Biological research in support of stingless beekeeping in Australia

Tim Heard,
Honorary Associate, University of Sydney
Director, Sugarbag Bees
tim@sugarbag.net

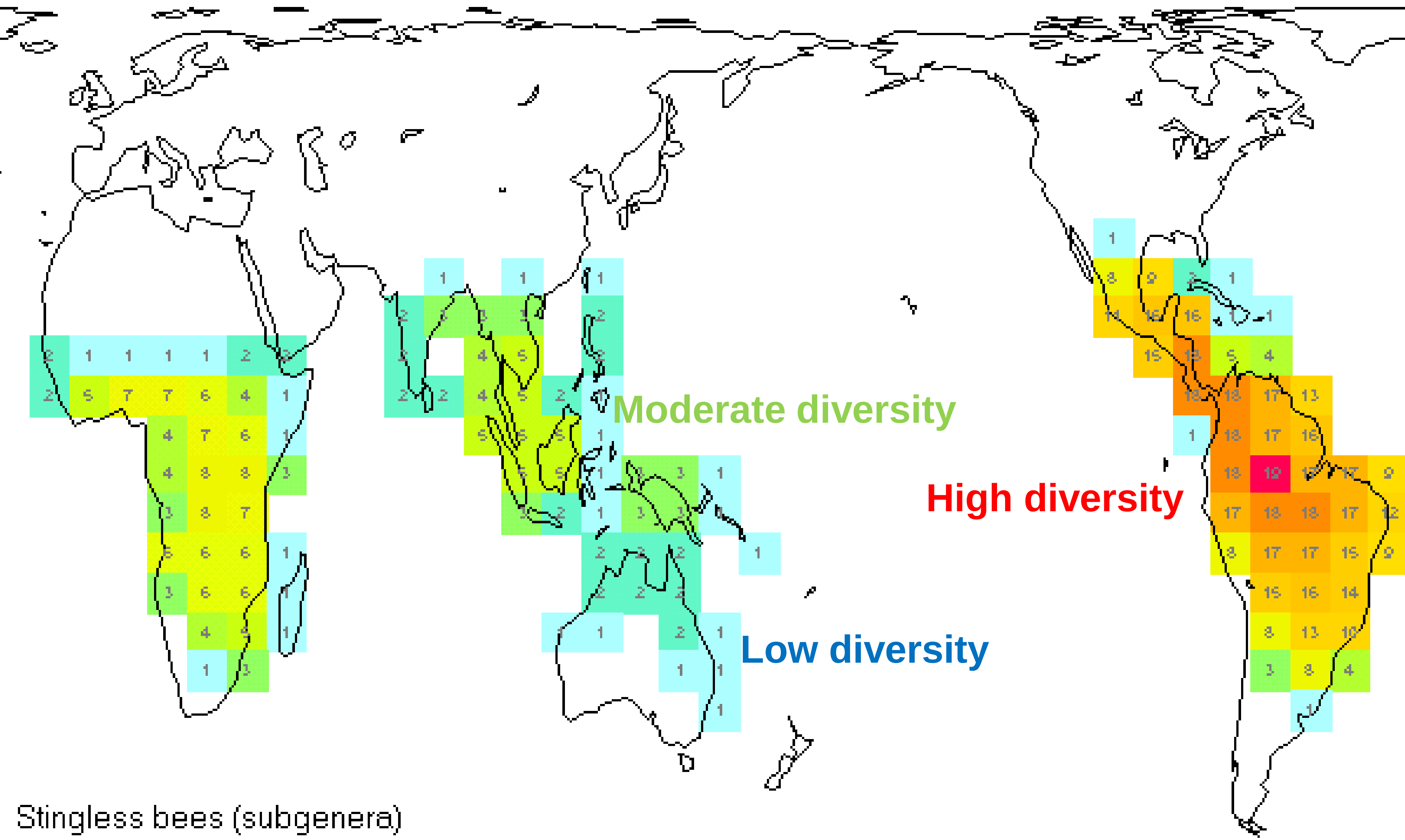
Overview

- Introduction to Stingless bees
- Stingless beekeeping in Australia
- Recent research that has supported the practice of Stingless beekeeping
  - Taxonomy
  - Domestication
  - Natural enemies and defence mechanisms
  - Studies on the products of hives: propolis and honey,
  - Queen replacement
  - Fighting swarms
  - The flight range and homing behaviour
  - Effect of habitat type on colony success
  - Use of these bees as crop pollinators.

Stingless bees

- Apidae: Meliponini
- The “other” group of highly eusocial bees
- C. 500 species globally,
  - 11 in Australia,
  - approximately 40 in malaysia
- Meliponiculture: stingless bee keeping

