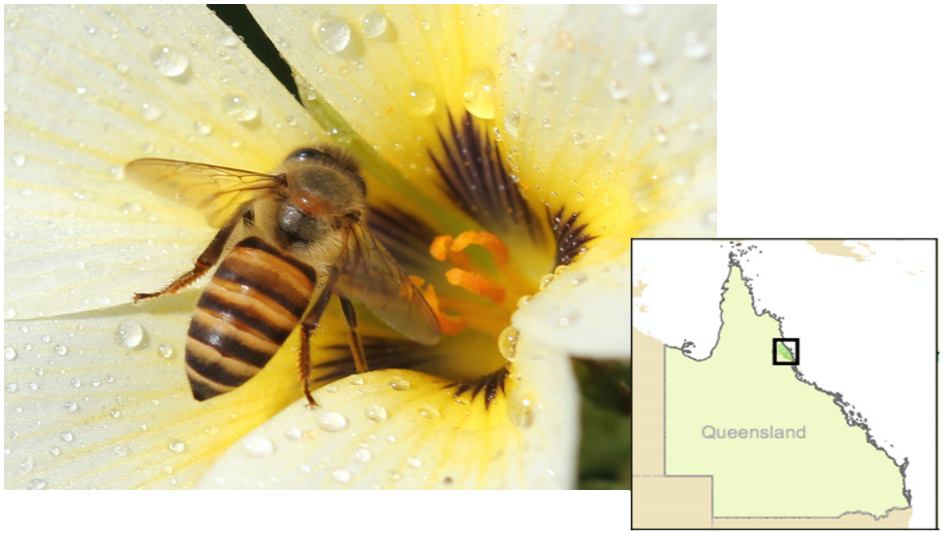
Biosecurity lessons from honey bee invaders: *Apis cerana* and their Varroa hitchhikers

THE UNIVERSITY OF SYDNEY

Ros Gloag
Behaviour and Genetics of Social Insects Lab
School of Life and Environmental Sciences

