and their products
- Sustainable increase in native bee honey yield while maintaining or enhancing beneficial content (e.g. trehalulose)
- Development of the bioactive marker of native bee honey, trehalulose, to prevent fraudulent or adulterated products being sold
- Development and agreement of quality parameters for stingless bee products, including trehalulose content, with associated certification and labelling to ensure consumer confidence
- Hobbyists and community groups can become involved in the industry through, for example, selling honey, building hives, enhancing local pollination or enhancing biodiversity
- Improved efficiency and effectiveness of managing Australian native bees, and development of industry standards/regulation, quality assurance and certification of hives and hive products, including bee health and welfare
- Development of stingless bee husbandry skills, including mass rearing
- Development of ethical care standards for migratory beekeeping to ensure conservation of species, while minimising issues such as maximum carrying capacity or introduction of species outside their native range
- Baseline survey of native bee populations across the country
- Incorporation of native vegetation for foraging into crop/orchard design to support bee health and apiary management
- Development of niche markets (e.g. incorporated into Australian camel milk industry products) and export markets
- Improved shelf-life of native bee honey

### Semi-social and solitary bees

- Investigation of the pollination efficacy, nesting habits, diseases and ecology of crop-pollinating species
- Development of bee husbandry skills for pollination in protected cropping
- Development of targeted action to support beneficial crop pollinators in agroecosystems and peri-urban/urban environments

## Threats

### Native bees

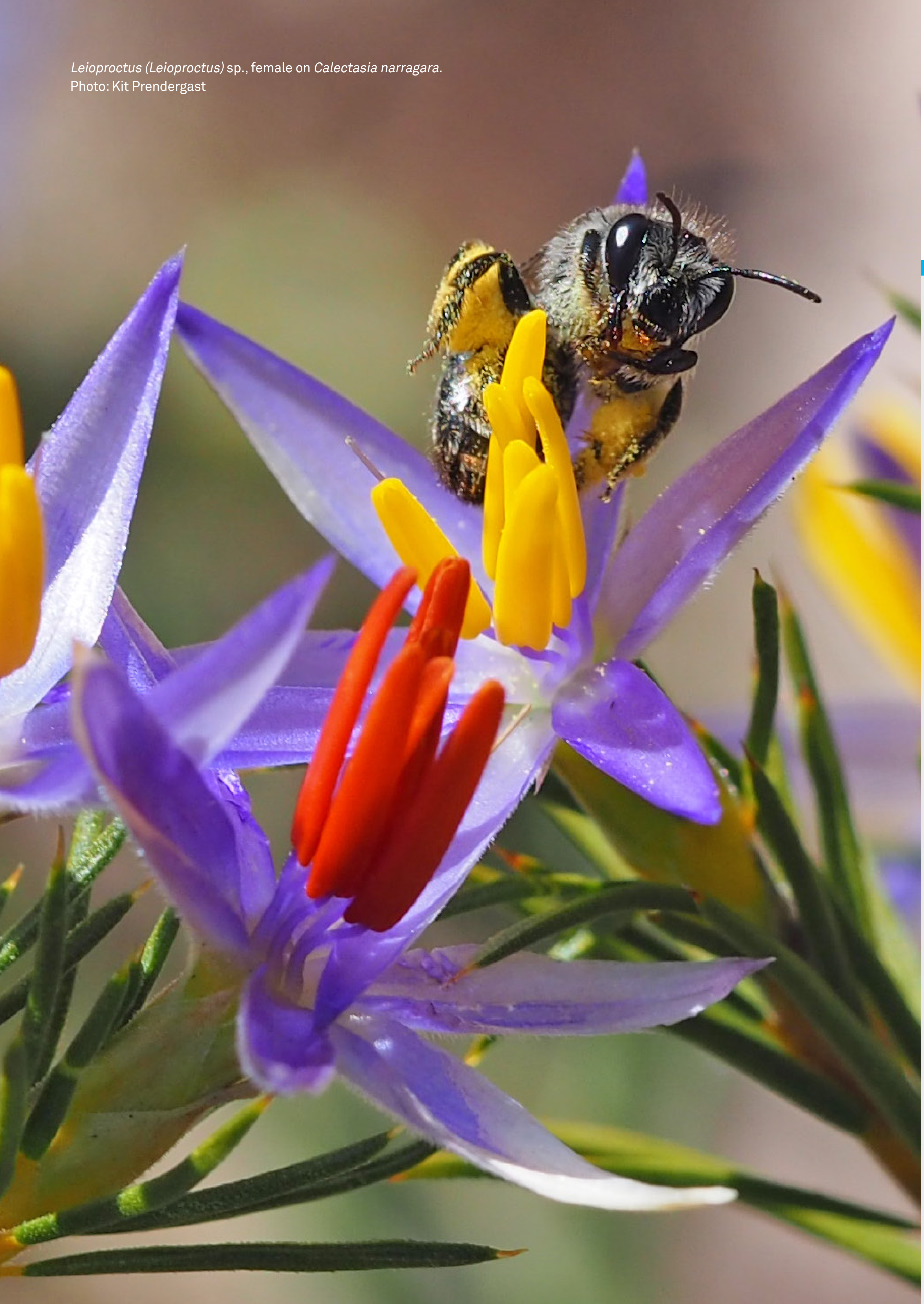
- Lack of RD&E investment in an emerging industry
- Exotic pests and diseases; biosecurity
- Changing climate (heat, drought, flood, bushfires)
- Pesticides, including residues – those used in agriculture and to control pests of humans and the environment
- Land clearing/habitat loss
- African tulip trees – native bees enter and die in the flower
- Biopiracy/lost opportunities – establishment of a native bee industry internationally using Australian bees
- Potential competition with *Apis* and other non-native bee species
- Underestimation of the importance of resilience in crop pollination services

### Stingless bees

- Fraud – 'fake' or adulterated honey sold as authentic Australian native bee honey
- Supplementation of the native bee diet with sucrose, which will impact the unique flavour of native bee honey, as well as bee diet and health
- Regulation requirements that currently don't meet industry needs
- Market dynamics – the highest value for native bee honey may be within the country it is produced
- Native bee honey marketed internationally without robust scientific underpinning, resulting in poor personal relations outcomes and potential damage to future marketing opportunities
- Invasive wave of *Tetragonula hockingsi* moving south and movement of stingless bee species outside of their natural range
- Limited knowledge of what harmful compounds may be contained within bee products, e.g. pesticide residues
- Unregulated removal of hives from public/Crown land/native bushland, which can have negative impacts on the environment and the social licence of the industry to operate

### Solitary and semi-social bees

- Bees lost from the wild before they can be taxonomically identified
- Underestimation of the value of solitary bees as crop pollinators



*Leioproctus (Leioproctus)* sp., female on *Calectasia narragara*.
Photo: Kit Prendergast



# Industry consultation

This Australian Native Bee Strategic RD&E Plan has been developed in close consultation with a key group of industry stakeholders. In June 2021, a core group of interested individuals and organisations were identified via communications distributed through AgriFutures Australia and ANBA that were facilitated by the project team. This group of more than 100 stakeholders, from public and private business, government (federal and state), and research organisations formed the basis of the Native Bee Industry Reference Group (NaBIRG). To enhance the consultation process, numerous project lead/team conversations were held over Zoom, or over the phone with individual stakeholders, to further develop ideas and contributions to the Plan. One stakeholder was contracted to develop Appendix 1 together with the project lead, which was peer-reviewed by three anonymous reviewers.

In mid-June 2021, the NaBIRG was contacted by email to introduce the project team, and to arrange a series of four inception meetings. During these meetings, held on 2 July and 5 July 2021 and attended by 47 stakeholders, the project team outlined the scope, requested any relevant documentation, and sought additional stakeholder contacts. This was followed by a discussion and input from stakeholders on an initial vision for industry, opportunities and challenges that may be faced and initial insights into key thematic areas for research.