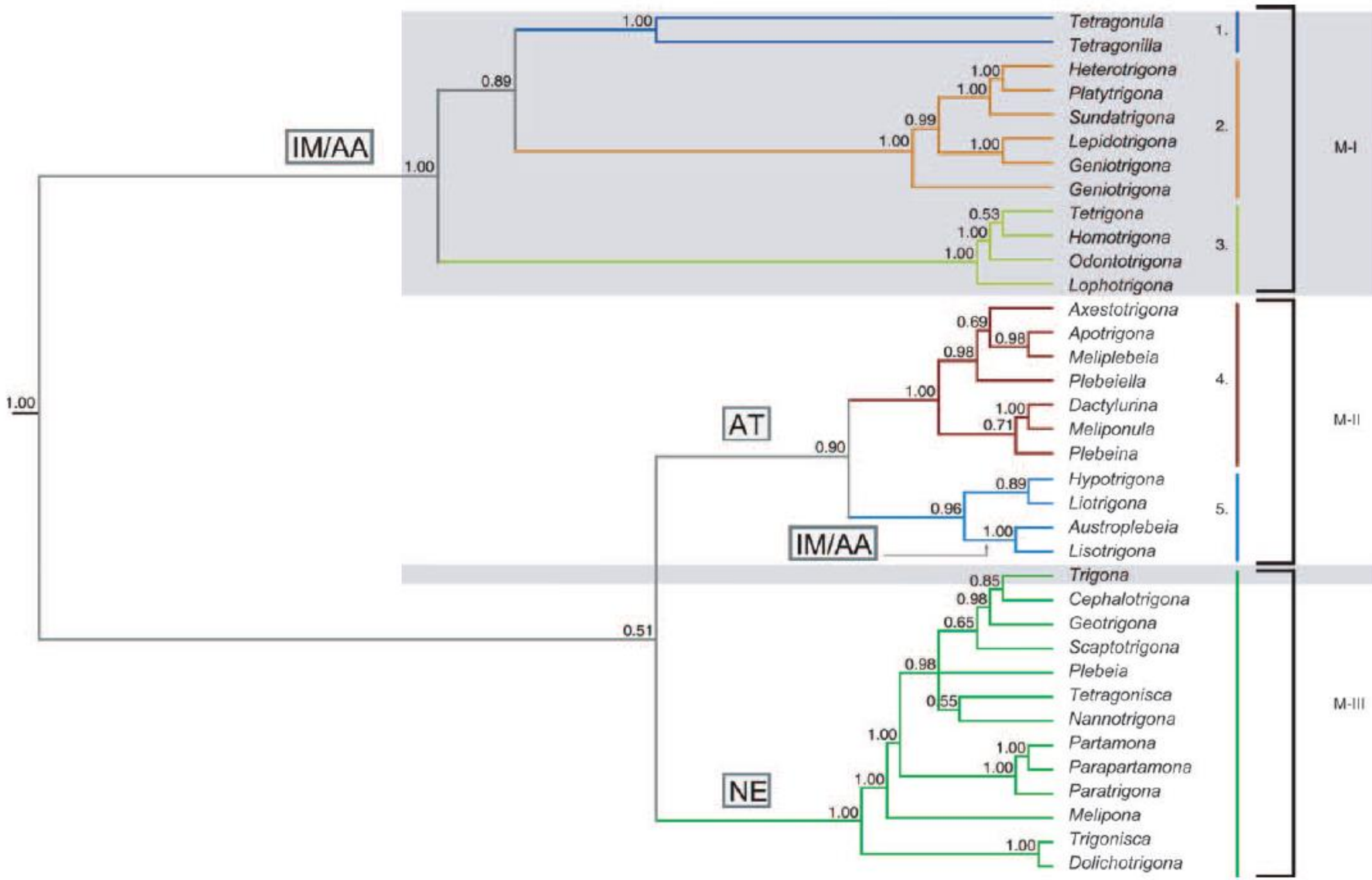
Global diversity of stingless bees



Stingless bees (subgenera)
Natural History Museum, UK

Phylogeny of stingless bees

Rasmussen and Cameron 2007



Stingless bee diversity in Australia

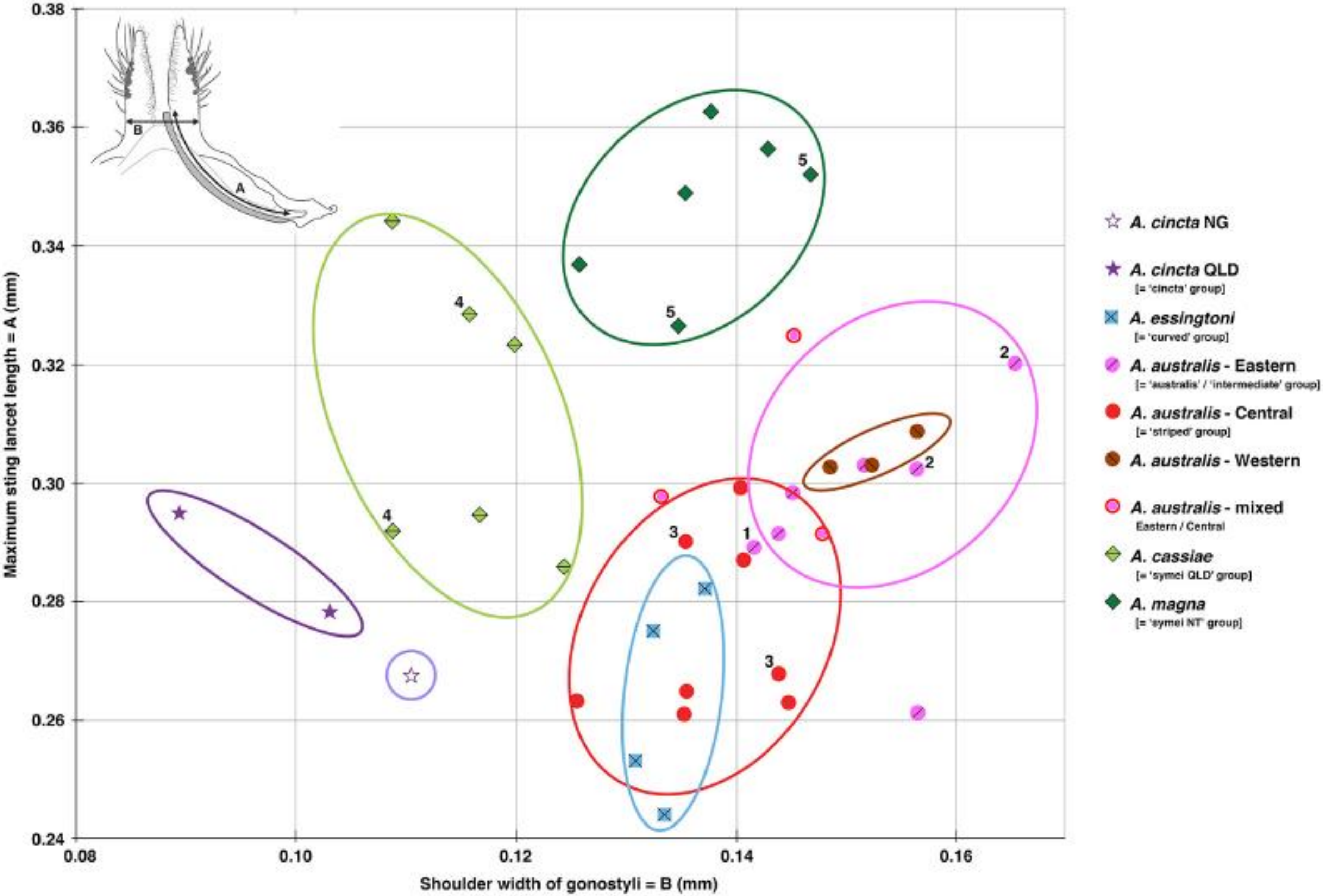
11 species in two genera:

– *Tetragonula*

– *Austroplebeia*

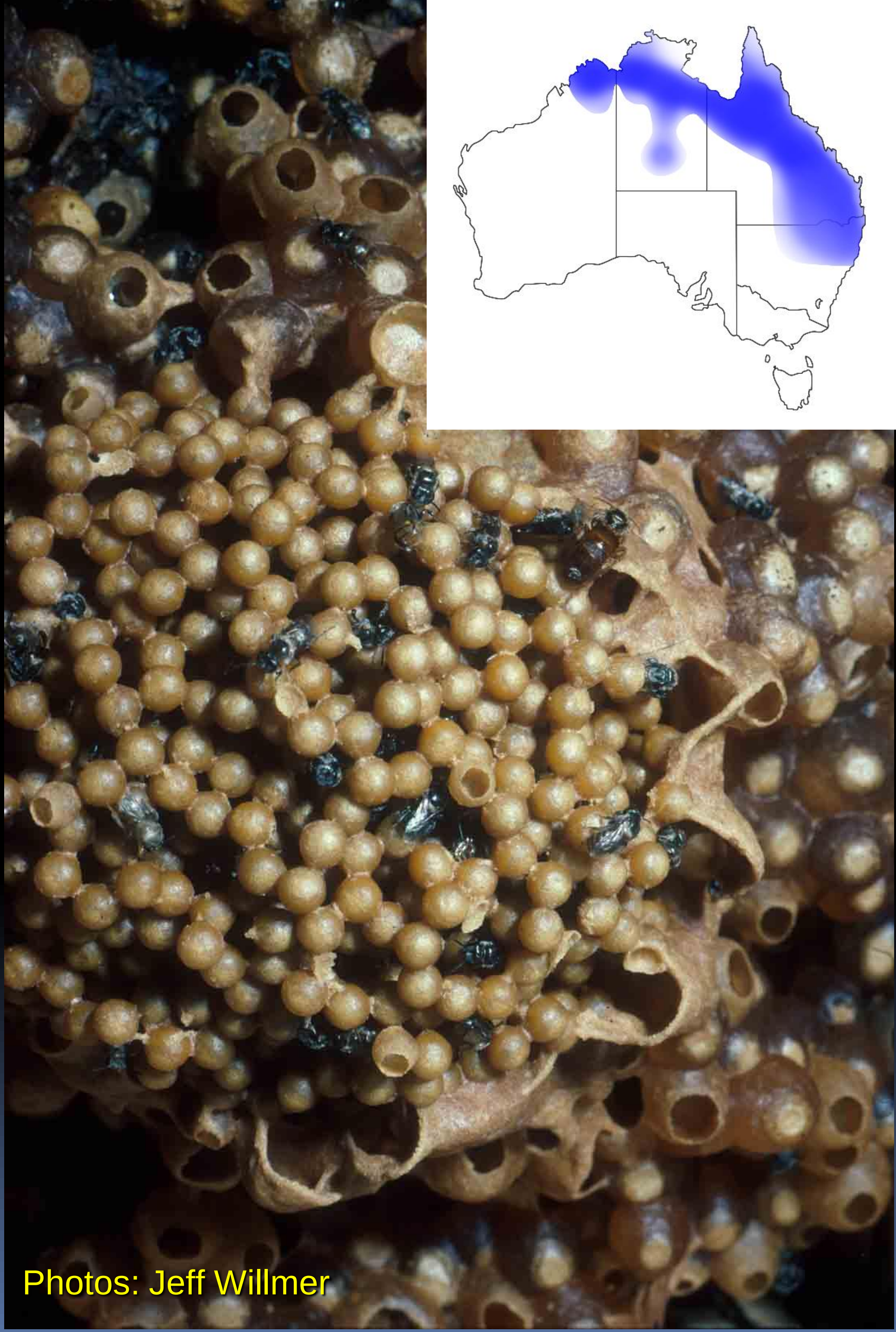
Photos: Tobias Smith

Australian and New Guinean Stingless Bees of the Genus *Austroplebeia* Moure (Hymenoptera: Apidae)—a revision



Austroplebeia australis

Wide distribution, particularly common in drier areas from Hunter Valley to the Kimberley