Apis cerana: Australia's *other* honey bee



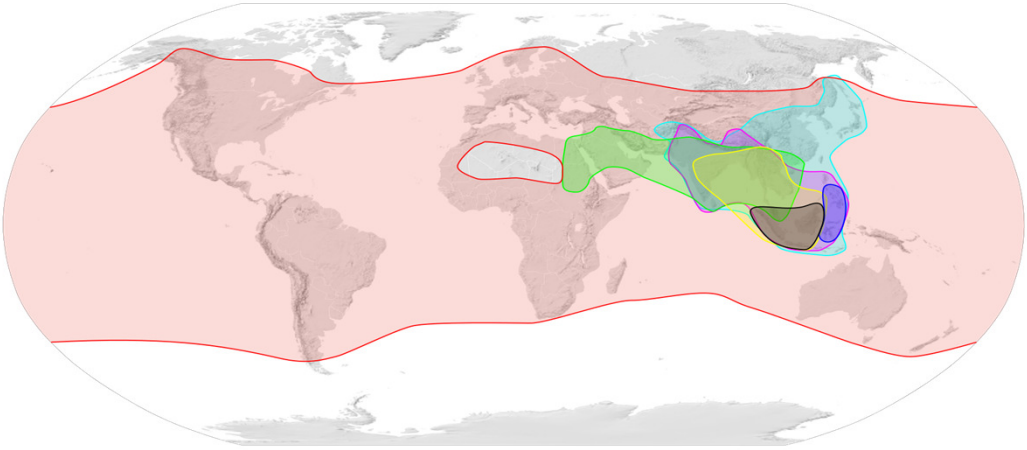
https://www.daf.qld.gov.au/

Apis cerana
Asian honey bee
AHB

Apis mellifera
European honey bee
EHB

https://www.daf.qld.gov.au/

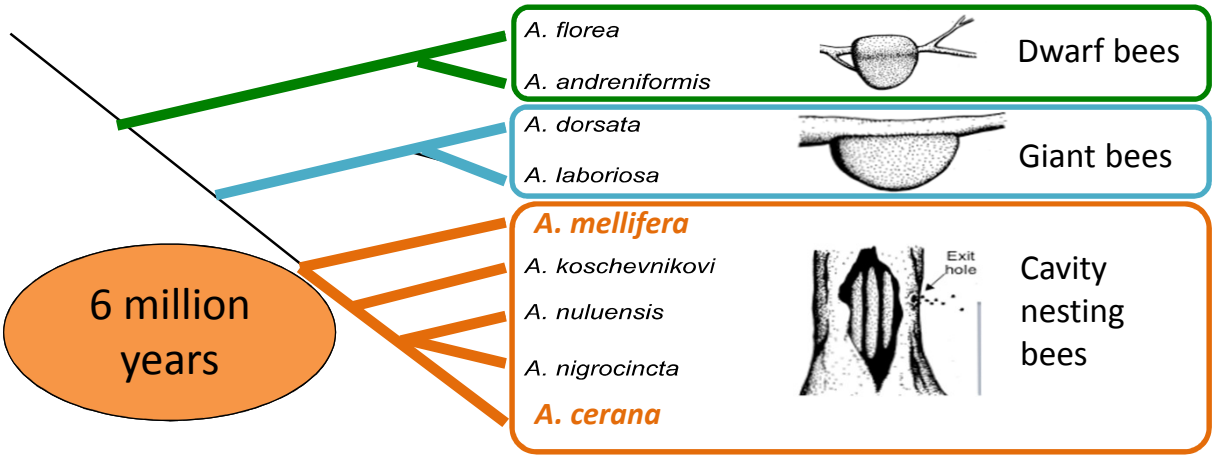
The honey bee family



The European honey bee
Apis mellifera

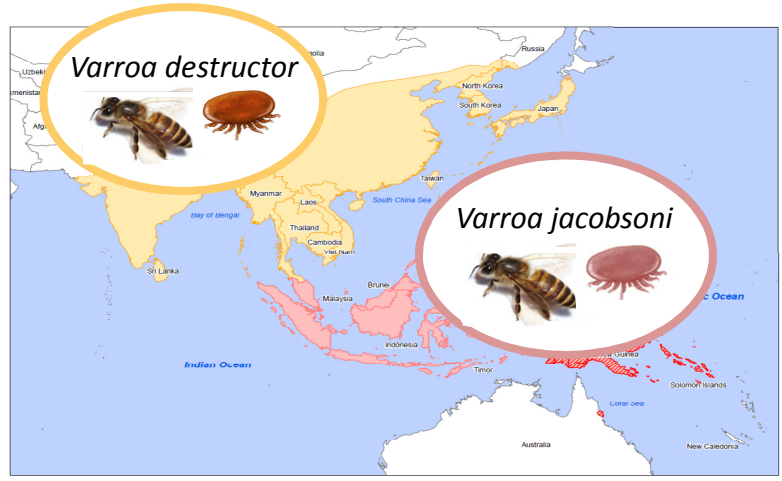
The Asian honey bees

The honey bee family



Varroa destructor

Apis cerana and their mites

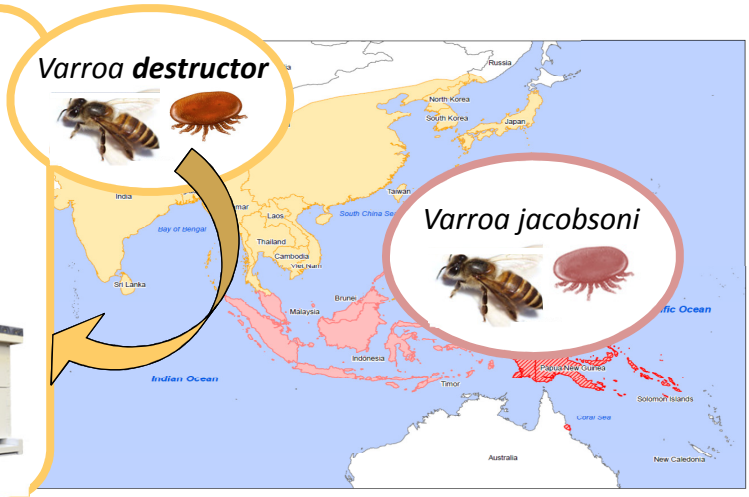


A. cerana mainland *A. cerana* "Java type"

Varroa switches host

c. 1960s
Global pest of
A. mellifera

"Bad Varroa"



Varroa switches host

c. 1950s
Global pest of
A. mellifera

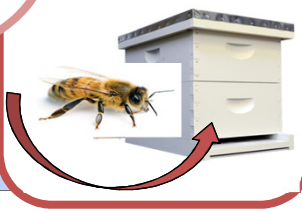
"Bad Varroa"

Varroa ***destructor***

Varroa jacobsoni

c. 2000s
PNG pest of
A. mellifera

"Bad Varroa 2"



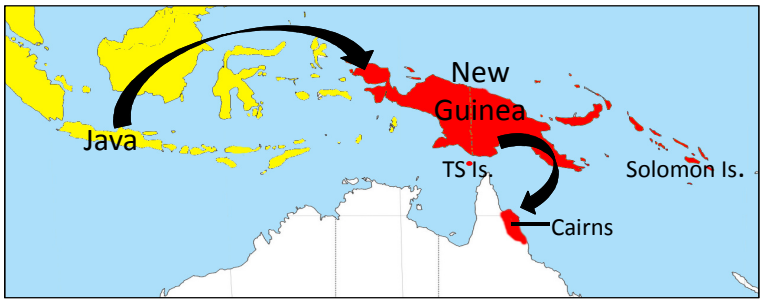
Roberts et al. 2015 *Mol Ecol* 24, 2379