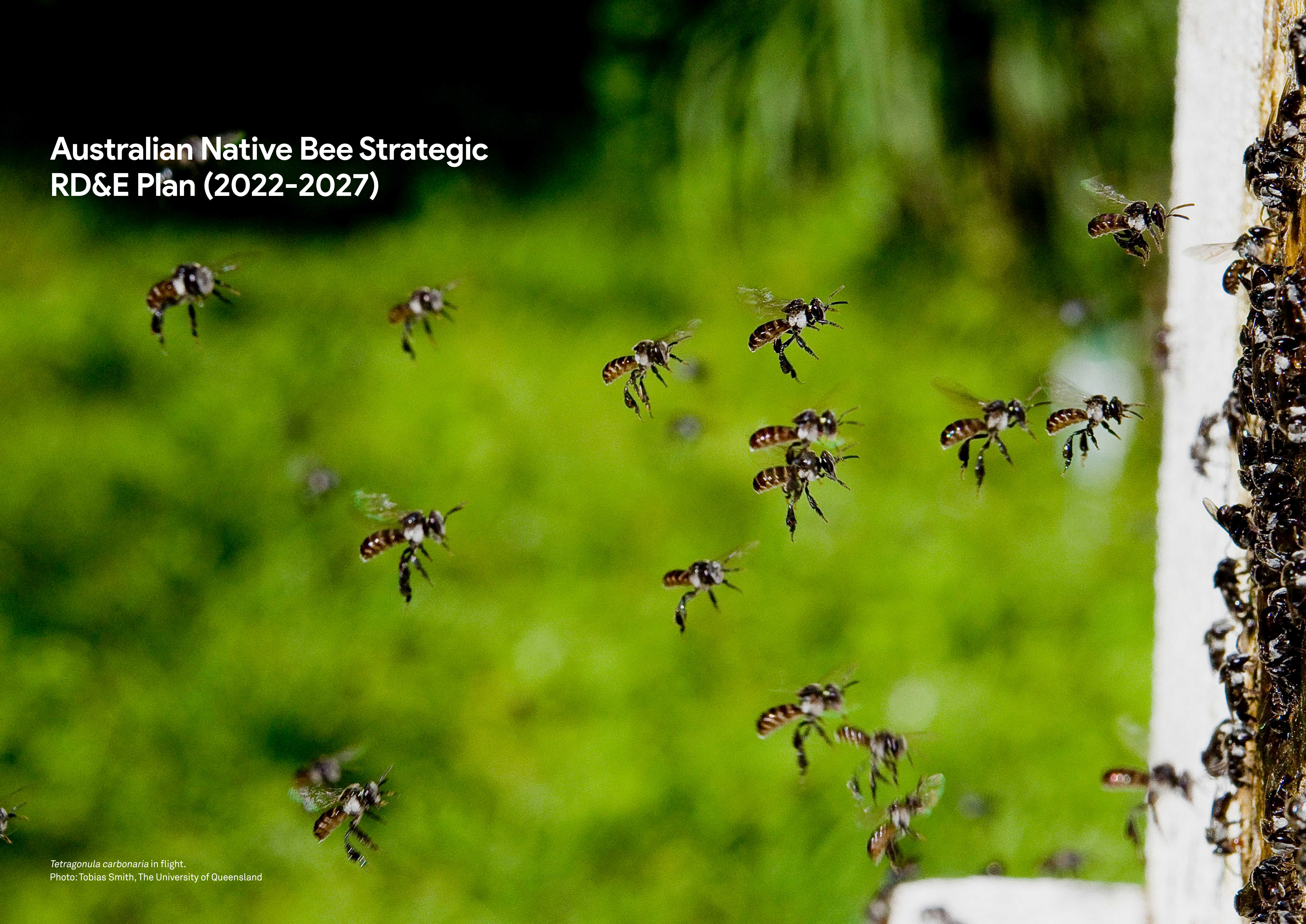
Subsequently, a first draft of the industry situation analysis, a strengths, weaknesses, opportunities and threats (SWOT) analysis, and RD&E themes were prepared and provided to the NaBIRG. From 14-16 July 2021, 51 NaBIRG members participated in a series of interview meetings via Zoom to obtain input on these papers via a semi-structured questionnaire approach. Six meetings were held to ensure maximum input from the range of stakeholders. The focus was to:

1. Provide feedback on the industry situation analysis and SWOT
2. Develop a 10-to-15-year vision and mission
3. Identify the key gaps in the themes and strategies of the Strategic RD&E Plan
4. Commence discussion to identify a peak industry body

The second major draft of the Strategic RD&E Plan was prepared and included a series of activities aligned to each strategy. It was sent to the NaBIRG in late July 2021, followed by a one-day workshop (Zoom) limited to 23 NaBIRG members to ensure effective input online, on 5 August 2021. Stakeholders workshopped the vision and mission, SWOT, goals, outcomes, strategies and activities, and added key performance indicators (KPIs) across each activity. With KPIs articulated against each 'investible' activity, and activities contributing to strategies, in turn contributing to goals, outcomes and the vision, the monitoring, evaluation and reporting (MER) framework was embedded in the Plan. The foundations of communication and extension (C&E) and implementation plans were also developed

Working groups of six individuals were established to provide final input into both the situation analysis and SWOT.

Following the August workshop and working group feedback, a third draft of the Strategic RD&E Plan was developed. In mid-August 2021, the body of the Plan, comprising only the goals, strategies, activities and KPIs, was circulated to the NaBIRG for review and prioritisation of the activities via a poll. These were then collated and incorporated into the final draft of the Strategic RD&E Plan. The final draft was presented to AgriFutures Australia and the workshop and working group stakeholders on 2 September 2021, with 25 in attendance, and the Australian Native Bee Strategic RD&E Plan was endorsed by ANBA and in-principle by Indigibee on 28 September 2021.



# Australian Native Bee Strategic RD&E Plan (2022-2027)

*Tetragonula carbonaria* in flight.
Photo: Tobias Smith, The University of Queensland

# Australian Native Bee Strategic RD&E Plan (2022-2027) At a glance

## Vision

A highly valued and sustainable native bee industry that provides widespread pollination services, produces multiple premium products and services, and promotes conservation and biodiversity, based on best environmental, ethical and social practices.

## Mission

The Australian native bee industry will:

- Provide managed and support wild pollination of a broad range of agricultural crops and the environment.
- Produce high-quality, high-value native bee honey, propolis and other products for domestic and export markets.
- Be recognised as a best management practice industry (nationally and internationally) with regards to accepted product and service standards, and conservation of native bees to protect their welfare and role in the environment.
- Increase broad community awareness and knowledge, raise the profile, and support use and ownership of native bees.
- Engage with Aboriginal and Torres Strait Islander communities for mutual exchange of knowledge and development of opportunities.
- Secure investment and undertake collaborative and coordinated RD&E necessary to support the vision.

## Goals

- Pollination by native bees is widely recognised, valued and utilised across agroecosystems.
- Stingless bee products (native bee honey and propolis) are viably produced, widely recognised and highly valued.
- Native bee management is ethical and regenerative.
- The industry is cohesive and collaborative, and underpinned by enhanced awareness, knowledge, capacity and community support for native bees.
- Biodiversity and conservation of native bees is underpinning a regenerative and successful industry and healthy ecosystems.

### Outcomes

- Native bees are highly valued managed and wild pollinators of agricultural crops in Australia.
- Native bee honey and propolis are in high demand as valued products with significant health, social and environmental benefits.
- Knowledge of managed native bees and their environment is considerably enhanced to ensure their management is ethical and regenerative, and supports the sustainable development of pollination and native bee products.
- Knowledge of wild native bees and their habitat is significantly enhanced to support the conservation of bees and identify opportunities for enhanced ecosystem services and land restoration.
- Aboriginal and Torres Strait Islander enterprises are an integral and integrated component of the native bee industry.
- There is increased capability and capacity of skilled labour for the industry.
- Australian Native Bee Association (ANBA) is recognised as the peak industry body for managed and wild native bees, providing leadership, driving implementation of the RD&E Plan, and operating collaboratively across the industry.

## The road ahead

The Australian Native Bee Strategic RD&E Plan describes the RD&E activities to be implemented to achieve the vision, mission and outcomes. While it is nominally a five-year plan (2022-2027), realistically the level of funding and investment secured, and any potential events outside the control of industry (e.g., establishment of Varroa Mite), will determine progress towards industry goals.

Each strategy and activity are informed by the SWOT and are related to the goals, outcomes and vision. Each activity describes an area of potential RD&E investment, and includes at least one key performance indicator as an indicator of progress.

The Strategic RD&E Plan should be evaluated on a regular basis for progress towards the outcomes as measured by KPIs. The nominal owner of the Plan, ANBA, should lead this exercise, potentially as part of or adjunct to its biennial conference and through an RD&E subcommittee.

Furthermore, a detailed review and evaluation should be undertaken early in the final year of the Plan, with a view to developing a revised version for 2027-2032.

**“The Australian Native Bee Strategic RD&E Plan describes the RD&E activities to be implemented to achieve the vision, mission and outcomes ... the level of funding and investment secured, and any potential events outside the control of industry, will determine progress towards industry goals.”**

# Australian Native Bee Strategic RD&E Plan (2022-2027)

## 1 Pollination by native bees is widely recognised, valued and utilised across agroecosystems

### Justification

To maximise the opportunity for native bee pollination of agricultural crops, significant new knowledge is required. Managed and wild native bees can provide significant pollination to agricultural crops, complementing pollination provided by European honey bees and potentially as standalone pollinators, particularly if buzz pollination is required. This is potentially of great importance should Varroa Mite enter and establish in Australia, and threaten European honey bees.

### Strategies

**1.1** Understand which species of native bees can and do pollinate (which) agricultural crops.

**1.2** Develop hive and habitat management strategies to enhance pollination by stingless bees.

**1.3** Improve construction and placement of artificial management structures and habitat to enhance pollination by solitary and semi-social bees.

**1.4** Consider native bees in APVMA registration requirements for agricultural/industrial chemicals.

**1.5** Understand the potential impacts of climate change and develop adaptation strategies.

### Activities

**1.1.1** Research and document which stingless bees currently pollinate or could pollinate which agricultural crops.

**KPI** Pollination efficacy is quantified for the 4-5 main stingless bee species across at least 10 established agricultural crops and at least one emerging crop.

**KPI** Pollination efficacy is quantified for 4-5 stingless bee species that we know something about across five crops where stingless bees are complementary to *Apis*.

**KPI** Crops that lesser-known stingless bee species pollinate are identified

**Priority** Very high

**1.1.2** Research which solitary bees could pollinate agricultural crops, including by buzz pollination and for protected cropping.

**KPI** The six most abundant pollinators to promote/manage by region and crop type are understood.

**Priority** High

**1.1.3** Develop better understanding of the current role of wild native bees in crop pollination.

**KPI** The diversity of pollinators to promote/manage by region and crop type is understood.

**Priority** High

**1.1.4** Establish whether there is a role for managed solitary bees to be utilised in protected cropping systems.

**KPI** Opportunities to manage the six most efficient native pollinators are evaluated

**Priority** Medium

**1.2.1** Identify optimal hive stocking rates, considering efficiency (hives/ha/crop); movement of bees within the crop and foraging distances; optimised pollen delivery and timing for best fruit set; permanent hives; and aggregated pollination services for mobile hives.

**KPI** Stocking rates are established for crops that are already known to benefit from native bee pollination per region.

**Priority** Very high

**1.2.2** Develop best practice guidelines so hives and associated habitat are managed for optimal and regenerative bee health, including during non-bloom period.

**KPI** Best practice guidelines for hive practice and bee health are developed.

**Priority** Very high

**1.3.1** Research benefit, design and placement of artificial management structures for proven useful native bee pollinators for bee health and pollination.

**KPI** Guidelines for design (including substrates) and placement of artificial management structures that enhance pollination are researched.

**Priority** Low

**1.3.2** Identify habitat requirements of solitary and semi-social native bee species that pollinate crops, and develop guidelines to better manage habitat, including expansion of feeding and nesting resources.