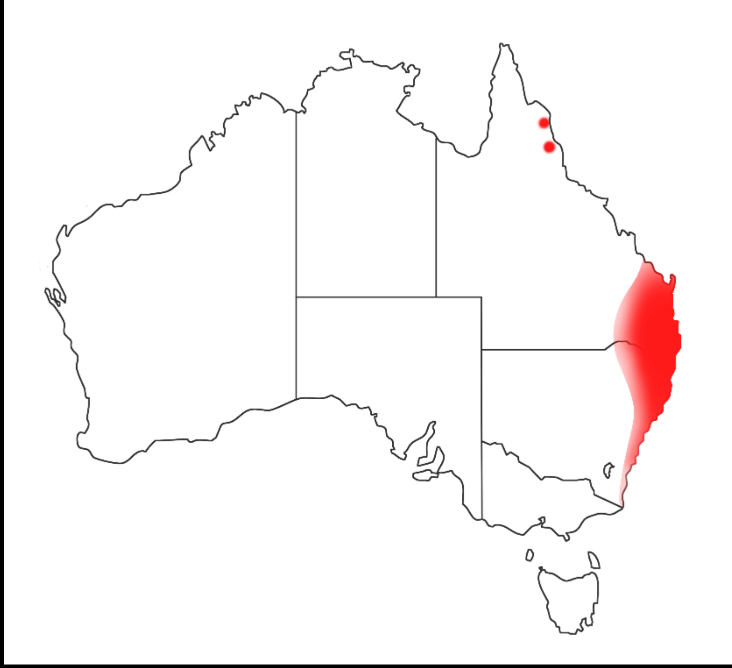


Photos: Jeff Willmer

Tetragonula carbonaria

-Excellent species for keeping

-Model study organism



Stingless bee nest

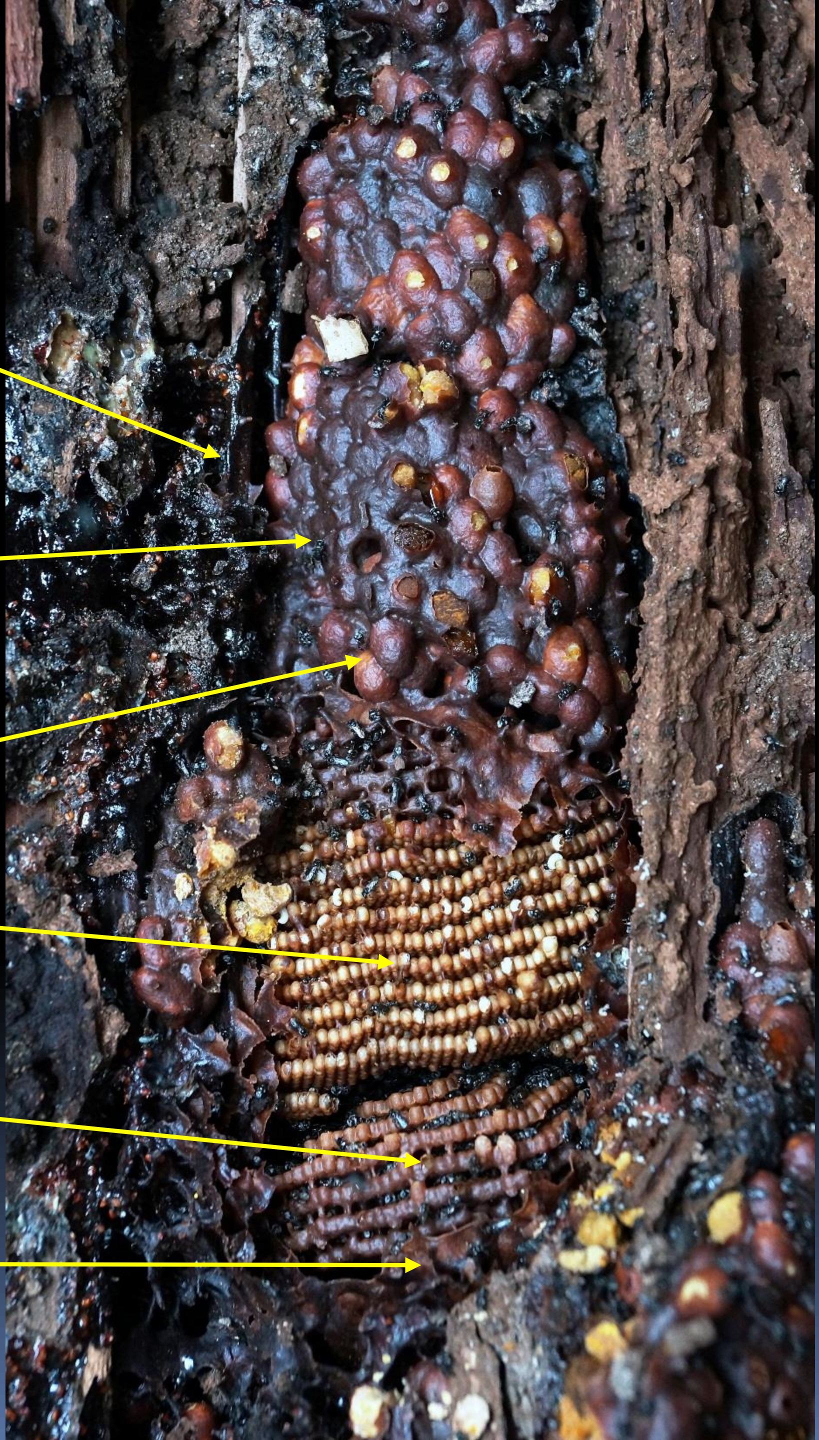
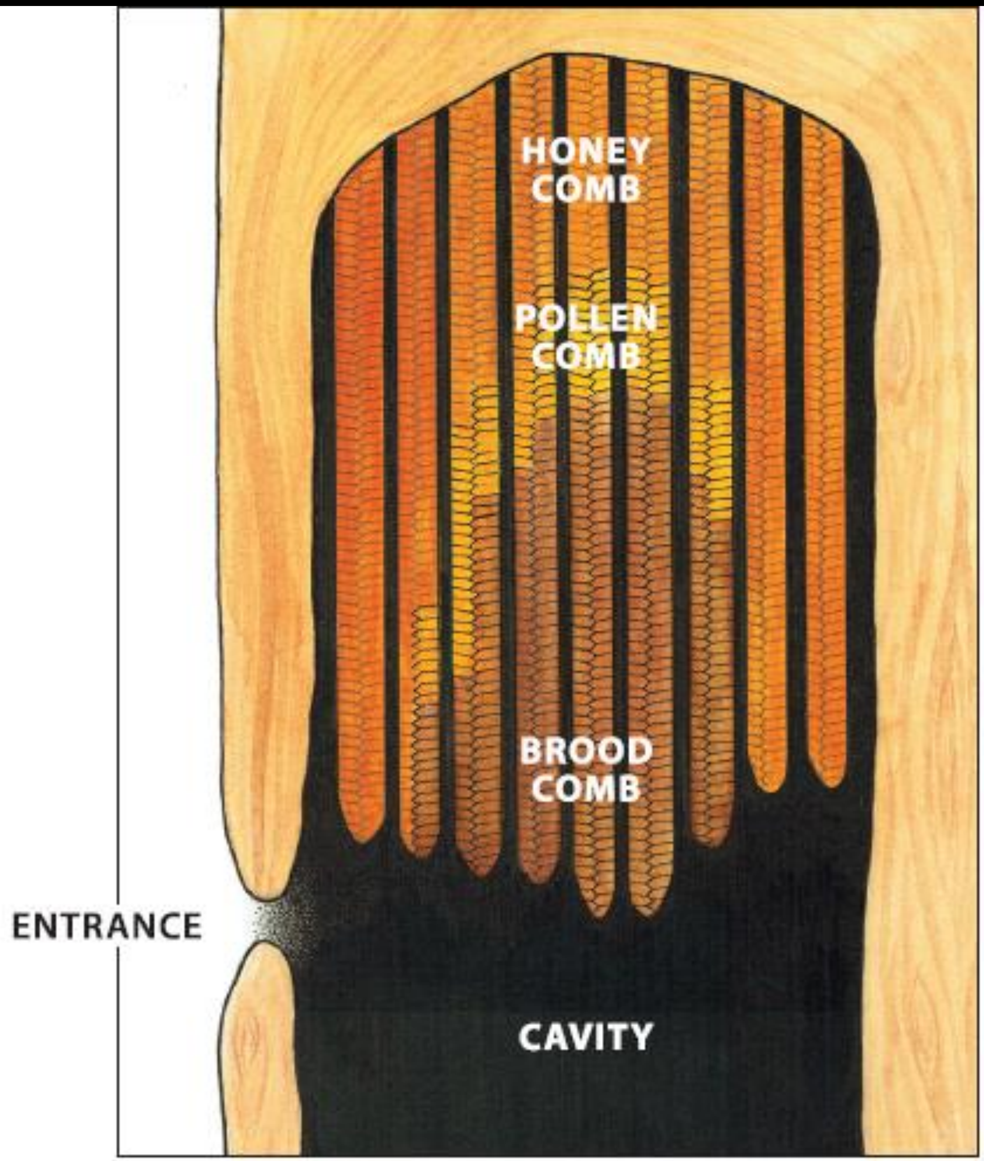
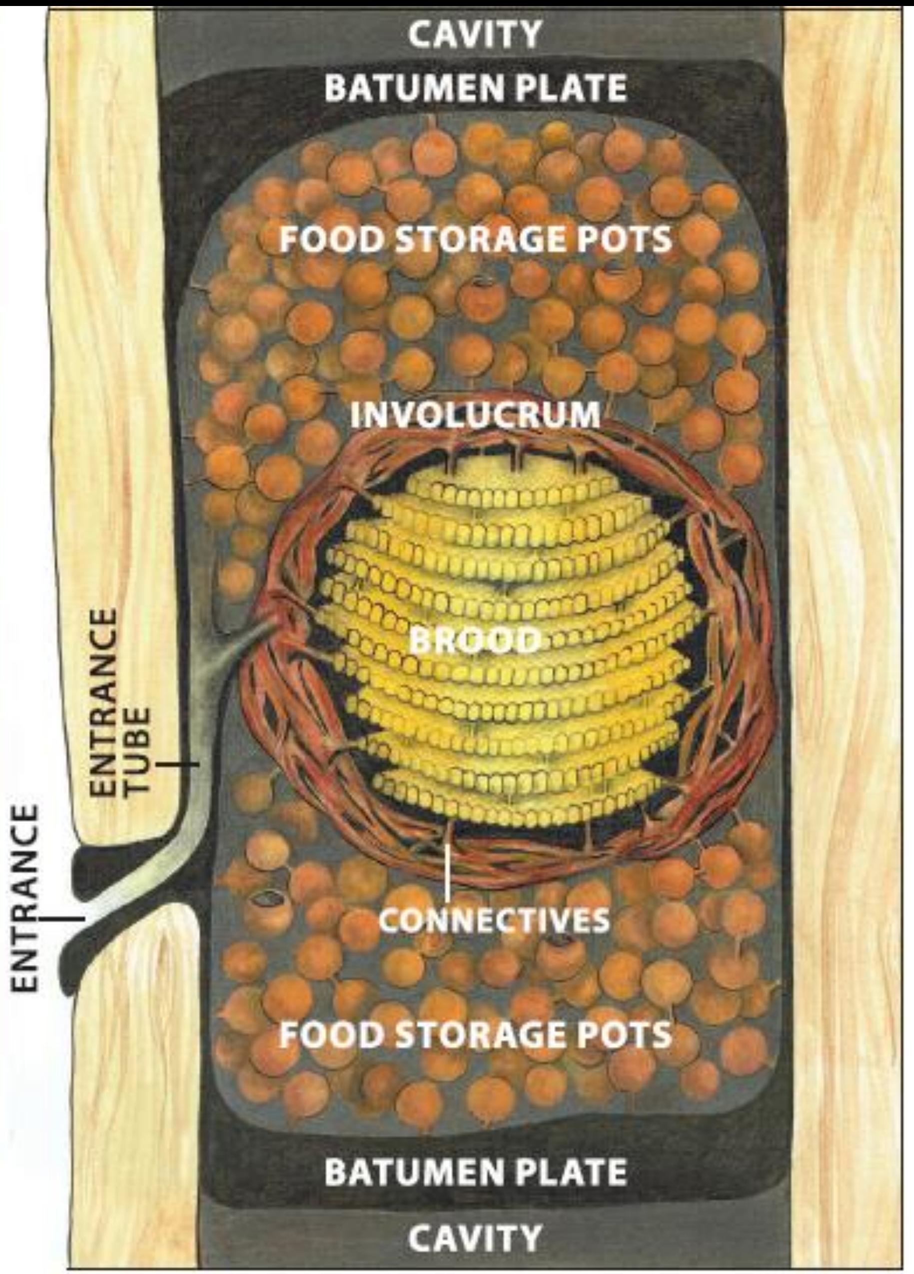