New *A. cerana* incursions risk bringing Varroa

What can Queensland's resident *A. cerana* tell us about the risk of new incursions?

An invasive history in the Austral-Pacific

1970s West Papua → 1993 Torres Strait → 2003 Solomon Is. → 2007 Queensland



Native range Invasive range

Queensland's *A. cerana* have (likely) PNG origin.

Koetz 2013 *Insects* 4: 558

Good stowaways







Queensland's *A. cerana*

How many swarms does it take to found a population?

https://www.daf.qld.gov.au/

Inbreeding is a problem for honey bees

Because sex (male or female) is determined by a single gene

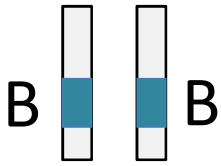
Female

Normal Male

Diploid Male

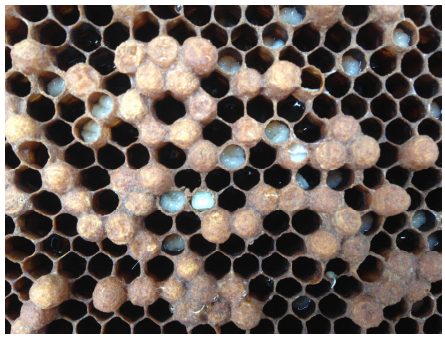
Two **distinct** alleles

One allele (haploid)

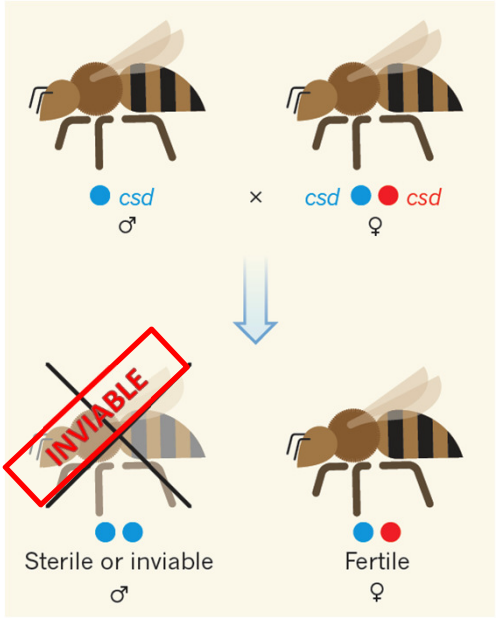


Two **identical** alleles

Populations with low genetic diversity at the “sex locus” and are prone to extinction