**KPI** The plants/floral resources used by bees in agroecosystems are identified following a critical analysis, identification of research gaps and development of an implementation plan.

**KPI** Regional guidelines for habitat management and enhancement are developed.

**Priority** Medium

**1.4.1** Work with the Australian Pesticides & Veterinary Medicines Authority (APVMA) to ensure that applications for the registration of AgVet chemicals consider the protection of native bees.

**KPI** Published evidence that documents the impact of key chemicals on native bees, and how (if) this differs to honey bees, is recognised by the APVMA.

**Priority** High

**1.4.2** Develop best practice guidelines for use of agricultural chemicals that incorporate research into complementary, cumulative and synergistic effects, to ensure native bees are protected.

**KPI** A good practice guideline is developed that details how to protect native bees in agricultural and urban settings.

**Priority** Medium

**1.4.2** Research the potential impact of climate change on native bee pollinators, and develop risk management and adaptation strategies.

**KPI** Case studies of key groups of native bee species are published and include a comprehensive understanding of the physiology and distributions of bee species.

**Priority** Low

## 2 Stingless bee products (native bee honey and propolis) are viably produced, widely recognised and highly valued

### Justification

The benefits of stingless bee products should be verified to enhance their premium. Certification and provenance testing systems are required to build consumer confidence. Stingless bees produce a range of products that are potentially highly valuable, highly nutritious, have medicinal and therapeutic properties and currently command a significant premium. However, optimal regenerative production techniques of native bee honey and propolis are not well established for large-scale production and consistency of supply.

### Strategies

**2.1** Explore management techniques to increase sustainable production volume and beneficial bioactive content (e.g., trehalulose) of native bee honey.

**2.2** Develop and deploy sustainable product extraction techniques and processing and storage techniques.

**2.3** Verify the positive health, medicinal, wellbeing and therapeutic properties of native bee products, and develop new high-value products from native bee honey and propolis.

**2.4** Demonstrate the purity, safety, provenance and quality of stingless bee products against associated industry standards, and highlight these attributes in labelling to protect against impure products (particularly those substituted and adulterated) and to enhance consumer confidence.

### Activities

**2.1.1** Examine hive design and management techniques to improve production volume of native bee honey while maintaining the beneficial bioactive content (e.g., trehalulose).

**KPI** Guidelines for hive(s) that optimise sustainable production of native bee honey and bee health for each region are developed.

**Priority** High

**2.1.2** Examine genetics of bees to improve production volume while maintaining beneficial bioactive content (e.g., trehalulose) of native bee honey.

**KPI** Identification of optimal genetics of bees for honey production has commenced.

**KPI** A breeding program has been initiated.

**Priority** Low

**2.1.3** Develop best practice guidelines so hives are managed to maximise sustainable native bee honey production, including placement of hives near plant species with sucrose-rich nectar.

**KPI** Guidelines are researched, produced and accepted by industry.

**Priority** Medium

**2.1.4** Develop good practice guidelines for honey harvest in native environments that ensure regeneration of hives and prevent extraction in protected conservation areas, except for Aboriginal and Torres Strait Islander use.

**KPI** Good practice guidelines for extraction of honey from hives in native environments are produced.

**Priority** Low

**2.1.5** Examine floral nectar sugar profiles (sucrose/fructose/glucose) to improve/optimise trehalulose content of native bee honey.

**KPI** Non-crop species with sucrose-rich nectar with the potential to produce trehalulose-rich native bee honey are identified.

**KPI** Crops with sucrose-rich nectar with the potential to produce trehalulose-rich native bee honey (concomitant with pollination) are identified.

**KPI** List of target plants with sucrose-rich nectar to enable production of native bee honey with more consistent high trehalulose content is published and distributed to industry.

**Priority** High

**2.2.1** Develop and document clean, safe, regenerative and repeatable techniques to extract honey (minimising pollen content) that maximise product while protecting hive health and welfare. Techniques should consider opportunities for automation.

**KPI** Native bee honey extraction techniques are developed, documented and extended, utilising existing documents.

**KPI** Automation of honey extraction methods has been explored.

**Priority** High

**2.2.2** Develop clean, safe, sustainable and repeatable techniques to extract propolis that maximise product while protecting hive health and welfare

**KPI** Native bee propolis extraction knowledge is developed, documented and extended, utilising existing documents.

**Priority** Low

**2.2.3** Explore the integrity of native bee honey and propolis under processing and storage conditions.

**KPI** The storage life of products per bee species and region is known.

**Priority** Low

**2.3.1** Research native bee honey and propolis to verify positive health, medicinal and therapeutic properties (e.g., presence of trehalulose, antioxidant and antimicrobial properties).

**KPI** The chemical compositions of native bee products, including the bioactives and therefore the benefits, are known and published.

**KPI** The nutritional and medicinal properties of native bee products are established.

**KPI** Properties (key components) of native bee products are established to support an application to the TGA, to enable sale as a therapeutic good.

**Priority** Very high

**2.3.2** Develop with food, cosmetic, wellbeing and pharmaceutical industries (and others) new commodities based on the beneficial properties of stingless bee products.

**KPI** Properties (key components) of stingless bee products are established to support an application to the TGA, to enable sale.

**Priority** Low

**2.3.3** Develop the positive, socially conscious and environmentally conscious backstory for stingless bee products to aid awareness and marketing.

| | |
|---|---|
| **KPI** | Traditional uses of native bee products are documented following collaboration with or by Aboriginal and Torres Strait Islander groups, with knowledge shared and Aboriginal and Torres Strait Islander IP appropriately protected. |
| **Priority** | Low |

**2.4.1** Develop (or adapt) techniques to measure stingless bee product safety, provenance and quality, including standardised sampling procedures.

| | |
|---|---|
| **KPI** | Products conform to FSANZ requirements (name and quality standards). |
| **KPI** | Standardised technique/s are developed and readily available. |
| **KPI** | Reference signatures of products for different provenances are developed. |
| **KPI** | Naturally occurring toxins are identified and managed. |
| **Priority** | High |

**2.4.2** Develop and agree quality parameters for stingless bee products, including trehalulose, with associated certification and labelling to ensure consumer confidence.

| | |
|---|---|
| **KPI** | A quality assurance system describing parameters and certification process is developed. |
| **Priority** | Medium |

**2.4.3** Research the impact of using chemicals to ensure residues are not detected in stingless bee products.

| | |
|---|---|
| **KPI** | The presence of unwanted chemical residues (e.g., agrochemicals, heavy metals) in bee products is documented. |
| **Priority** | Low |

*Tetragonula carbonaria* queen and workers on brood.
Photo: Tim Heard

# 3 Native bee management is ethical and regenerative

## Justification

The native bee industry understands the need to be driven by regenerative practices across the board. A holistic approach to ensuring social stingless, solitary and semi-social bees are managed respectfully is required, to ensure their welfare is protected and their populations are regenerated, be they managed or wild bees. Managed stingless bees must have hive, nutrition, habitat and welfare requirements satisfied.

Note: This goal recognises that solitary and semi-social bees are currently in the research, not management, stage in Australia.

## Strategies

**3.1** Undertake management of stingless bees to the highest industry standards.

**3.2** Ensure nutritional requirements of stingless bees are met, to guarantee health, productivity, pollination efficiency and sustainability.

**3.3** Ensure construction and management of stingless bee hives is fit for purpose, to maintain hive health.

**3.4** Better understand the limiting factors for population growth and reproduction, to assist growth of stingless bee populations.

**3.5** Manage the biosecurity risks for managed native bees.

## Activities

**3.1.1** Develop standards and certification systems (with industry auditing procedures) to manage native bees, for commercial operators, hobbyists and land developers.

**KPI** Standards and certification systems (with industry auditing procedures) are developed, published and accepted by industry.

**Priority** High

**3.1.2** Develop good practice guidelines for colony rescue (e.g. from water meter boxes) that prevent wild harvesting (except for Aboriginal and Torres Strait Islander use).

**KPI** Good practice guidelines for wild harvesting and colony rescue are developed, published and widely distributed.

**Priority** Medium

**3.2.1** Develop standards to manage the nutritional needs of managed stingless bees under various circumstances (e.g. outside of field bloom periods, protected cropping scenarios), including where artificial feeding may be required.

**KPI** Nutritional requirements of stingless bees across species and regions, including floral resources and supplementation, are understood, including sugar profiles (sucrose/fructose/glucose).

**KPI** Standards to manage the nutritional needs of managed stingless bees are published.

**Priority** High

**3.3.1** Understand how stingless bees respond to various hive box attributes fit for purpose.

**KPI** Research on how stingless bees respond to hive attributes is published.

**Priority** Low

**3.3.2** Understand the thermal tolerance capacity of managed bees and their hives.

**KPI** The thermal tolerance/characteristics of key native bee species is known.

**KPI** The optimal thermal properties of hive materials – both natural and man-made – under a range of scenarios, including environmental factors, are published.

**Priority** Medium

**3.3.3** Understand optimal construction and management of hives for stingless bees.

**KPI** Good practice guidelines are developed and accepted by industry for management of hives, including construction, placement, splitting, propagation, eduction, log transfers, budding, pest management and establishment.

**Priority** Medium

**3.4.1** Research factors limiting the growth in managed colony numbers.

**KPI** Factors that limit colony growth, including natural enemies and disease, climatic limitations, management practices, hive design and substrates, positioning, movement between seasons, resource availability, and propagation techniques, are understood, improved and documented.

**Priority** High

**3.4.2** Research commercial bee reproduction strategies, including mass breeding and artificial insemination techniques.

**KPI** The impacts of queen performance characteristics on colony growth are better understood.

**Priority** Low

**3.5.1** Understand, regularly review and actively manage the biosecurity risks for native bees.

**KPI** A biosecurity manual is developed and published, with a process in place for regular review and active management.