Photo: Dan Coughlan

Honey bee nest Stingless bee nest





ARTWORK **GINA CRANSON**

Australian stingless bee species
Hive volume

Scientific name	Worker length (mm)	Nest volume (litres)	Brood volume (litres)	Brood structure	External entrance tunnel	Common name
Tetragonula carbonaria	4	8	2	Regular comb	No	carbonaria
Tetragonula hockingsi	4.5	10	2	Semi-comb	No	hockingsi
Tetragonula davenporti	4	8	2	Semi-comb	No	davenporti
Tetragonula mellipes	4	4	0.5	Semi-comb	Usually	mellipes
Tetragonula clypearis	3.5	4	0.5	Cluster	Usually	clypearis
Tetragonula sapiens	4	4	0.2	Cluster	Usually	sapiens
Austroplebeia australis	4	5	0.5–1	Cluster	Variable	australis
Austroplebeia cassiae	4	8	1–2	Cluster	Usually	cassiae
Austroplebeia magna	4	2	0.5	Cluster	Usually	magna
Austroplebeia essingtoni	3.5	1	0.2	Cluster	Usually	essingtoni
Austroplebeia cincta	3.5	4	1	Concentric layers	Yes	cincta

Transferring a nest into an artificial hive

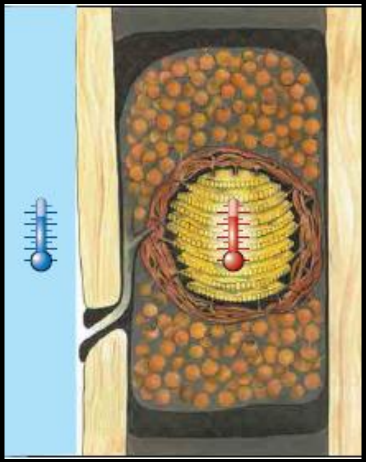
Transferring a nest into an artificial hive

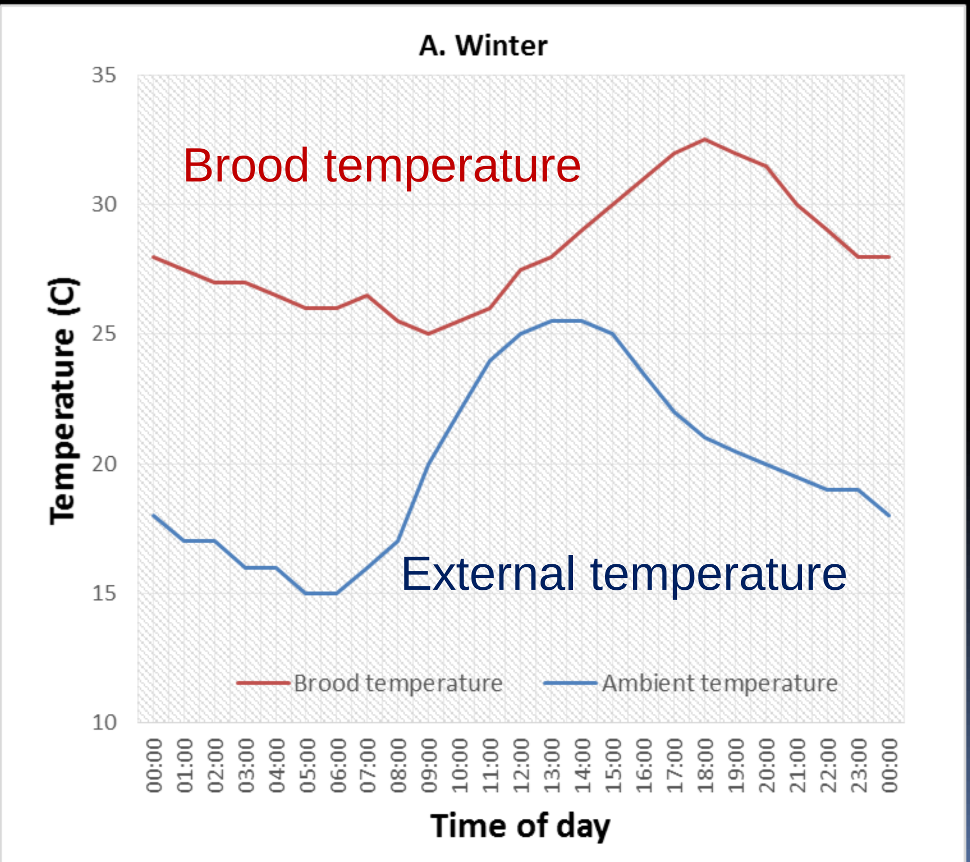
Transferring a nest into an artificial hive

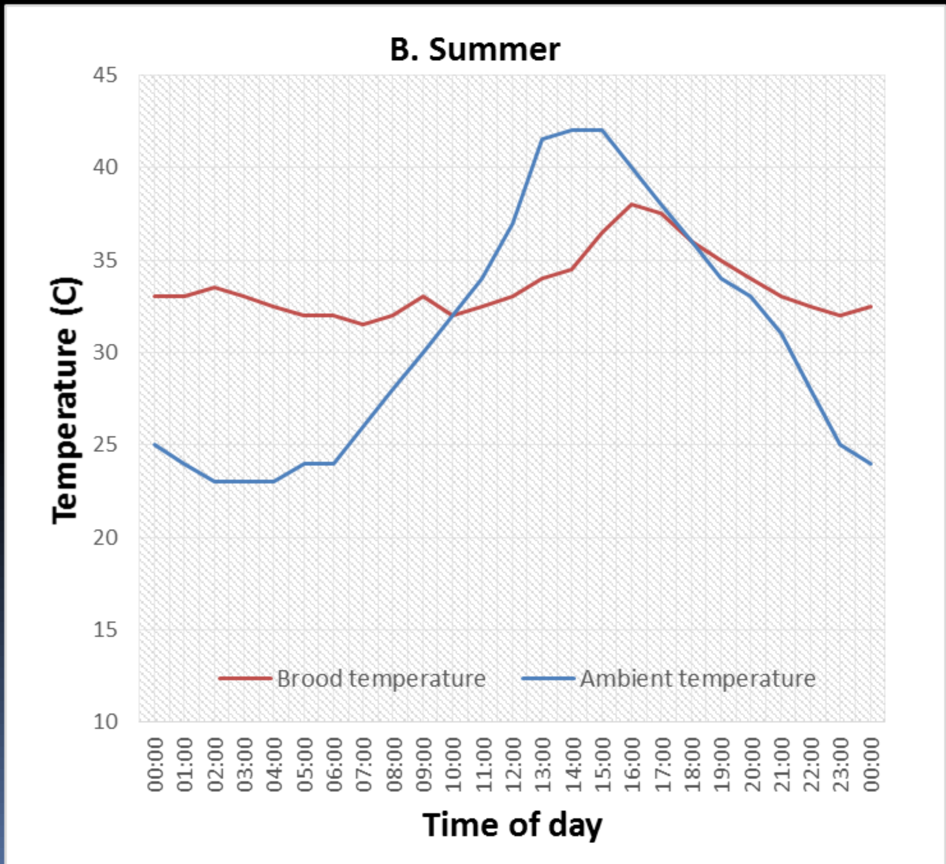
Get the bees into the box

Temperature regulation

Highly social bees maintain standard temperature in nest, even in cool conditions