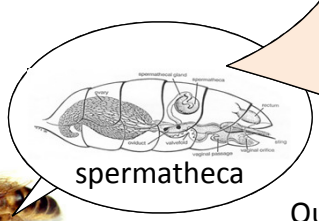
Zayed and Packer 2005, PNAS, 102: 10742

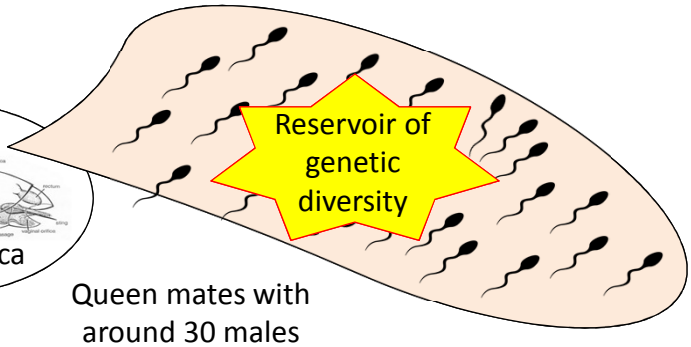


A. cerana’s 3-step solution to survive a bottleneck

Step 1: Mates lots and store the sperm

FOUNDING QUEEN



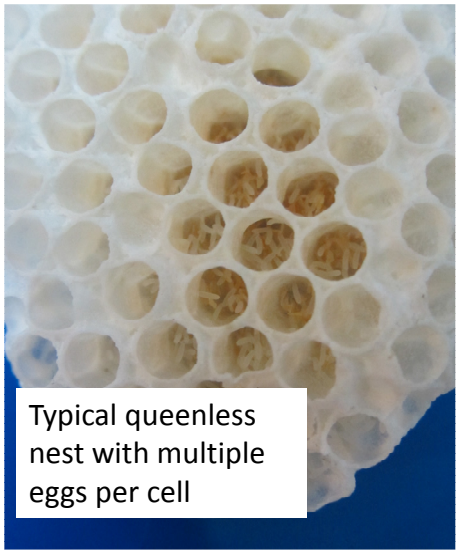


Queen mates with around 30 males

Ding et al. 2017 *Heredity* 119: 381

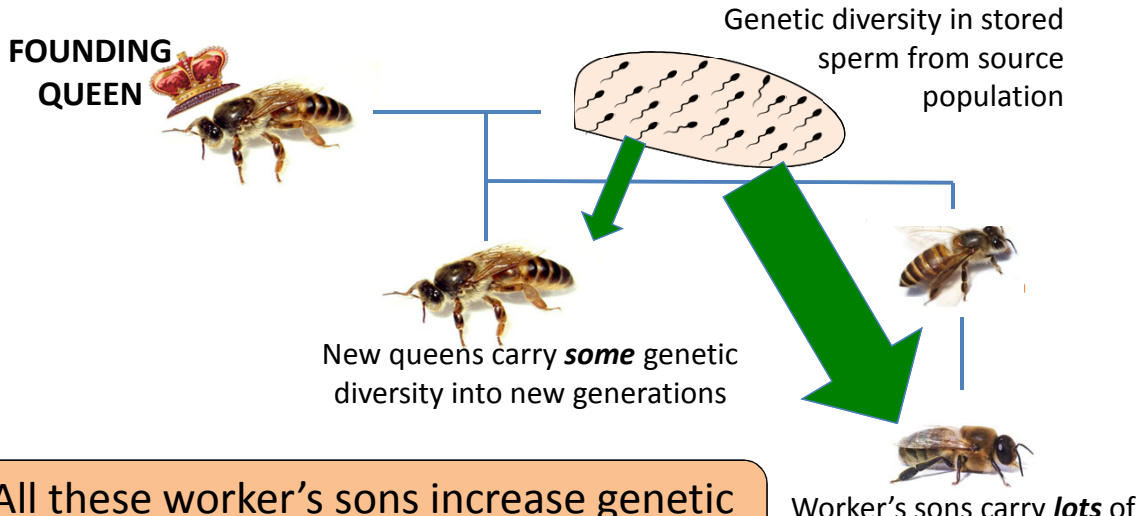
Step 2: Workers produce sons

38% of drone-producing nests in Cairns are queenless workers rearing drones



Typical queenless nest with multiple eggs per cell

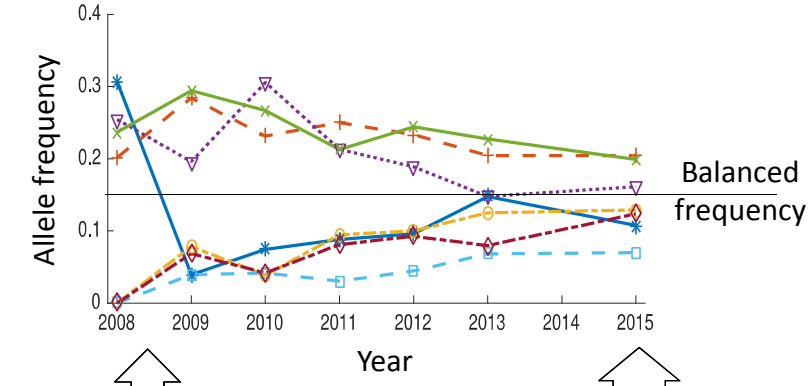
Gloag, Ding, Christie, Oldroyd et al. unpubl.