**Priority** Medium

# 4 A cohesive and collaborative industry underpinned by enhanced awareness, education, capacity and community support for native bees

## Justification

The native bee industry currently lacks the capacity to meet current and future demand for services and products. To achieve the industry's commercial and sustainability goals, the agricultural sector and the broader community must be supportive of the industry and the positive environmental, social and product attributes.

## Strategies

**4.1** Raise awareness and understanding of the important role of native bees in agriculture, the environment and the broader community, to generate widespread community and consumer support and grow the industry.

**4.2** Raise awareness and understanding of the multiple positive attributes of native bee products, to generate widespread community and consumer support and grow the industry.

**4.3** Ensure the long-term growth and sustainability of the industry by increasing capability and capacity of the native bee science community, commercial operators and hobbyists.

**4.4** Ensure the industry has a strong, inclusive and proactive industry body.

**4.5** Ensure Aboriginal and Torres Strait Islander communities are an integral part of the industry, as they have significant traditional knowledge about managing native bees.

## Activities

**4.1.1** Increase the agricultural sector's understanding of the importance of and opportunity for pollination by native bees.

**KPI** Native bee stakeholders are better engaged with farmers through involvement and inclusion in projects (where relevant), attendance and participation at workshops and conferences, and the development and distribution of evidence-based grower guides.

**Priority** Very high

**4.1.2** Increase community appreciation and utilisation of native bees for food production, health and environmental benefits.

**KPI** A program of science communication and engagement targeted at the broader community that links current and historical research is developed and available in a single portal.

**Priority** Medium

**4.2.1** Develop communication extension products and disseminate information about the benefits of native bees and native bee products.

**KPI** ANBA, working collaboratively with other organisations, is leading outreach and engagement.

**KPI** An industry commercialisation plan for current and future products is developed.

**Priority** Medium

**4.3.1** Develop training and certification programs.

**KPI** The framework for a training and certification program that encompasses solitary, semi-social and social bees is developed and recognised by the Vocational Education and Training (VET) system and registered training organisations (e.g., Technical and Further Education; TAFE).

**KPI** The industry has engaged with the Primary Industries Education Foundation (PIEF) to incorporate native bees in the school curriculum.

**Priority** Medium

**4.3.2** Working with universities, promote undergraduate native bee activities in agricultural and environmental courses, and postgraduate/postdoctoral project opportunities.

**KPI** The industry is engaging with academic institutions to create native bee and pollination courses for incorporation in undergraduate degrees more broadly.

**KPI** The industry is engaging with academic institutions to encourage postgraduate/postdoctoral projects that address industry needs.

**Priority** High

**4.4.1** Working collaboratively with others, ANBA to enhance its role to become recognised and operate as the peak industry body (PIB) for managed and wild native bees.

**KPI** ANBA has strengthened the depth and breadth of its membership, and is made up of a broad range of industry stakeholders with a range of views.

**KPI** ANBA has attracted further funds through increased membership, corporate events, and funding bodies to enhance its impact and support implementation of the Strategic RD&E Plan.

**KPI** ANBA is representing the native bee industry and is recognised as the PIB by major stakeholders, including government.

**Priority** Very high

**4.4.2** Develop a national source of reliable quality information and knowledge about managed native bees.

**KPI** ANBA has established a national information portal.

**Priority** High

**4.4.3** Develop, through the ANBA, strong alignment, collaboration and communication with other strategic and international native bee initiatives and organisations, to stay abreast of the latest research and industry development activities of relevance.

**KPI** ANBA has established links with international organisations and continues to grow linkages and report to members.

**Priority** Medium

**4.5.1** Undertake proactive and respectful engagement with Aboriginal and Torres Strait Islander communities for mutual exchange of scientific and traditional knowledge of native bees (while protecting IP and respecting international conventions).

**KPI** An Aboriginal and Torres Strait Islander advisory body or network is formed with ANBA to assist Indigenous-led research on native bees.

**KPI** An engagement model and communication framework are developed by and with multiple Aboriginal and Torres Strait Islander communities to establish trust and support empowerment, growth and dual communication.

**Priority** Medium

**4.5.2** Support Aboriginal and Torres Strait Islander communities in development of regenerative Indigenous native bee enterprises.

**KPI** Regenerative Aboriginal and Torres Strait Islander native bee product enterprises have been established with the support of the native bee industry.

**Priority** High



# 5 Biodiversity and conservation of native bees is underpinning a regenerative and successful industry and healthy ecosystems

## Justification

The role of native bees in pollination and ecosystem function in natural systems is little understood for most species, but they are a natural component and potentially play a critical role in maintaining the healthy and biodiverse function of native ecosystems, and in habitat conservation and restoration. Equally, the role of conservation and biodiversity of native bees to underpin a growing commercial industry needs to be understood for long-term sustainability.

## Strategies

**5.1** Consider the long-term sustainability of native bee populations to ensure a sustainable industry and healthy ecosystems.

**5.2** Develop habitat management and restoration practices to enhance wild native bee populations, their pollination potential and ecosystem function.

**5.3** Protect wild native bee populations against biosecurity risks.

## Activities

**5.1.1** Increase the baseline understanding of wild native bees, including taxonomy, range, behaviour and ecology.

**KPI** Existing knowledge and data is consolidated (e.g., national database) through engagement with institutions (e.g., museums) and communicated.

**KPI** A robust taxonomy system is developed and used, and specifically utilises valid names when databasing.

**KPI** A COI (DNA) barcode facility for valid species is finalised and used consistently.

**KPI** Funding for bee taxonomists is secured.

**Priority** High

**5.1.2** Increase understanding of role of potential vectors of disease and ecosystem effect/environmental interactions with managed bees to ensure the health and sustainability of wild populations.

**KPI** The understanding of existing diseases that impact native bees is greatly enhanced.

**Priority** High

**5.1.3** Establish surveillance systems for native bees to monitor populations, using citizen science and other methods.

**KPI** Citizen science strategies are developed or adapted from existing systems, and are in operation, including the on-share and aggregation of data captured.

**KPI** Native bee stakeholders are using platforms such as Atlas of Living Australia to share and aggregate native bee data.

**Priority** Low

**5.2.1** Develop habitat management and restoration practices to conserve and enhance wild native bee populations.

**KPI** Good practice guides that support wild native bees in different environments are developed and provide information on food and nesting resources, phenology, diet width and connection of landscapes.

**Priority** Medium

**5.3.1** Understand biosecurity risks to native bees and develop biosecurity strategies, including ensuring against the import of exotic bees, pests and diseases, and protection from genetic material that may carry disease.

**KPI** Extension materials for the highest-risk exotic bee species and pathways are developed and distributed.

**Priority** High

# Communication and extension

The objectives of the communication and extension plan are:

- Generate awareness of native bees and their diversity, importance to agriculture as pollinators, importance in the environment and role in community wellbeing
- Generate awareness of the value and health benefits of native bee products
- Generate awareness of Aboriginals and Torres Strait Islanders' cultural connection to native bees
- Generate awareness of the Strategic RD&E Plan and potential funding opportunities
- Maximise adoption of RD&E outputs

The development of native bee industry-wide communication products should be led by ANBA, with activities undertaken across industry. As the Strategic RD&E Plan is implemented, the quality and value of native bee products is promoted, the importance of bees to agriculture and the environment is better understood, and guidelines and quality assurance (QA) systems are developed, then communication and engagement activities will need to evolve and expand, supported by the data.

## Key messages and products

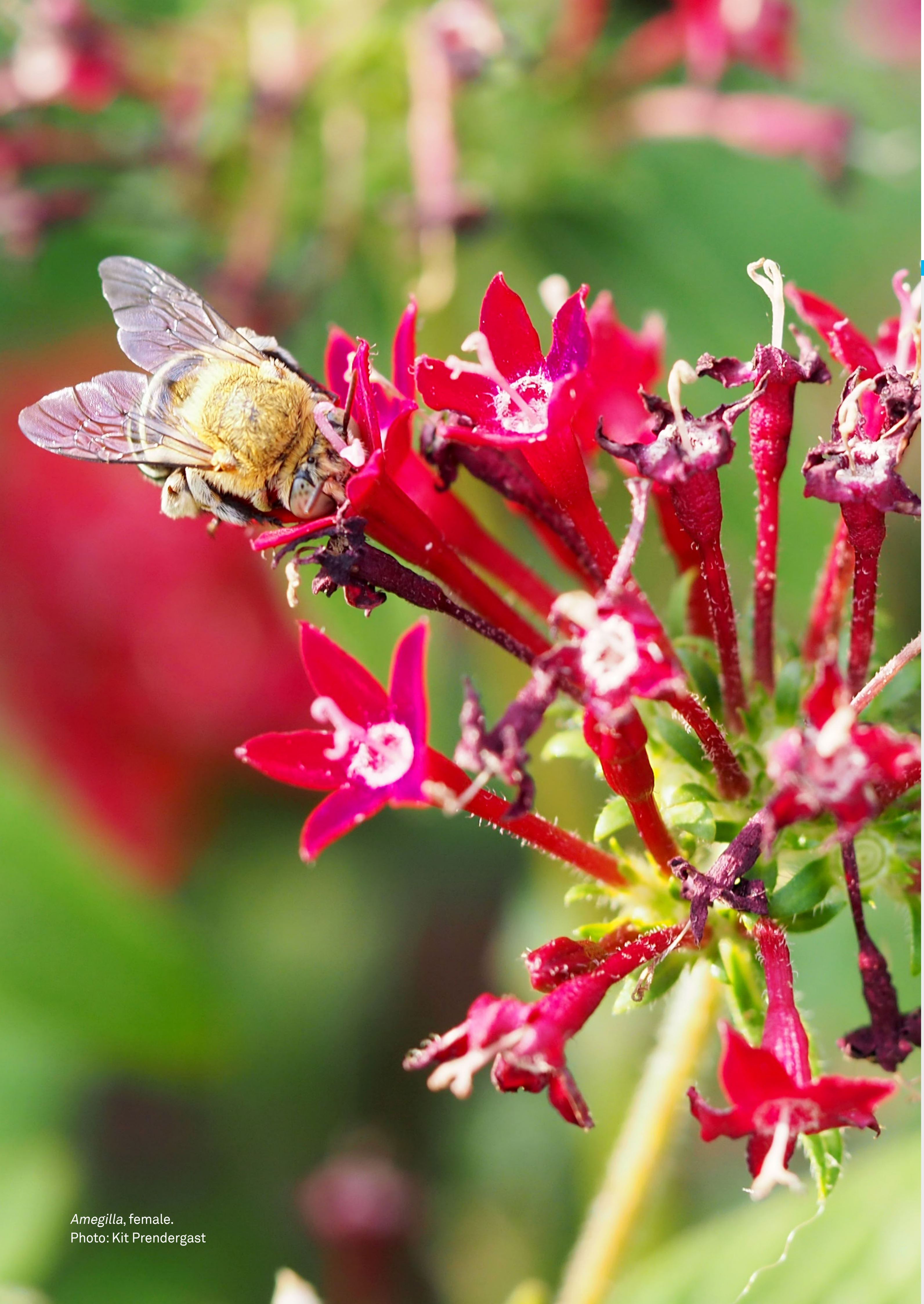
- Stingless native bees are valuable pollinators for agricultural crops. Further, the use of native bees will be important to build resilience in our pollination systems.
- Native bees are an integral, irreplaceable and biodiverse component of Australian native ecosystems, and can play a role in environmental restoration and climate adaptation.
- Native bees and native bee products are environmentally positive.
- Native bees can be socially beneficial – with many health and wellbeing benefits.
- Native bee products have positive nutritional and medicinal applications, including potential uses in nutraceuticals and pharmaceuticals.
- Aboriginals and Torres Strait Islanders have used native bees for honey and propolis for millennia, and have a deep understanding and respect for them.
- The native bee industry has an opportunity to be a leader in innovative and regenerative agtech.