Stingless beekeeping
-dividing a hive

Stingless beekeeping
-dividing a hive

Stingless beekeeping
-dividing a hive

Split through advancing front

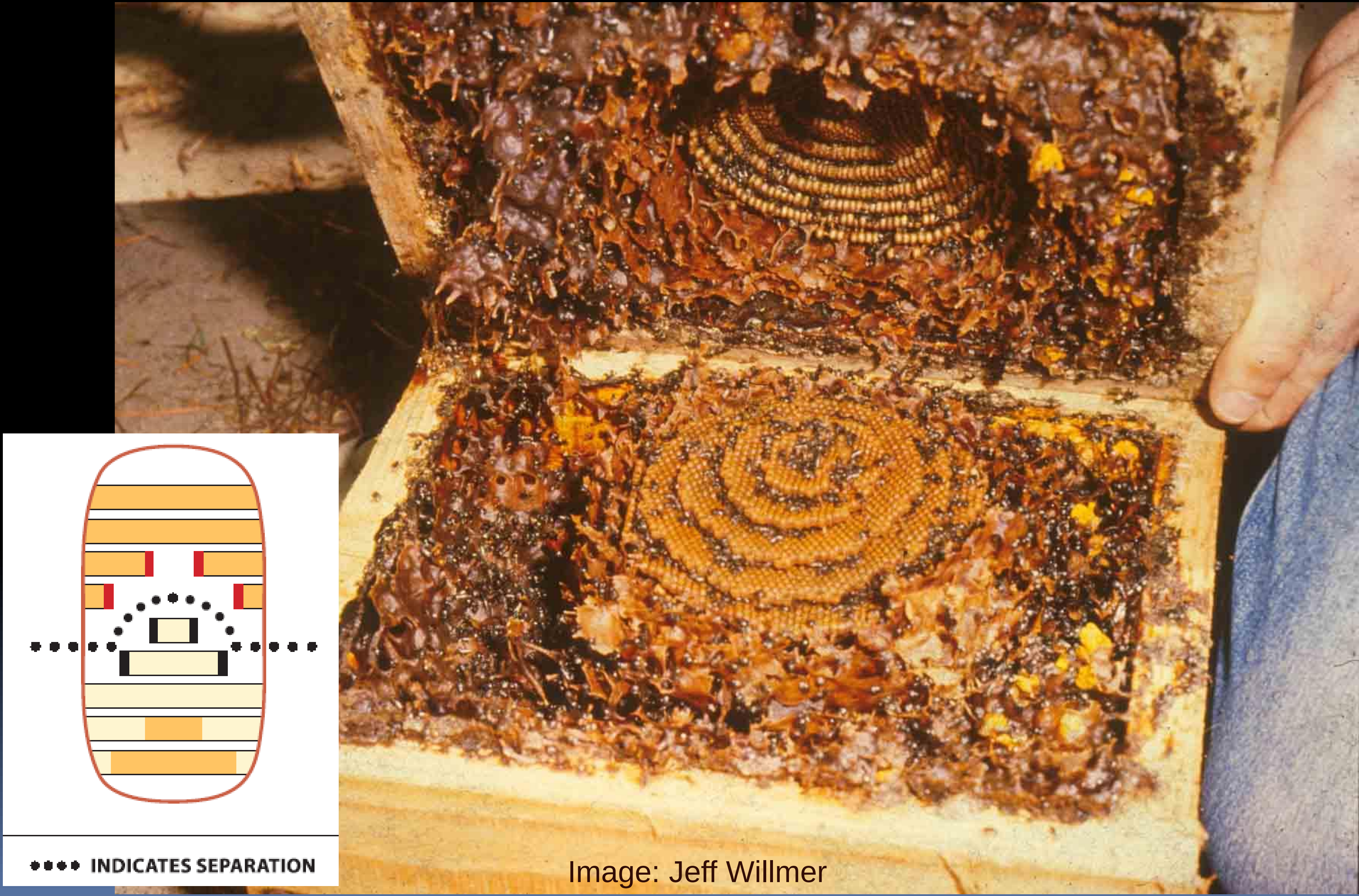


Image: Jeff Willmer

Queen replacement

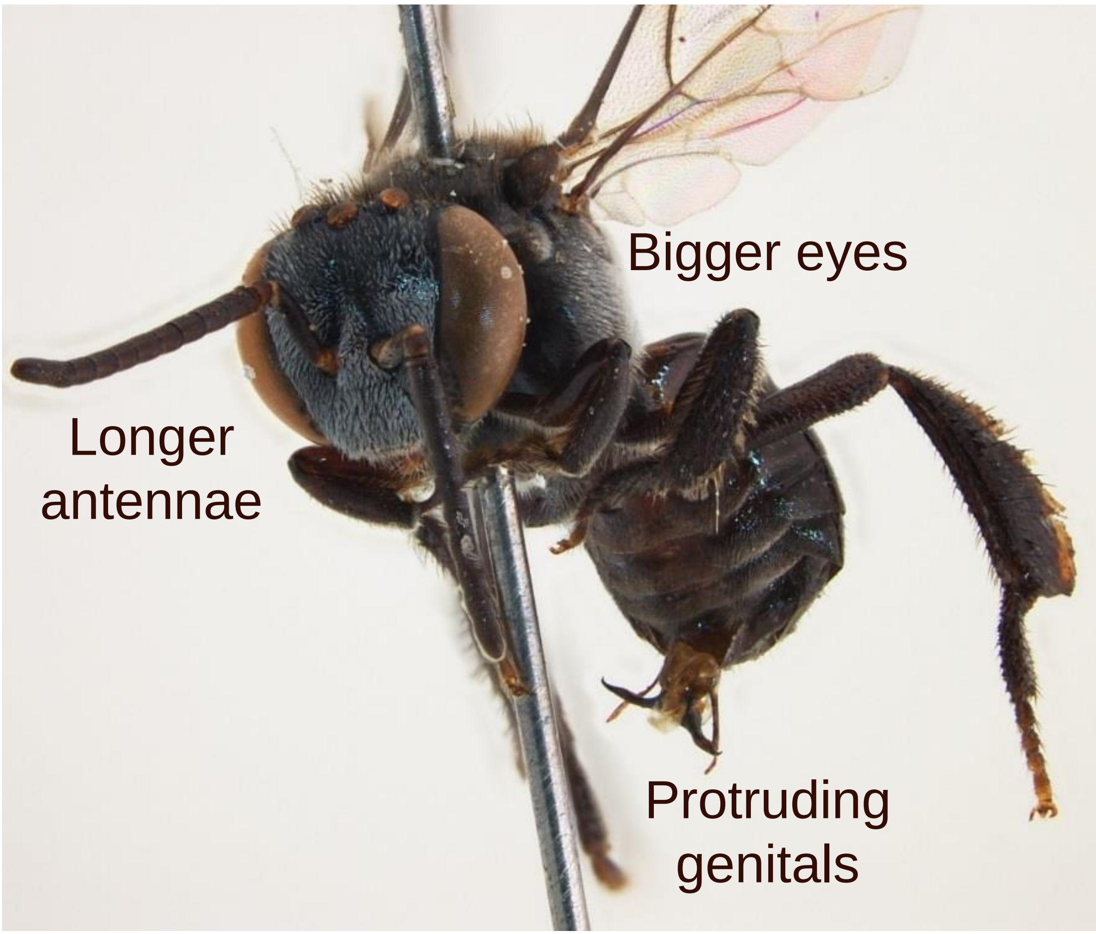
Highly social behaviour

- Cooperative brood care
- Presence of castes (inflexible)
- No solitary phase in life cycle of colonies
- Perennial colonies

