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AIM OF THE SUPER POLLINATORS WORKSHOP

This workshop aims to create informed and passionate bee enthusiasts via an engaging presentation and hands-on learning experience. The principles and practices communicated can also be applied to other native species benefiting human wellbeing and biodiversity as a whole.

ABOUT THE SUPER POLLINATORS WORKSHOP

Bees are the most effective pollinators of all (Klein 2007), and yet despite our enormous dependence on them for food production and ecosystem function they are facing increasing threats from habitat loss, chemical use, monocultures, climate change, pests and diseases (Potts et al 2010). While honey bees *(Apis mellifera)* are the most iconic of all bee species, Australia has 1660 described native bee species (Heard 2016) that in many cases have been shown to be more effective pollinators than honey bees. In addressing the threats to bees, researchers have demonstrated the need to enhance pollinator diversity and abundance to ensure pollination success for human wellbeing and biodiversity (Radar et al 2012, Klein 2007).

The good news is that there is enormous diversity of Australian bee species and a huge capacity, with good habitat management, for them to fulfil an even greater role in pollination. Not only that, but for many people it is a revelation to discover the fascinating species' that have been right under their nose all this time.
The issue then becomes how best to communicate the plight of bees and also engage more people to discover and nurture the bee species in their immediate area.

The Super Pollinators Workshop is designed to fulfil that need. This workshop is grounded by the science in the forthcoming rationale. The wow factor and love affair with bees is sparked with the aid of amazing images from talented researchers, photographers and illustrators. And the whole package is realised when the participant is empowered to actually provide habitat for their local bee species by the end of the workshop. One workshop at a time, we aim to encourage people to fall in love with bees.

In the workshop, participants can build either a timber and bamboo hotel, or a mud-brick nest for select solitary native bee species. Hotels are made from sustainably sourced untreated pine and bamboo. Ideally recycled timber would be used however the inconsistency in availability, size, and provenance (whether it is treated or not) makes it impractical at a repeatable scale. We harvest untreated bamboo from properties trying to eradicate this invasive plant.

The bee hotel is designed to be most attractive to about 35 bee species known from the Wider Sydney Region (E.g. Halcroft and Batley 2014). Additionally, constructing a timber hotel is providing basic carpentry skills.

We also highlight additional methods to create bee habitat such as bundling pithy stemmed plants for reed bees (Halcroft 2012), making mud bricks for blue banded bees (Dollin 2006), keeping social native bees (stingless bees) in a hive (Heard 2016), and planting locally occurring native plants.

As part of the workshop we provide a collection of locally found preserved invertebrates for participants to observe under magnification lights, giving them experience in identifying a range of species including many native bees. These invertebrates (dead when found) have been collected over many years by myself and friends.

While the theoretical and practical skills gained at the workshop empower the student to be proactive in conservation, the workshop is also designed to align to vital syllabus outcomes, deliberately dovetailing with a number of core units.
Our intention is that by educating children about the exciting world of bees we can assist them to understand and enhance habitat for native bees, and also apply the same principles to other species benefiting human wellbeing and biodiversity as a whole.

I hope you will join with me in nurturing the bee-loving environmental champions of the future.

RATIONALE: THE SCIENCE BEHIND THE SUPER POLLINATORS

THE WORLD OF BEES

There are 20,000 bee species worldwide, 1660 formally described in Australia (Heard 2016) with the likelihood that this may increase to over 2000 species (Hogendoorn and Keller 2011, Batley and Hogendoorn 2009, Heard 2016) as we continue to discover and identify them. The majority of bees are solitary species, whereby as opposed to living in a colony like a honey bee, they live by themselves or in a small aggregation. The solitary bee secures her own nest, either in cavities or burrows, where she provides pollen for each of the eggs that she lays. Australia also has a native social bee species, stingless bees (Meliponini) that live as a colony in a hollow tree or log, but do equally well in a managed hive.

Overall animals, including bees, pollinate approximately 87% of all flowering plants making them all vital for ecosystem function (Ollerton et al 2011). 75% of all agricultural crops are reliant on pollinators, equating to 30% of the food we eat (Hodendoorn 2011); about one in every 3 mouthfuls.

Bees perform a vital role in pollination however surprisingly, only 11% of flowering plants are pollinated by managed bees (chiefly the honey bee *Apis mellifera*), while 50% of pollination is from unmanaged bees (wild). The remaining pollinators are other insects, birds and mammals (Klein 2007).