## Key audiences and why they are needed

- Researchers – to undertake the activities of the Strategic RD&E Plan.
- Commercial and hobbyist native bee industry participants – to ensure they are aware of the current state of the industry, the Strategic RD&E Plan and the outputs that will arise from it, and the importance of working within the industry.
- National and state farmer groups – to raise awareness and understanding of native bees and the emerging industry.
- Agricultural investors – to inform them of the importance of native bees and potential investment opportunities.
- Land management and conservation groups – to ensure they understand the importance of native bees and are aware of best practice guidelines for management and enhancement of native bees.
- Educators – to raise awareness of and support for native bees.
- General public – to raise awareness of and support for native bees.
- Australian Native Foods and Botanicals and First Nations Bushfoods and Botanicals Alliance Australia – to ensure they are aware of the Strategic RD&E Plan and the opportunities for native food products from native bees.
- Local governments and the Australian Local Government Association – to support their local environmental programs and regulations
- Philanthropic organisations and not-for-profits with an interest in regenerative production, biodiversity and native bees in particular (e.g., Wheen Bee Foundation) – to raise awareness and understanding of native bees.
- Horticulturalists and horticulture suppliers – to raise awareness and understanding of the importance of native bees to the environment and pollination.
- National nursery organisations (e.g., Greenlife Industry Australia), nurseries and nursery suppliers, including to home gardeners (e.g., Bunnings) – to raise awareness and understanding of the importance of native bees to the environment and pollination.

## Key activities

- Stage a biennial ANBA conference.
- Produce and widely distribute 'The Cross-Pollinator' magazine.
- Publish research results in high-quality scientific journals and industry outlets.
- Post on social media platforms.
- Engage with the Primary Industries Education Foundation (PIEF).
- Engage with Vocational Educational and Training (VET) providers.
- Participate in National Aborigines and Islanders Day Observance Committee (NAIDOC) Week and Indigenous Business Month, and engage with Indigenous Business Australia.
- Attend and present at relevant business/industry development conferences
    - Developing Northern Australia
    - Northern Australia Food Futures
- Undertake outreach workshops with stakeholder groups (i.e., farmer groups).
- Attend and present at agricultural field days.
- Attend and present at local festivals/stands.
- Actively participate and engage in Australian Pollinator Week, National Honey Month and World Bee Day.



*Amegilla*, female.
Photo: Kit Prendergast



# Implementation

The native bee industry is an emerging industry with significant potential to grow through its impact as a pollination industry, the provision of native bee honey and propolis products, and the expansion of awareness, interest and conservation of native bees. It is an industry consisting of diverse stakeholders with varied curiosities, all of whom have a responsibility to develop an industry that is economically sustainable and socially valued, and that regenerates native bee populations. Equally, it is the responsibility of all native bee stakeholders to proactively implement this Strategic RD&E Plan, working collaboratively and in concert with ANBA.

While the development of the Strategic RD&E Plan has been supported by AgriFutures Australia, ANBA, the key industry body representing native bee stakeholders, will take overall leadership and responsibility for coordination of the Plan. Specifically, ANBA should:

- Take responsibility for proactively driving and co-ordinating implementation of the Plan;
- Proactively engage and collaborate with key stakeholder organisations (e.g. Wheen Bee Foundation, IndigiBee, Australian Honey Bee Industry Council) to develop opportunities aligned with the Plan;
- Serve as the key communication agent for the industry, including raising awareness of the Plan, latest RD&E activities and new knowledge;
- Proactively explore and secure funding for the Plan;
- Regularly update members on the activities and status of the Plan;
- Ensure the ANBA Strategic Plan aligns with this Plan; and
- Consider an RD&E subcommittee as part of ANBA.

The key risks and mitigation strategies for implementing this Strategic RD&E Plan are outlined below.

| Risk | Mitigation measure |
|---|---|
| The Strategic RD&E Plan is not widely known or accepted. | ANBA and its members and collaborators must proactively own and implement the Strategic RD&E Plan, raise awareness, and support and encourage participation by stakeholders, including pollination enterprises, honey and propolis producers, land managers, conservation and biodiversity groups, funding bodies, educational organisations, and researchers. |
| There is a lack of RD&E funding – science investors don't engage with or support the Plan. | Native bee scientists, supported by and collaborating with ANBA, must communicate the importance of native bees and the Strategic RD&E Plan to generate funding from multiple sources to implement the Plan. |
| The native bee industry is unable to generate matched funds or resources that would assist with securing RD&E investment from funding bodies. | ANBA and collaborators must specifically target key funders, research agencies and industry stakeholders to develop collaborative proposals. ANBA should consider securing funds to implement the Plan and undertake a range of activities outlined in the Plan (e.g., communications and guidelines development). |
| ANBA not perceived as representing the whole industry. | ANBA should seek to expand its membership so it represents the diversity of the industry, in the best interests of the industry. |

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# Appendix 1

Prendergast, K. and Reynolds, O. L. 2021. Australian native bee sociality, nesting habits and current and future potential as pollinators of commercial crops for human consumption or forage/fodder for stock, and of Australian native bushfoods. AgriFutures Australia, Wagga Wagga, NSW, Australia.

It should be noted that this appendix is an initial documentation of Australian native bees as current and potential pollinators of commercial crops and Australian native bushfoods. It is by no means exhaustive and should be expanded and continually updated.

## Apple

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Exoneura* | Pithy stems/reeds | Semi-social | Yes: pollen on scopa[1] |
| Apidae | *Exoneura* (Brevineura) melaena | Pithy stems/reeds | Semi-social | No[2] |
| Apidae | *Exoneura* (*Exoneura*) hamulata | Pithy stems/reeds | Semi-social | No[2] |
| Apidae | *Exoneura* (*Exoneura*) spp. | Pithy stems/reeds | Semi-social | No[3] |
| Apidae | *Exoneura* (*Exoneura*) tasmanica | Pithy stems/reeds | Semi-social | No[2] |
| Apidae | *Exoneura* (*Exoneura*) turneri | Pithy stems/reeds | Semi-social | No[2] |
| Apidae | *Exoneura* spp. | Pithy stems/reeds | Semi-social | No[4] |
| Apidae | *Tetragonula* | Hollows | Eusocial | No[5] |
| Colletidae | Euryglossinae sp.2, Euryglossa sp. | Ground-nesting | Solitary | No[4] |
| Halictidae | *Lasioglossum (Chilalictus)* spp. | Ground-nesting | Semi-social | No[3] |
| Halictidae | *Homalictus* | Ground-nesting | Semi-social | Yes: pollen on scopa[1] |
| Halictidae | *Lasioglossum* | Ground-nesting | Semi-social | Yes: pollen on scopa[1] |
| Halictidae | *Lasioglossum (Chilalictus)* cf. *clelandi* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus)* cf. *orbatum* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus) cognatum* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus) opacicalle* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus)* sp. | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus)* spp. | Ground-nesting | Semi-social | Yes: pollen on scopa[1] |
| Halictidae | *Lasioglossum* (Parasphecodes) cf. *hilactum* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum* (Parasphecodes) spp. | Ground-nesting | Semi-social | No[3] |
| Halictidae | *Lasioglossum* spp. | Ground-nesting | Semi-social | No[4-6] |

## Australian finger lime

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Megachilidae | *Megachile* sp. | Small pre-made cavities often created by wood-boring beetles | Solitary | No[6] |

## Avocado

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Meliponini* spp. | Hollows | Eusocial | Yes (anecdotal)[7–9] |
| Apidae | *Tetragonula carbonaria* | Hollows | Eusocial | Yes: pollen deposition[1] but see[10] |
| Apidae | *Xylocopa* sp. | Wood burrow | Solitary/semi-social | No[11] |
| Halictidae | *Lasioglossum (Chilalictus)* spp. | Ground-nesting | Semi-social | No[12] |

## Basil

| Family | Bee taxa (species/ genus/taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Exoneura* spp. | Pithy stems/reeds | Semi-social | No[13] |
| Megachilidae | *Megachile (Eutricharaea) obtuse* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[13] |
| Megachilidae | *Megachile (Eutricharaea) serricauda* | Ground-nesting | Solitary | No[13] |
| Megachilidae | *Megachile (Eutricharaea) chrysopyga* | Ground-nesting | Solitary | No[13] |