All these worker's sons increase genetic diversity carried into new population…

Step 3: Natural selection lends a hand

Timeline of samples
2008-2015



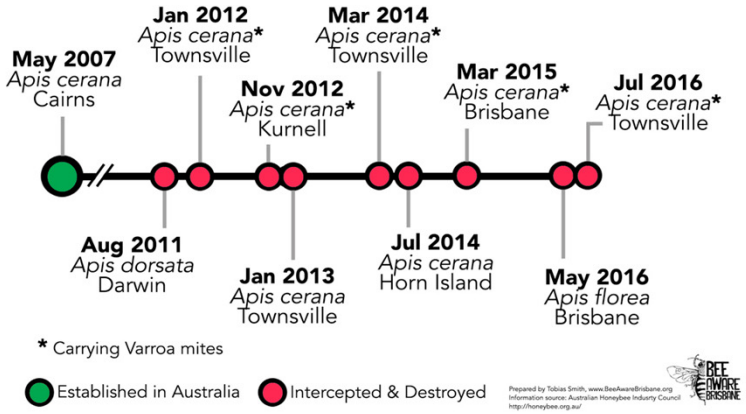
Gloag et al. 2017 *Nature Ecology Evolution* 1, 001

Lessons from past invasions

A. cerana are adept invaders: **one swarm** enough to found a population → high invasion risk

Not all incursions are equal → inbred populations may spread slowly and struggle to adapt, compared to outbred populations

Recent honey bee incursions to Australia



And they keep coming…

16 May 2018: *A. cerana* swarm found in Darwin….

New incursion could also bring Varroa to existing Cairns population….