Even so, honey bee pollination accounts for $4-6 billion worth of agricultural produce per annum (CSIRO 2014). Studies indicate that the world requires a 300% increase in pollinator services (mobile bee hive hire used to pollinate seasonal crop flowering) to meet food demands with population growth. However actual figures show a decline in bee keeping in the USA and Europe and only an increase of 45% worldwide (Potts et al 2010).

Challenging the demand for pollinator services are the serious threats facing honey bees (Bee Aware 2015). Among the most notorious issues are the mite, *Varroa destructor*, Colony Collapse disorder and systemic chemicals.
Varroa destructor is a sesame-seed-sized mite that attaches itself to the bee and sucks the haemolymph (insects' version of blood), making the bee more vulnerable to disease.
No country has been able to eradicate *Varroa destructor* once it has established, and Australia remains the only country free of the mite. The impact is dire, for example, *Varroa destructor* arrived in the USA in 1987 and now honey bees only exist within hives managed for the mite (Cunningham and De Barro 2014). The decline in

the total number of available managed hives in the USA, along with an increasing demand, has seen a 4-5 fold increase in the cost of hive hire and an annually increasing gap between demand for hives and the capacity to supply them (De Barro 2007). Overseas examples highlight the impact that this mite would have in Australia in escalating agricultural costs (passed on to the consumer) due to the reduction in both managed pollination services and available wild honey bee populations (E.g. The White House 2014).

The CSIRO suggest invasion of the mite in Australia is likely. In 2000, the mite established in New Zealand, despite the country having similar quarantine protocols to Australia. Several scares in Australia have highlighted vulnerability to invasion. The National Bee Pest Surveillance Program adopts 126 sentinel hives strategically placed at high-risk locations, (an average of six per location) to provide early detection for *Varroa destructor* mites and other major honey bee pests that may arrive in Australia on cargo ships (CSIRO 2014).

Colony Collapse disorder (CCD) is a relatively recent concern, the term only coined in 2006. CCD sees the sudden mysterious disappearance of almost all adult bees from the hive, leaving behind the queen, food stores and capped brood. The USA and Europe have experienced huge bee loss due to CCD averaging 30% of colonies over successive years in the USA (Leendertz 2014) with serious ramifications for food security. In Australia it is less common though has been recorded (CSIRO 2014, Goodwin 2012) and beekeepers struggle to recoup numbers over warmer months by introducing supplements and splitting hives (Leendertz 2014).

Potential reasons for CCD include contamination from infection, malnutrition, chemical use, mites, immunodeficiencies, beekeeping practices, constant change (transporting hives), monocultures, genetically modified crops, habitat loss and climate change. Many of these reasons are also attributed to pollinator decline globally (Goodwin 2012, Perry et al 2015, De Barro 2007, Goodman 2014).
The latest research on CCD, (Perry et al 2015) suggests that individual experienced bee foragers may be dying from a multitude of the aforementioned factors resulting in expedited development of immature bees (normally undertaking in-hive tasks) to replace experienced foragers as they die. In a healthy hive, a strong foraging force delays the onset of maturation (to foraging) by younger bees. However the sudden death of experienced foragers sees replacement by inexperienced foragers (more likely to die in their maiden flight, often heavier, less efficient fliers, less developed wing muscles), causing a negative feedback loop and greater stress on the colony. Possible solutions include inhibiting the inexperienced foragers from leaving prematurely via subsidized feeding or enhancing brood stocks. Obviously reducing the compounding triggers should be a priority.

A second catalyst for CCD is offered by Schofield and Mattila (2015) who have demonstrated that poor nutrition of bee larvae translates to unhealthy adults – less capable of foraging and communicating where foraging should focus (via waggle dancing). Poor nutrition is attributed to monocultures and habitat loss. Evidence suggests that the practices behind providing intense honey bee services is in part the reason for honey bee decline. Put simply, vast hectares of a single flowering crop provide no alternatives for pollinators that are limited by their physical ability to move beyond their flight range.