## Berry

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Tetragonula carbonaria* | Hollows | Eusocial | No[14] |



## Blackberry

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Meliponini* spp. | Hollows | Eusocial | No[7] |

## Blackberry and raspberry

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Tetragonula carbonaria* | Hollows | Eusocial | Yes: pollen on scopa, fruit size[1] |
| Halictidae | *Homalictus (Homalictus) urbanus* | Pithy stems/reeds | Semi-social | Yes: pollen on scopa, fruit size[1] |

## Blueberry

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Exoneura (Exoneura)* spp. | Pithy stems/reeds | Semi-social | No[3] |
| Apidae | *Exoneura* spp. | Pithy stems/reeds | Semi-social | Yes: fruit set[15] |
| Apidae | *Meliponini* spp. | Hollows | Eusocial | Yes (anecdotal)[7–9] |
| Halictidae | *Lasioglossum (Parasphecodes) spp.* | Ground-nesting | Semi-social | No[3] |
| Halictidae | *Lasioglossum (Chilalictus)* spp. | Ground-nesting | Semi-social | No[3] |
| Halictidae | *Lasioglossum* spp. | Ground-nesting | Semi-social | Yes: fruit set[15] |
| *Meliponini* | *Tetragonula carbonaria* | Hollows | Eusocial | Yes: fruit set[15] |

## *Brassica oleracea*

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Megachilidae | *Megachile (Eutricharaea) obtusa* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[6] |
| Megachilidae | *Megachile (Eutricharaea) serricauda* | Ground-nesting | Solitary | No[6] |
| Megachilidae | *Megachile (Eutricharaea) simplex* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[6] |

## Broad beans

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Megachilidae | *Megachile (Eutricharaea) obtusa* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[6] |
| Megachilidae | *Megachile (Eutricharaea) serricauda* | Ground-nesting | Solitary | No[6] |
| Megachilidae | *Megachile (Eutricharaea) simplex* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[6] |

## Canola

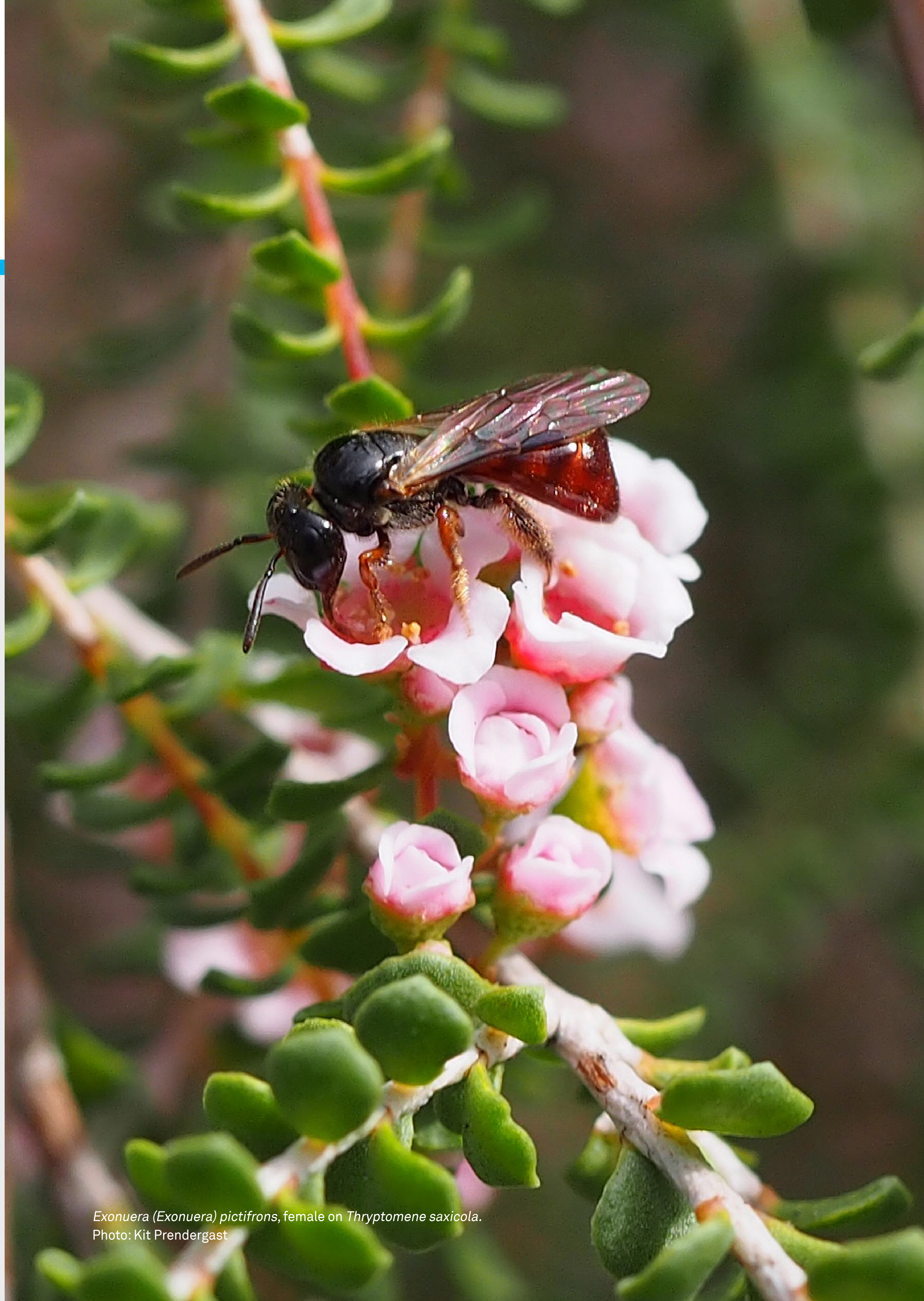
| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Amegilla (Notomegilla) chlorocyanea* | Ground-nesting | Solitary | No[16] |
| Colletidae | *Leioproctus* spp. | Ground-nesting | Solitary | No[16] |
| Halictidae | *Lasioglossum (Chilalictus): L. cognatum, L. eremaean, L. erythrurum, L. instabilis, L. occiduum*, and *L. vitripenne; L. (Parasphecodes) sulthicum, Homalictus urbanus* | Ground-nesting | Semi-social | No[1] |
| Halictidae | *Lasioglossum* | Ground-nesting | Semi-social | No[16] |
| Halictidae | *Lasioglossum (Chilalictus)* sp. | Ground-nesting | Semi-social | No[13] |

## Capsicum

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Austroplebeia australis* | Hollows | Eusocial | Yes: pollen on stigma and pollen tube growth, fruit size, weight and "grade" in greenhouses compared with control[17] |
| *Meliponini* | *Tetragonula carbonaria* | Hollows | Eusocial | Yes: pollen on stigma and pollen tube growth, fruit size, weight and "grade" in greenhouses compared with control[17] |

## Carrots

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Exoneura* sp. | Pithy stems/reeds | Semi-social | No[18] |
| Colletidae | *Leioproctus (Leioproctus) clarki* | Ground-nesting | Solitary | No[18] |
| Halictidae | *Lasioglossum (Chilalictus) clelandi* | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lasioglossum (Chilalictus) cognatum* | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lasioglossum (Chilalictus) gilesi* | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lasioglossum (Chilalictus) lanarium* | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lasioglossum (Chilalictus) orbatum* | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lasioglossum (Chilalictus) sphecodoides* | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lipotriches (Austronomia) australica* | Ground-nesting | Semi-social | No[18] |
| Megachilidae | *Megachile ordinaria* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[18] |



*Exonuera (Exonuera) pictifrons*, female on *Thryptomene saxicola*.
Photo: Kit Prendergast

## Cashew

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Amegilla aeruginosa* [misclassified as *Xylocopa*] | Ground-nesting | Solitary | No[19] |
| Apidae | *Tetragonula* [previously *Trigona*] | Hollows | Eusocial | No[19] |
| Apidae | *Xylocopa aruana* [misclassified as *Amegilla*] | Wood burrow | Semi-social | No[19] |
| Halictidae | *Nomia* [misclassified as Anthophoridae] | Ground-nesting | Semi-social | No[19] |
| Megachilidae | *Megachile turneri* [previously *Torridapis*] | Small pre-made cavities often created by wood-boring beetles | Solitary | No[19] |

## Celery

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Austroplebeia australis* | Hollows | Eusocial | Yes: seed set [20] |

## Choko

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Meliponini* spp. | Hollows | Eusocial | No[21] |



## Citrus

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Meliponini* spp. | Hollows | Eusocial | No[21] |
| Halictidae | *Lasioglossum (Parasphecodes)* spp. | Ground-nesting | Semi-social | No[3] |
| Halictidae | *Lasioglossum (Chilalictus)* spp. | Ground-nesting | Semi-social | No[3] |

## Clover

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Halictidae | *Lasioglossum (Chilalictus) cf. clelandi* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus) cf. orbatum* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus) cognatum* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus) lanarium* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum* spp. | Ground-nesting | Semi-social | No[22] |

## Kakadu plum (*Terminalia ferdinandiana*)

| Family | Bee taxa (species/genus/taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Tetragonula mellipes* [misclassified and misspelt as *Trigona melipes*] | Hollows | Eusocial | No[23] |

## Leek

| Family | Bee taxa (species/genus/taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Colletidae | *Leioproctus (Leioproctus) clarki* | Ground-nesting | Solitary | No[18] |
| Halictidae | *Homalictus (Homalictus) sphecodoides* [mislabelled as *Lasioglossum (Chilalictus) sphecodoides*] | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lasioglossum (Chilalictus) hiltacum* | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lasioglossum (Chilalictus) lanarium* | Ground-nesting | Semi-social | No[18] |
| Halictidae | *Lipotriches (Austronomia) australica* | Ground-nesting | Semi-social | No[18] |
| Megachilidae | *Megachile erythropyga* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[18] |