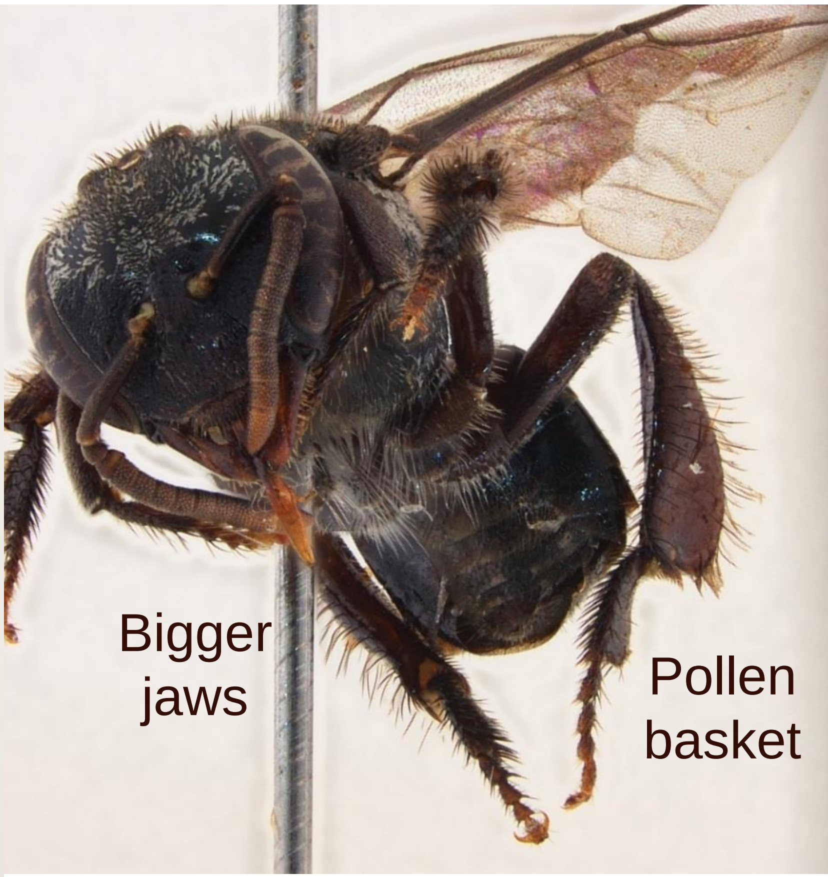
Photo: James Dorey

Males and females Photos: Justin Bartlett

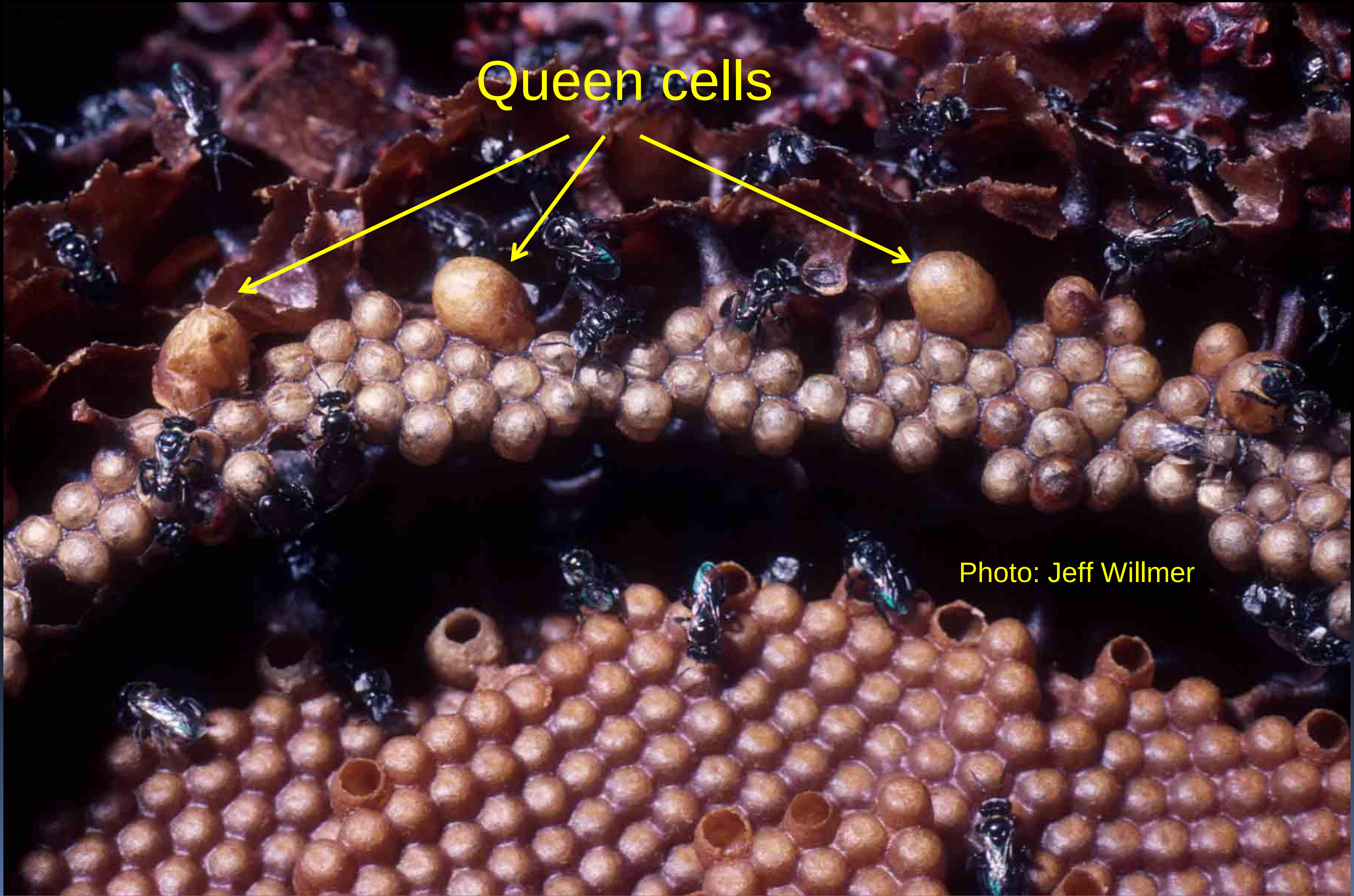
Male



Female worker



Queen production



Males roosting outside nest, towards nightfall

Photo: Corrine Jordan

Mating

- Takes place outside nest, on the wing
- Queen only ever does one mating flight
- Males form a congregation in anticipation
- Queen flies through the male congregation
- She mates with one male
- Return to nest and use the stored sperm for rest of her life

Queen replacement: Emergency queen cells

Austral Entomology (2014) ••, ••–••

Emergency queens in *Tetragonula carbonaria* (Smith, 1854) (Hymenoptera: Apidae: Meliponini)

Túlio M Nunes,[1]* Tim A Heard,[2] Giorgio C Venturieri[2,3] and Benjamin P Oldroyd[1]

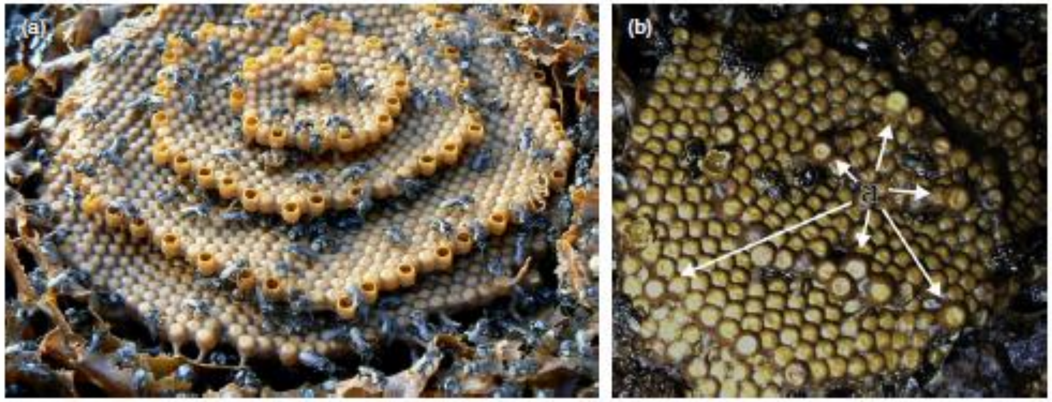


Fig. 3. (a) Brood comb of *Tetragonula carbonaria* in a queenright colony. Note the spiral shape of the brood comb. (b) Brood comb of *T. carbonaria* 1 week after queen removal showing royal-sized cells ('a') constructed by workers, provisioned with food and capped without egg laying.