Many chemicals used for pest control in both agricultural and domestically can kill bees. Currently the focus is on neonicoinoids which are systemic insecticides used to control agricultural pests such as sap sucking insects and grubs. By their nature, systemic chemicals invade all parts of the plant tissue meaning that pollen and nectar sourced by the bees also contain the chemicals. Pollinator decline and CCD have been linked to pesticide use, particularly neonicotinoids (E.g. Goodwin 2012, Blacquie`re et al 2012, Perry et al 2015).
Several countries worldwide have restricted their use, and the effect of neonics on bee health and bee decline is hotly debated. Certainly though the impact of chemicals harmful to beneficial species like pollinators can be minimized or even avoided, and brochures such as NSW Government (2016) and NSW DPI (2015) provide important information for best practice pest management.

HONEY BEES IN AUSTRALIA

Focusing on the situation in Australia, there are 500,000 registered hives in Australia (held by 10,000 beekeepers), but 70% of keepers own less than 200 hives. The value of crops pollinated by bees has been estimated to be $1.7b pa, and the honeybee industry valued at $80m pa, including 30,000 tonnes of honey production (Hornitzky 2014). Clearly Australian's have become hugely reliant on honey bees since their introduction to Australia in 1822 for honey production (NSW OEH 2015).

However wild (feral) honey bee populations are listed as a key threatening process due to competition for tree hollows with native animals (303 Australian native species are hollow dependent; Gibbons & Lindenmayer 2002) as well as competition for floral resources with native pollinators (TSC Act 1995: NSW OEH 2015, Paini 2004). This listing does not preclude the undertaking of commercial beekeeping activities.
Arundel et al (2014) placed feral bee estimates in South Eastern Australia at about 2-7 colonies per km^2.
This demonstrates the likely decline in free pollinating services offered by feral honey bees should *V destructor* invade Australia, and also the huge negative impact that existing feral bees have on Australian biodiversity.

NATIVE AUSTRALIAN BEES

The importance of pollinator services is clear, and the threats to honey bees significant. As such growing research is focusing on the effectiveness and behaviour of native bees as pollinators, the overall finding that pollinator diversity provides the greatest chance of pollination success (Radar et al 2012, Rodgers et al 2015, Kennedy et al 2014).
In many case studies native bees were actually found to be better pollinators of crops than honey bees which were shown to supplement rather than substitute pollination success (Garibaldi et al 2013, Heard and Dollin 1998).
Other often referenced examples include Winfree et al (2008), showing that native bees deposited 62% of pollen on crops, Radar et al (2015) demonstrating crop yield increased incrementally with the presence of each additional bee species, and Kennedy et al (2014) who found native bees to be more effective pollinators than honey bees across 41 different crop systems world wide. In Australia several researchers have shown huge potential for Australian native bees in agricultural production (E.g. Hogendoorn and Keller 2011, Coventry and Keller 2007, Hogendoorn 2011, Letini et al 2012). But paramount to pollinator diversity was the availability of appropriate habitat within the flight range of constant flowering resources (agricultural, native or otherwise) for each species (Cunningham et al 2013, Abrol 2012, Klein 2007, Potts et al 2010, Leech et al 2012).

So why is greater bee diversity so effective? Put simply, it is because all bee species behave differently (E.g. Aussie Bee 2015, Dollin 2010, Batley and Hogendoorn 2009, Housten 2010,). They forage under different weather conditions (rain, wind, daily temperature, season), access and carry nectar and pollen differently, have variation in the distance that they forage from their nest, use different nesting substrates (soil, borer holes, mud, pithy stems) and target different floral species. Pollination processes also differ with flower structure, fertility windows and pollinator triggers and therefore maximizing pollinator diversity and abundance is also maximizing the opportunity for pollination.

The single greatest threat to native bees in Australia is habitat loss, in its extreme resulting in extinction. The example of the local extinction of the great carpenter bee *(Xylocopa (Lestis) aeratus)* from Mainland South Australia and Victoria (Hogendoorn 2013) is a case in point.
While species such as the honey bee are generalist foragers (selecting pollen and nectar from a wide variety of plants), about 100 Australian native bee species are known or suspected to be, specialist pollinators (Batley and Hogendoorn 2009) meaning they target very specific plants for resources, the plant often equally dependent on that bee species for continued pollination (Menz et al 2011, Rymer et al 2004, Housten 1993). This co-dependence is compounded with the impact of threatening processes such as land clearing, bush fire and climate change causing a shift in flowering times (Phillips et al 2010, Potts et al 2010).

Agricultural lands are often cleared for few crop types offering no diversity over vast landscapes with small flowering windows. Retaining and increasing local flora amongst agriculture and providing nectar corridors (e.g. Saunders et al 2013, Letini et al 2013, NSW Government 2016a, Ricketts et al 2008) will increase bee abundance.