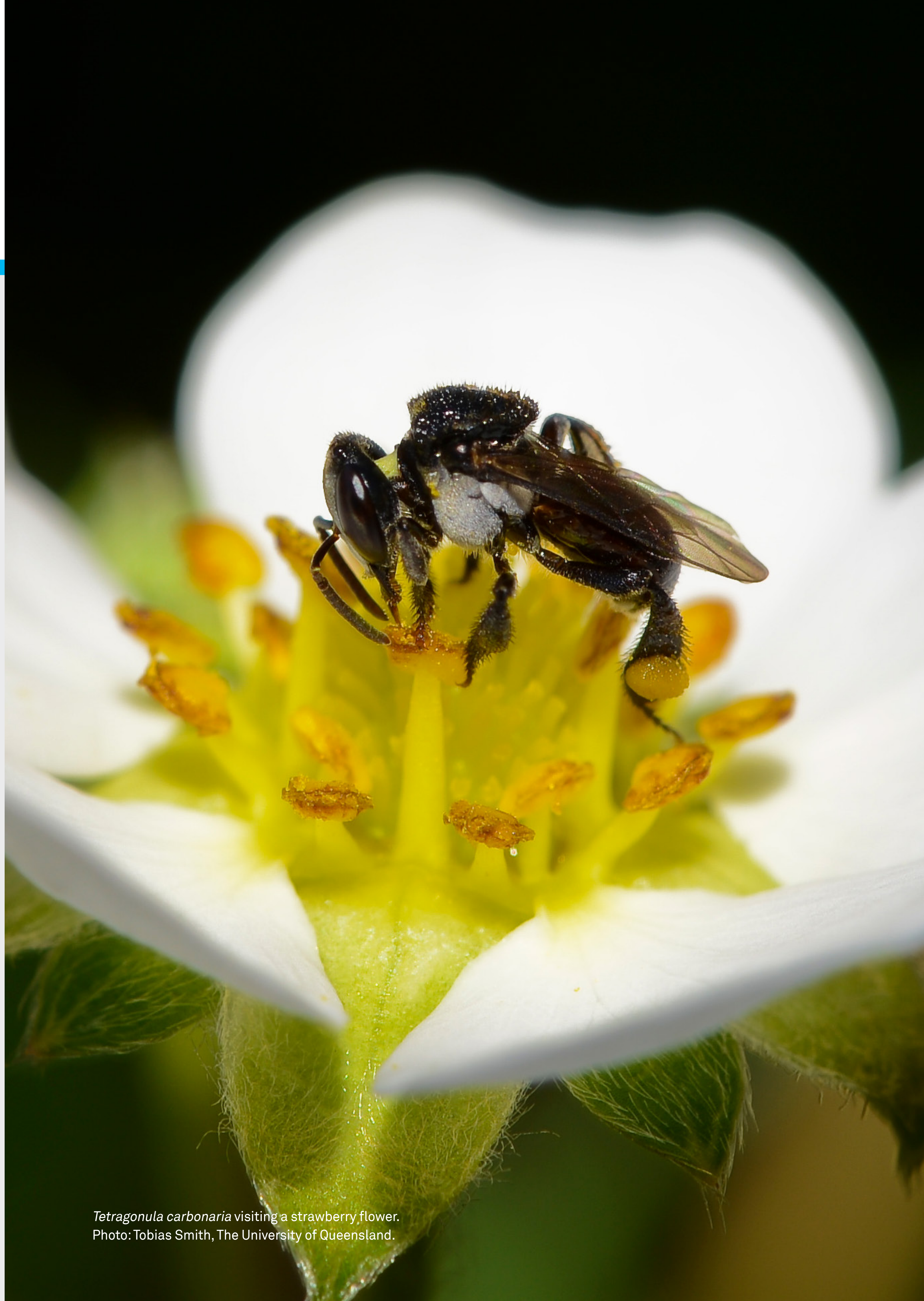
## Lucerne

| Family | Bee taxa (species/genus/taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Amegilla (Notomegilla) chlorocyanea* | Ground-nesting | Solitary | No[1] |
| Halictidae | *Lasioglossum (Chilalictus) chapmani* | Ground-nesting | Semi-social | No[1] |
| Halictidae | *Lasioglossum (Chilalictus) lanarium* | Ground-nesting | Semi-social | No[1,24] |
| Halictidae | *Lipotriches (Austronomia) australica* | Ground-nesting | Semi-social | No[24] |
| Halictidae | *Lipotriches (Austronomia) flavoviridis* species-group | Ground-nesting | Semi-social | Yes: tripped flowers[24] |
| Megachilidae | *Megachile (Eutricharaea) rhodogastra* | Small pre-made cavities often created by wood-boring beetles | Solitary | Yes: tripped flowers[25] |
| Megachilidae | *Megachile (Eutricharaea) macularis* | Ground-nesting | Solitary | Yes: tripped flowers[25] |
| Megachilidae | *Megachile (Callomegachile) mystaceana* (previously *Calicodoma mystaceana*) | Small pre-made cavities often created by wood-boring beetles | Solitary | Yes: tripped flowers[25] |
| Megachilidae | *Megachile (Eutricharaea) pictiventris* | Small pre-made cavities often created by wood-boring beetles | Solitary | Yes: tripped flowers[25] |
| Megachilidae | *Megachile (Eutricharaea) quinquelineata* | Small pre-made cavities often created by wood-boring beetles | Solitary | Yes: tripped flowers[25] |
| Megachilidae | *Megachile (Eutricharaea) cetera* | Small pre-made cavities often created by wood-boring beetles | Solitary | Yes: tripped flowers[25] |

| Family | Bee taxa (species/ genus/taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Megachilidae | *Megachile (Eutricharaea) obtusa* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[1] |
| Megachilidae | *Megachile nigrovittata* | Small pre-made cavities often created by wood-boring beetles | Solitary | Yes: % pod set in tunnels[24] |
| Megachilidae | *Megachile quinquelineata* | Small pre-made cavities often created by wood-boring beetles | Solitary | No[24] |

## Lychee

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Meliponini* spp. | Hollows | Eusocial | Yes (anecdotal)[8,9,21] |
| Apidae | *Tetragonula spp.* | Hollows | Eusocial | Yes: collected pollen and nectar, but did not frequently contact stigma[46] |



*Tetragonula carbonaria* visiting a strawberry flower.
Photo: Tobias Smith, The University of Queensland.

## Macadamia

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Meliponini* spp. | Hollows | Eusocial | No[21] |
| Apidae | *Tetragonula* | Hollows | Eusocial | No[26] |
| Apidae | *Tetragonula carbonaria* | Hollows | Eusocial | Yes: nut set[27–29] |
| Apidae | *Tetragonula carbonaria* | Hollows | Eusocial | Yes: pollen on legs[30] |
| Colletidae | *Leioproctus (Leioproctus)* sp. | Ground-nesting | Solitary | No[30] |
| Colletidae | *Hylaeus (Prosopisteron)* sp. | Small pre-made cavities often created by wood-boring beetles | Solitary | No[30] |
| Halictidae | *Lasioglossum (Chilalictus) polygoni* | Ground-nesting | Semi-social | Yes: pollen on legs[30] |
| Halictidae | *Homalictus* | Ground-nesting | Semi-social | No[26] |
| Halictidae | *Homalictus* sp. | Ground-nesting | Semi-social | No[30] |

## Mango

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Xylocopa* sp. | Wood burrow | Solitary/ semi-social | No[11] |
| Apidae | *Meliponini* spp. | Hollows | Eusocial | No[21] |
| Apidae | *Tetragonula carbonaria* | Hollows | Eusocial | No[11] |
| Apidae | *Tetragonula mellipes* | Hollows | Eusocial | No[31] |
| Apidae | *Tetragonula* sp. [most likely *mellipes* or *essingtoni* based on distribution] | Hollows | Eusocial | Yes: germinated pollen grains[32] |
| Apidae | *Tetragonula* spp. | Hollows | Eusocial | Yes: pollen grains deposited[1] |

## Persimmon

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Tetragonula* spp. | Hollows | Eusocial | Yes (anecdotal)[33–35] |

## Plum

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Halictidae | *Lasioglossum (Chilalictus)* spp. | Ground-nesting | Semi-social | No[3] |

## Radish

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Halictidae | *Lasioglossum (Chilalictus)* cf. *clelandi* | Ground-nesting | Semi-social | No[2] |
| Halictidae | *Lasioglossum (Chilalictus) cognatum* | Ground-nesting | Semi-social | No[2] |

## Rambutan

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Tetragonula mellipes* | Hollows | Eusocial | Yes (anecdotal)[36] |

## Raspberry

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Exoneura* (*Exoneura*) spp. | Pithy stems/reeds | Eusocial | No[3] |
| Apidae | *Meliponini* spp. | Hollows | Eusocial | Yes (anecdotal)[7] |
| Apidae | *Tetragonula carbonaria* | Hollows | Eusocial | Yes: protected cropping; fruit height and druplets positively related to abundance37, but see[38] |
| Halictidae | *Lasioglossum (Parasphecodes)* spp. | Ground-nesting | Semi-social | No[3] |
| Halictidae | *Lasioglossum (Chilalictus)* spp. | Ground-nesting | Semi-social | No[3] |
| Halictidae | *Homalictus (Homalictus) urbanus* | Ground-nesting | Semi-social | Yes: fruit quality positively related to abundance[37] |

## Solanum (bush tomato)

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Amegilla* | Ground-nesting | Solitary | No[13] |

## Strawberry

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Amegilla* | Ground-nesting | Solitary | No[21] |
| Apidae | *Tetragonula carbonaria, Tetragonula hockingsi* | Hollows | Eusocial | Yes: fruit yield and quality[39] |