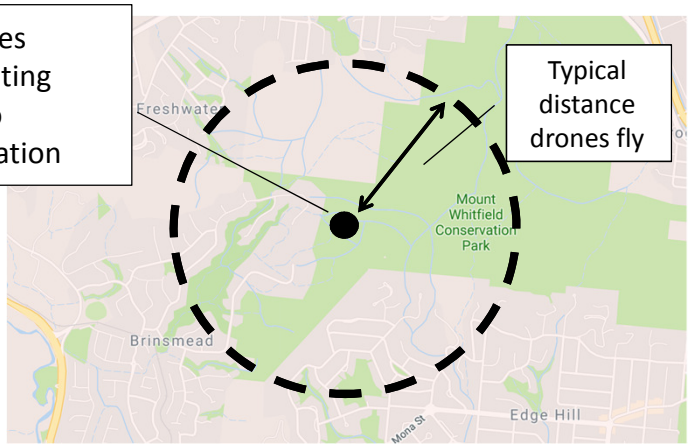
Reservoir of hosts ready and waiting!

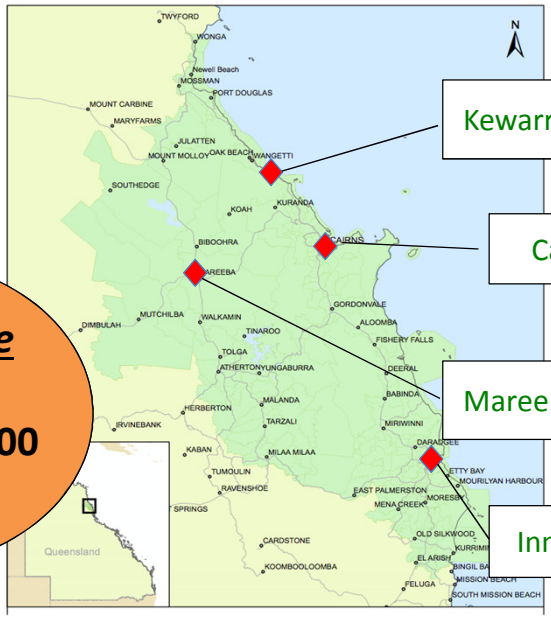
Without Varroa, are *A. cerana* in Australia a problem for beekeeping?

Using drones to estimate population size

Using drones to estimate population size

N colonies contributing males to congregation





Kewarra: 1.0-4.2 cols/km^2

Cairns: 1.1-4.6 cols/km^2

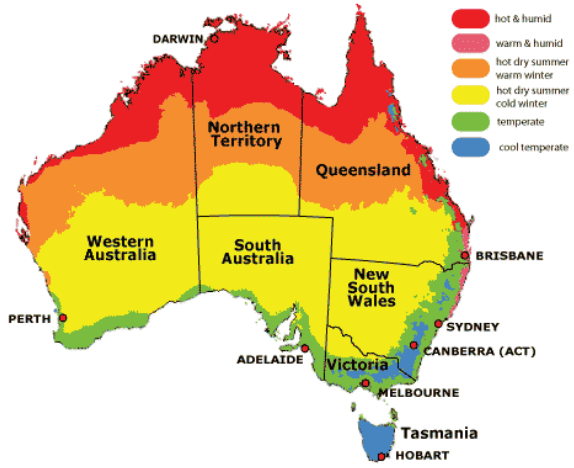
Mareeba: 0.8-3.6 cols/km^2

Innisfail: 0.9-3.7 cols/km^2

Conservative **estimate = 12,400 – 50,800 colonies**

T. Hagan, G. Ding, B, Oldroyd, R. Gloag, unpubl.

Future range?

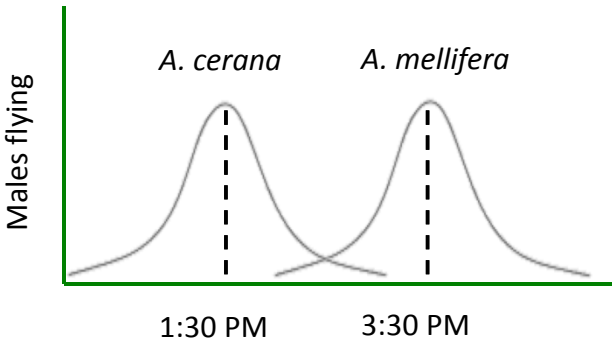


"Java type" adapted to hot humid tropics

But *A. cerana* adapted to colder drier climates in many parts of its native range….