Urban centres are becoming much more homogenized with an increase in exotic plants, non-flowering landscape plants and a complete decrease in local native flora (McKinney 2006). Equally the trend for perfectly manicured gardens and covering would-be bare earth with mulch or pebbles is leaving native bees without nesting substrate (Threstrell et al 2015), significant as 70% of Australian bee species nest in the ground (NSW Government 2016b). However native bees can thrive in urban centres provided habitat and floral resources are met (Threstrall et al 2015).

The installation of a bee hotel is one part of a broader solution. In the Greater Sydney Area, more than 30 solitary native bee species may utilize a hotel provided the hotel offers suitable hollows, particular to each species (Halcroft and Batley 2014, Hogendoorn and Keller 2011, Heard 2016a). Importantly, researchers such as McIvor et al (2015) warn that with the growing 'green washing' trend of bee hotels, they are often made without any scientific basis (for example the diameter of the cavities may be too large), meaning they are unsuitable for native bees. Similarly bee hotels must be placed correctly; securely with morning sun only, minimal wind, above 1 metre from the ground (Martin et al 2012).

It is worth reminding that the habitat provided by the bee hotel is also suitable for a number of species such as non-aggressive solitary mud wasps (Halcroft and Batley 2014), which are important predators of garden pests like caterpillars. Like the bees they play an important role in the ecosystem.

The Super Pollinators Workshop presents the diversity of Australian native bee species. We encourage the wider adoption of providing appropriate habitat such as bare earth, dead timber, hollows and pithy plants along side year round diverse floral resources (E.g. Leech 2012) to encourage greater bee diversity.

REFERENCES

Arundel J, Oxley P, Faiz A, Crawford J, Winter S, & Oldroyd B, 2014, Remarkable uniformity in the densities of feral honey bee *Apis mellifera* Linnaeus, 1758 (Hymenoptera: Apidae) colonies in South Eastern Australia, *Austral Entomology* (2014) 53, 328–336

Aussie Bee, 2015, The Australian Native bee Research Centre, www.aussiebee.com.au/

Batley M & Hogendoorn K, 2009, Diversity and Conservation status of native Australian Bees, *Apidologie* 40, Pp. 347-354

Bee Aware, 2015, http://beeaware.org.au/

Blacquie`re T, Smagghe G, van Gestel C, Mommaerts V, 2012, Neonicotinoids in bees: a review on concentrations, side-effects and risk assessment, *Ecotoxicology,* Vol. 21, Pp. 973–992

CSIRO, 2014, Watch bees on the job, http://csironewsblog.com/tag/varroa-mite/

Cunningham S and De Barro 2014, Expalianer: Varroa mite, the tiny killer threatening Australia's bees, The Conversation, https://theconversation.com/explainer-varroa-mite-the-tiny-killer-threatening-australias-bees-25710, accessed 18 June 2016

De Barro P, 2007, The future of the Australian Honeybee industry, *CSIRO*

Department of Environment, Climate Change, and Water, 2009, Biobanking: Guide to establishing a biobank site, *NSW Government*.

Dollin L, 2006, How to make nest blocks for Blue Banded Bees, Australian Native Bee Research Centre, Aussie Bee Online, April 2006 Article 8.

Dollin A, 2010, Introduction to Australian Native Bees (second edition), *Australian Native Bee Research Centre*, NSW.

Gibbons P & Lindenmayer D, 2002, Tree Hollows and Wildlife Conservation in Australia, *CSIRO*

Garibaldi L, Steffan-Dewenter I, Winfree R, Aizen M, Bommarco R, Cunningham S, Kremen C, Carvalheiro C, Harder L, Afik O, Bartomeus I, Benjamin F, Boreux V, Cariveau D, Chacoff N, Dudenhöffer J,. Freitas B, Ghazoul J, Greenleaf S, Hipólito J, Holzschuh A, Howlett B, Isaacs R, Javorek S, Kennedy C, Krewenka K, Krishnan S, Mandelik Y, Mayfield M, Motzke I, Munyuli T, Nault B, Otieno M, Petersen J, Pisanty G, Potts S, Rader R, Ricketts T, Rundlöf M, Seymour C, Schüepp C, Szentgyörgyi H, Taki H, Tscharntke T, Vergara C, Viana B, Wanger T, Westphal C, Williams N & Klein A, 2013, Wild Pollinators Enhance Fruit Set of Crops Regardless of Honey Bee Abundance,
Science, March, Issue 339, No. 6127, Pp. 1608-1611

Goodman R & Kaczynsk P, 2014, Australian Beekeepers Guide *Rural Industries research and Development Corporation*, Australian Government, https://rirdc.infoservices.com.au/downloads/14-098, accessed May 5

Goodwin M, 2012, Pollination of Crops in Australia and New Zealand, Rural Industries Research and Development Corporation.