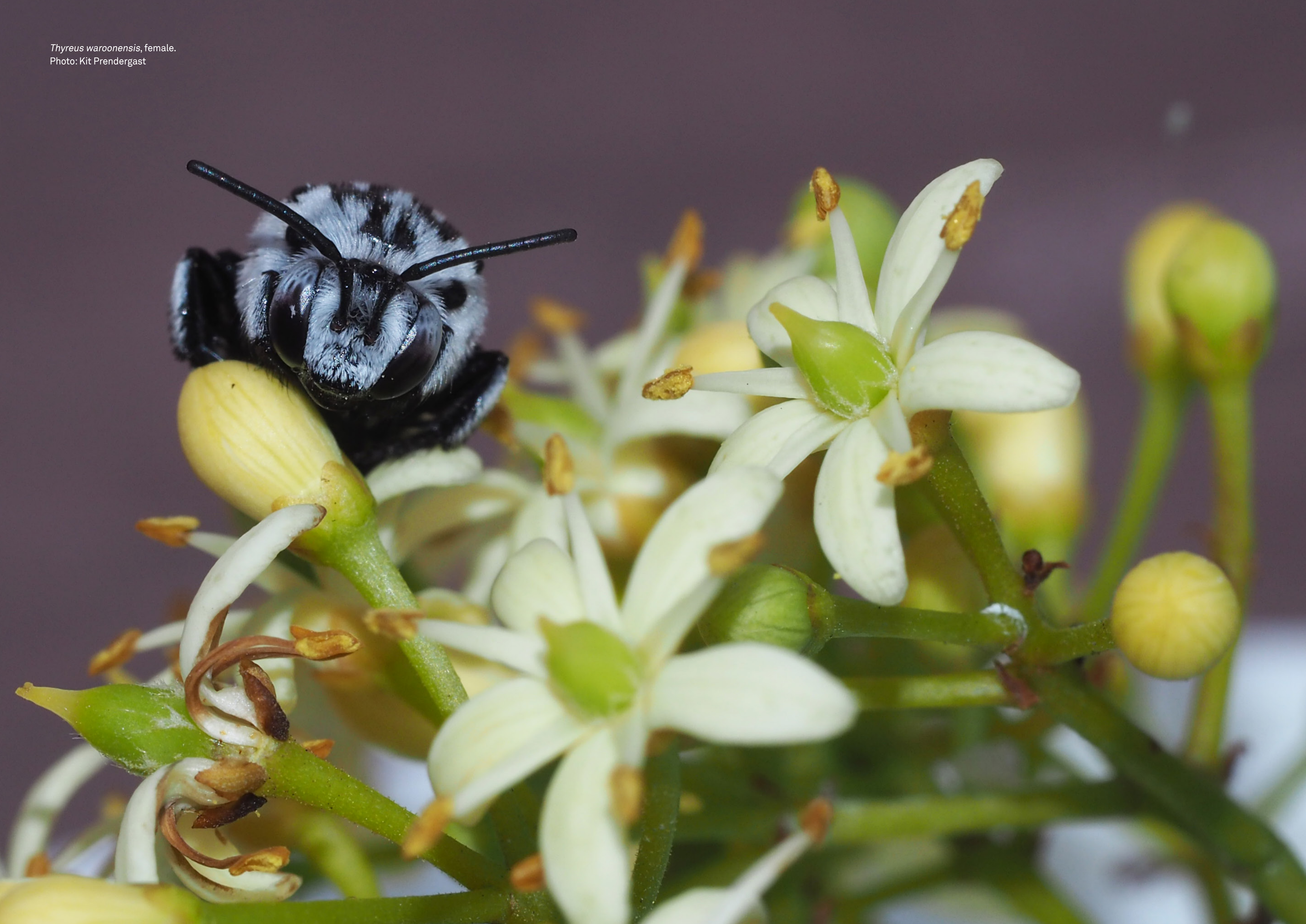


## Tomato

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Amegilla (Notomegilla) chlorocyanea* | Ground-nesting | Solitary | No[6] |
| Apidae | *Amegilla (Notomegilla) chlorocyanea* | Ground-nesting | Solitary | Yes: protected cropping; fruit set follow buzzes[40,41]<br><br>No: field[6] |
| Apidae | *Amegilla (Zonamegilla) pulchra* (previously *A. homelsi*) | Ground-nesting | Solitary | Yes: fruit set and quality[42] |
| Apidae | *Xylocopa (Lestis) aerata* | Wood burrow | Solitary/ semi-social | Yes: females buzzed[43] |
| Apidae | *Xylocopa (Lestis) bombylans* | Wood burrow | Solitary/ semi-social | Yes: females buzzed[43] |
| Halictidae | *Lipotriches (Austronomia) flavoviridis* species-group | Ground-nesting | Semi-social | No[6] |

## Watermelon

| Family | Bee taxa (species/genus/ taxonomic group) | Nesting | Sociality | Known pollinator (yes/no) |
|---|---|---|---|---|
| Apidae | *Meliponini* spp. | Hollows | Eusocial | No[21] |
| Apidae | *Meliponini* spp. | Hollows | Eusocial | Yes (anecdotal)[9,28], No[21] |
| Apidae | *Tetragonula hockingsi* | Hollows | Eusocial | No[44,45] |
| Halictidae | *Lasioglossum*, other halictids, stingless bees | Ground-nesting | Semi-social | Yes (pollen deposition)[1] |
| Halictidae | *Homalictus* sp. | Ground-nesting | Semi-social | Yes (anecdotal)[28] |



*Thyreus waroonensis*, female.
Photo: Kit Prendergast

# Appendix references

**Note:** All of the named native bees are known visitors of the respective crops, however this is anecdotal for *Meliponini* spp. in blackberry, choko, citrus, macadamia, mango and strawberry. Under 'Bee taxa (species/genus/taxonomic group)', where only a genus is provided there is insufficient detail in the cited reference to indicate whether this is a single species, or multiple species, with subgenus indicated in brackets. For 'Known pollinator', 'anecdotal' refers to all instances where there is no publicly available scientifically robust data to support the claim, and where 'yes' is indicated, a very brief descriptor is provided on why/how this species is considered a pollinator.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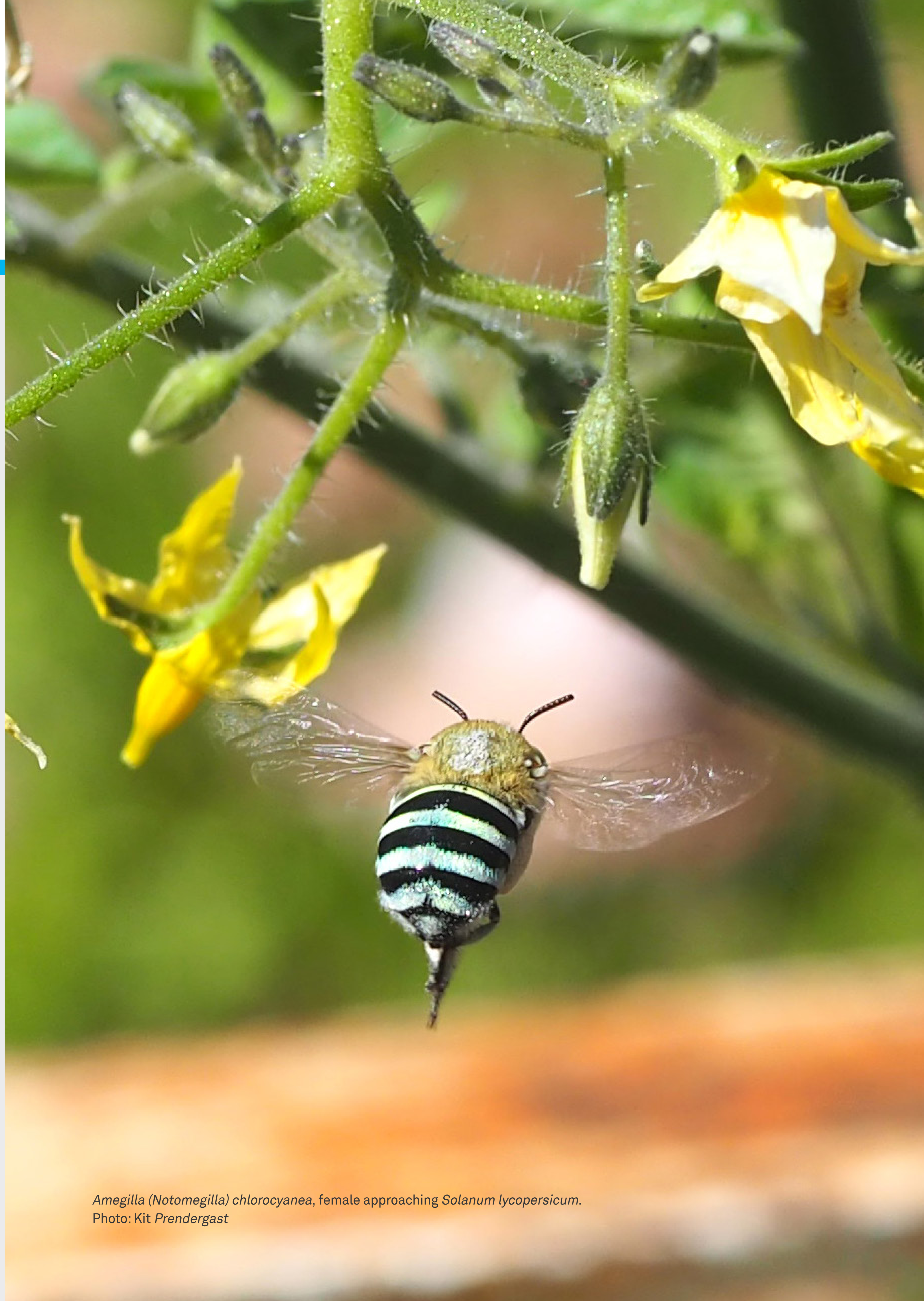

*Amegilla (Notomegilla) chlorocyanea*, female approaching *Solanum lycopersicum*.
Photo: Kit *Prendergast*

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