Interspecific mating

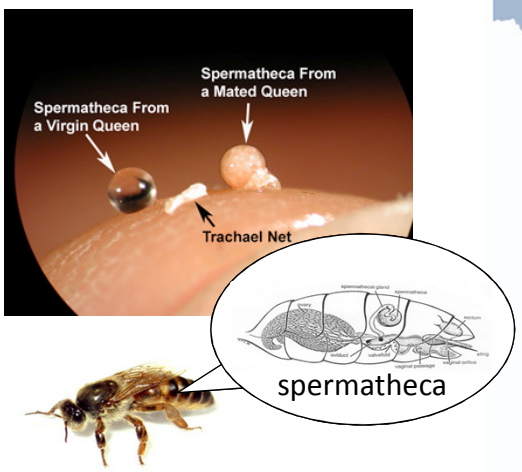
Different mating times, different mating places, and yet….



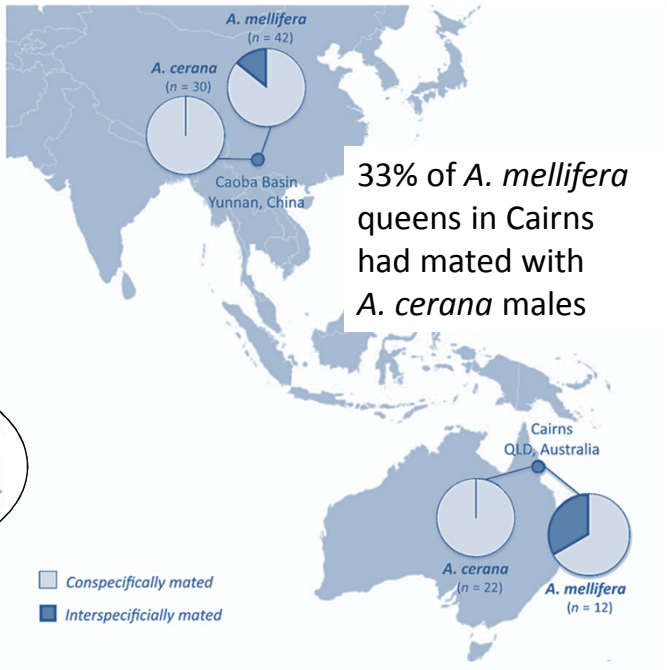
Sheltered

Open

Interspecific mating

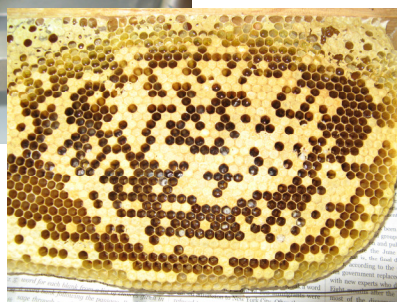


Remnant et al 2014 *Mol Ecol* 23: 1096



33% of *A. mellifera* queens in Cairns had mated with *A. cerana* males

Interspecific mating



Based on AI, interspecific mating gives:

- Unfertilized eggs (males)
- Hybrid offspring that fail to develop beyond larval stage

Remnant et al 2014 *Mol Ecol* 23:1096; Gloag et al 2016 *Ins Soc* 64:241

Other impacts on industry and environment

- Competition for nest sites
- Competition for food
- Reservoir of disease

(these impacts hard to measure)

Crop pollinators of the future?

Important pollinator in native range

More lessons from past invasions

- Genetic tools developed in Queensland population can aide monitoring and detection of incursions
- *A. cerana* might impact beekeeping even in absence of Varroa
- Informed beekeeper community and public essential to bee biosecurity

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