Halcroft M, 2012, How to make nests for Reed bees – bundles, www.beebusiness.com

Halcroft M and Batley M, 2014,The bee hotel ID guide, Office of Sustainability, University of Western Sydney.

Heard T, 2016, The Australian Native Bee Book, Sugarbag bees

Heard T 2016a, Bee walls, habitat and nesting blocks, Valley bees, Margaret River Catchment Coordinating Committee, www.mrccc.org.au, accessed 15th June 2015.

Heard T and Dollin A, 1998, Crop Pollination with Australian stingless Bees, Native Bees of Australia Series, Booklet 6, *Australian Native Bee Research Centre*

Hogendoorn K, 2013, have you seen the Green Carpenter bee, Department of Environment, water and Natural Resources, Government of South Australia.

Hogendoorn K, Coventry S, & Keller MA, 2007, Foraging behaviour of a blue banded
bee, *Amegilla chlorocyanea* in greenhouses: implications for use as tomato
pollinators, *Apidologie, Vol.* 38, Pp. 86-92

Hogendoorn K and Keller M, 2011, Development of native bees as pollinators of vegetable seed crops, *The University of Adelaide*

Hornitzky M, 2014, Colony Collapse Disorder, *Elizabeth Macarthur Agricultural Institute Camden NSW*

Housten T, 2011, Native Bees: Information sheet, museum.wa.gov.au/sites/default/files/Native%20Bees.pdf*, Western Australian Museum*, 26th August.

Housten T, Lamot B, Radford S and Errington S, 1993, Apparent Mutualism between *Verticordia Nitens* and *K. aurea* (Myratceae) and their Oil-ingesting Bee Pollinators (Hymenoptera: Colletidae), *Austral Journal of Biology,* Vol.41 Pp. 369-380.

Kennedy C, Lonsdorf E, Neel M, Williams N, Ricketts T, Winfree R, Bommarco R, Brittain C, Burley A, Cariveau D, Carvalheiro L, Chacoff N, Cunningham S, Danforth B, Dudenhoffer J, Elle E, Gaines H, Garibaldi L, Gratton C, Holzschuh A, Isaacs R, Javorek S, Jha S, Klein A, Krewenka K, Mandelik Y, Mayfield M, Morandin L, Neame L, Otieno M, Park M, Potts S, Rundlof M, Saez A, Steffan-Dewenter I, Taki H, Viana B, Westphal C, Wilson J, Greenleaf S, & Kremen C, 2013, A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems, *Ecology Letters,* Vol. 16, Pp. 584–599

Keogh R, Mullins I, Robinson A, 2010, Pollination Aware – the real value of pollination services in Australia, Strategen Environmental Consultants, for Australian Government Rural Industries and Development Centre, Australian Government

Klein, A.M. et al. (2007) Importance of pollinators in changing landscapes for world crops. Proc. R. Soc. London B. Biol. Sci. 274, 303–313

Leech M, 2012, Bee Friendly: A Planting Guide for European Honeybees and Australian Native Pollinators, for Australian Government Rural Industries and Development Centre, Australian Government.

Leendertz L, 2014, Bring back the Bees http://www.fix.com/blog/bring-back-the-bees/

Lentini P, Martin T, Gibbons P, Fischer J and Cunningham S, 2012, Supporting wild pollinators in a temperate agricultural landscape: Maintaining mosaics of natural features and production, *Biological Conservation*, Vol.149, Pp. 84-92.

MacIvor JS, *Packer L* (*2015*) '*Bee Hotels*' as *Tools* for *Native Pollinator Conservation*: A *Premature Verdict*? *PLoS ONE* 10(3): e0122126. *doi*:*10.1371/journal.pone.0122126*

Martins C, Ferreira R and Carneiro L, 2012, The influence of the orientation of nest entrance, shading and substrate on sampling trap nesting bees and wasps, Neotropical Entomology

McKinney M, 2006, Urbanisation as a major cause of biotic homogenization, Biological Conservation, Issue 127, Pp.247-260.

Menz M, Phillips R, Winfree R, Kreman C, Aizen M, Johnson S and Dixon K, 2011, Reconnecting plants and pollinators: challenges in the restoration of pollination mutualisms, *Trends in Plant Science,* Vol.16, No. 1, pp. 4-12.
NSW Government, 2016, 5 Tips to protect pollinators from pesticides, Local Land Services, Central Tablelands, accessed www.beebusiness.com.au 15 June 2016.

NSW Government, 2016a, Designing On-farm Tree Planting Programs for Pollinators, Local Land Services, Central Tablelands, accessed www.beebusiness.com.au 15 June 2016.

NSW Government, 2016b, Ground Dwelling Bees – Central Tablelands, Local Land Services, Central Tablelands, accessed www.beebusiness.com.au 15 June 2016.

NSW DPI, 2015, Organic Farming, http://www.dpi.nsw.gov.au/agriculture/farm/organic

NSW OEH, 2015, Competition from feral honeybees – key threatening process listing, http://www.environment.nsw.gov.au/determinations/feralhoneybeesktplisting.htm

Ollerton J, Winfree R and Tarrant S, 2011, How many flowering plants are pollinated by animals? Oikos, Vol 120, Issue 3, Pp.321-326

Organic Farming, NSW Department of Primary Inductries, http://www.dpi.nsw.gov.au/agriculture/farm/organic

Paini D, 2004 Impact of the introduced honeybee on native bees*Austral ecology*, Vol.26, Pp. 399-407.
Perry C, Søvik F, Myerscough M, Barron A, 2015, Rapid behavioral maturation accelerates failure of stressed honey bee colonies, *PNAS*, Vol. 112, No 11, 3427–3432

Phillips R, Hopper S and Dixon K, 2010, Pollination ecology and the possible impacts of environmental change in a Southwest Australian biodiversity hotspot, Royal Society Publishing, Issue.365, Pp. 517-528.

Potts S, Biesmeijer J, Kremen C, Neumann P, Schweiger O and Kunin W, 2010, Global pollinator declines: trends, impacts and drivers, Review, *Trends in Ecology and Evolution Elsevier,* Vol.25, No. 6, Pp. 345-353.

Rader R, Reilly J, Bartomeus I and Winfree R, 2013, Native bees buffer the negative impact of climate warming on honeybee pollination of watermelon crops, *Global Change Biology*, Vol.19, Pp. 3103-3110.

Ricketts T,1 Regetz J, Dewenter I, Cunningham S, Kremen C, Bogdanski A, Gemmill-Herren B, Greenleaf S, Klein A, Mayfield M, Morandin L, Ochieng A & Viana B, 2008, Landscape effects on crop pollination services: are there general patterns?, *Ecology Letters*, (2008) 11: 499–515 – check if needed

Rodgers S, Tarpy D and Burrack H, 2014, Bee species Diversity enhances productivity and stability in perennial crop, PLoS ONE 9(5): e97307.

Saunders M, Luck G and Mayfield M, 2013, Almond orchards with living ground cover host more wild insect pollinators, *Journal of Insect Conservation*, Vol.17, Issue 5, Pp.1011-1025.

Rymer P, Whelan R, Ayre D, Weston P and Russell K, 2005, Reproductive success and pollinator effectiveness differ in common and rare *Persoonia* species (Proteaceae), Biological Conservation, Issue 123, Pp. 521-532

Scofield H and Mattila H, 2015, Honey Bee Workers That Are Pollen Stressed as Larvae Become Poor Foragers and Waggle Dancers as Adults, Plos

The White House, 2014, The Economic Challenge Posed by Declining Pollinator Populations, https://www.whitehouse.gov/the-press-office/2014/06/20/fact-sheet-economic-challenge-posed-declining-pollinator-populations

Winfree R, Williams N & Dushoff J, 2007, Native bees provide insurance against ongoing honey bee losses, *Ecology letters*, Volume, Vol. 10, Issue. 11, Pp. 1105-1113

Zurbuchen A, Bachofen C, Muller A, Hein S and Dorn S, 2010, Are landscape structures insurmountable barriers for foraging bees? A mark-recapture study with two solitary pollen specialist species, Apidologie 41, Pp. 497-50