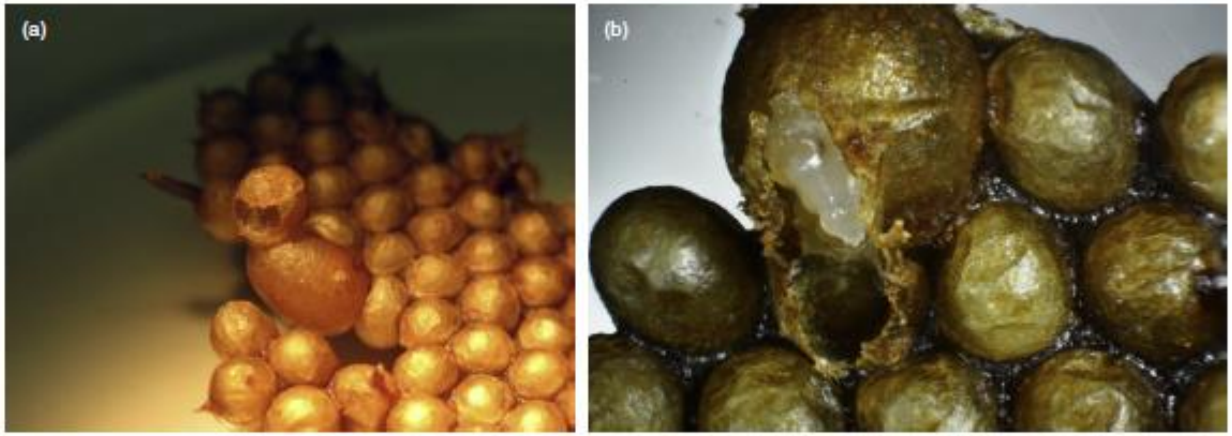


Fig. 4. (a) Mature brood comb of *Tetragonula carbonaria* from a queenless colony showing an emergency queen cell attached to an empty auxiliary cell on the top. (b) Queen larva of *T. carbonaria* adjacent to an empty brood cell.

Budding

(eduction or soft-splitting)

Connect a hive to a nest, with the intention of budding off a new colony into the hive

Budding (progress over time)

Week 1

Week 4

Week 8

Week 12
First brood seen

Week 16
Bud box disconnected

Week 45

Week 45

Stingless bee-keeping -results of surveys

	1998	2010
No of beekeepers (n)	257	637
No of nests (n)	1425	4935
Most popular species	*T. carbonaria* (69%) *T. hockingsi* (20%)	*T. carbonaria* (61.5%) *A. australis* (23%)
Nest locations		
Suburban	56%	67%
Near bush	24%	21%
Rural	20%	13%
Suburban + bush	--	18%
Reasons for keeping bees	(%)	(%)
Enjoyment	81	78
Conservation	68	67
Pollinate bushland	27	29
Pollinate crops	24	24
Crops pollination services	--	1
Honey production	8	11
Hives sales	5	4
Education	2	12
Research	2	4

Natural enemies

Syrphid fly: *Ceriana ornata*

Phorid fly
(Dohniphora)

Adult (right) compared to stingless bee (left)

Larvae destroying a colony of stingless bees

Defence behaviour

- Nest wall, Entrance and tube
- Biting
- Resin applying
- Removal of damaged brood
- Use of plant resins

Image: Paul Cunningham

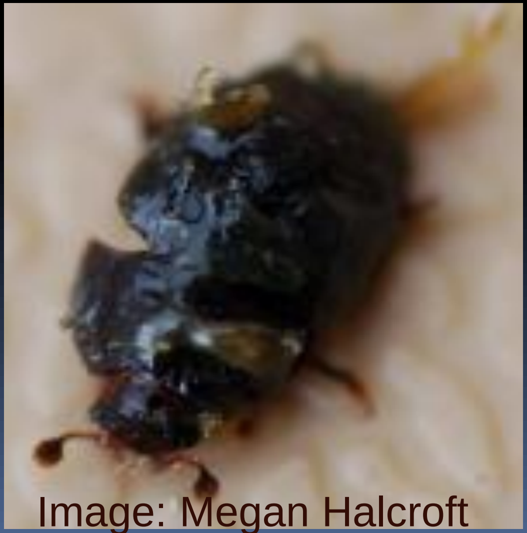


Image: Megan Halcroft

Defence behaviour

- Resin applying

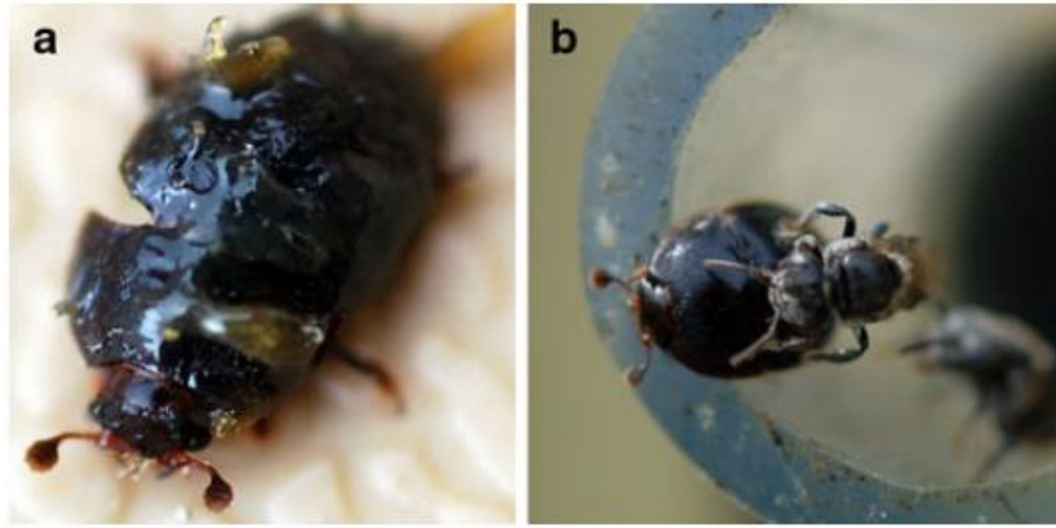


Fig. 3 **a** Ejected adult small hive beetle covered in sticky globules of resin. **b** *A. australis* worker 'riding' adult beetle out of hive entrance

Insect. Soc.
DOI 10.1007/s00040-010-0142-x

Insectes Sociaux

RESEARCH ARTICLE

Behavioral defense strategies of the stingless bee, *Austroplebeia australis*, against the small hive beetle, *Aethina tumida*

M. Halcroft · R. Spooner-Hart · P. Neumann

Naturwissenschaften
DOI 10.1007/s00114-009-0631-9

SHORT COMMUNICATION

The alternative Pharaoh approach: stingless bees mummify beetle parasites alive

Mark K. Greco · Dorothee Hoffmann · Anne Dollin · Michael Duncan · Robert Spooner-Hart · Peter Neumann

Fig. 1 A *T. carbonaria* worker mummifies a live small hive beetle by

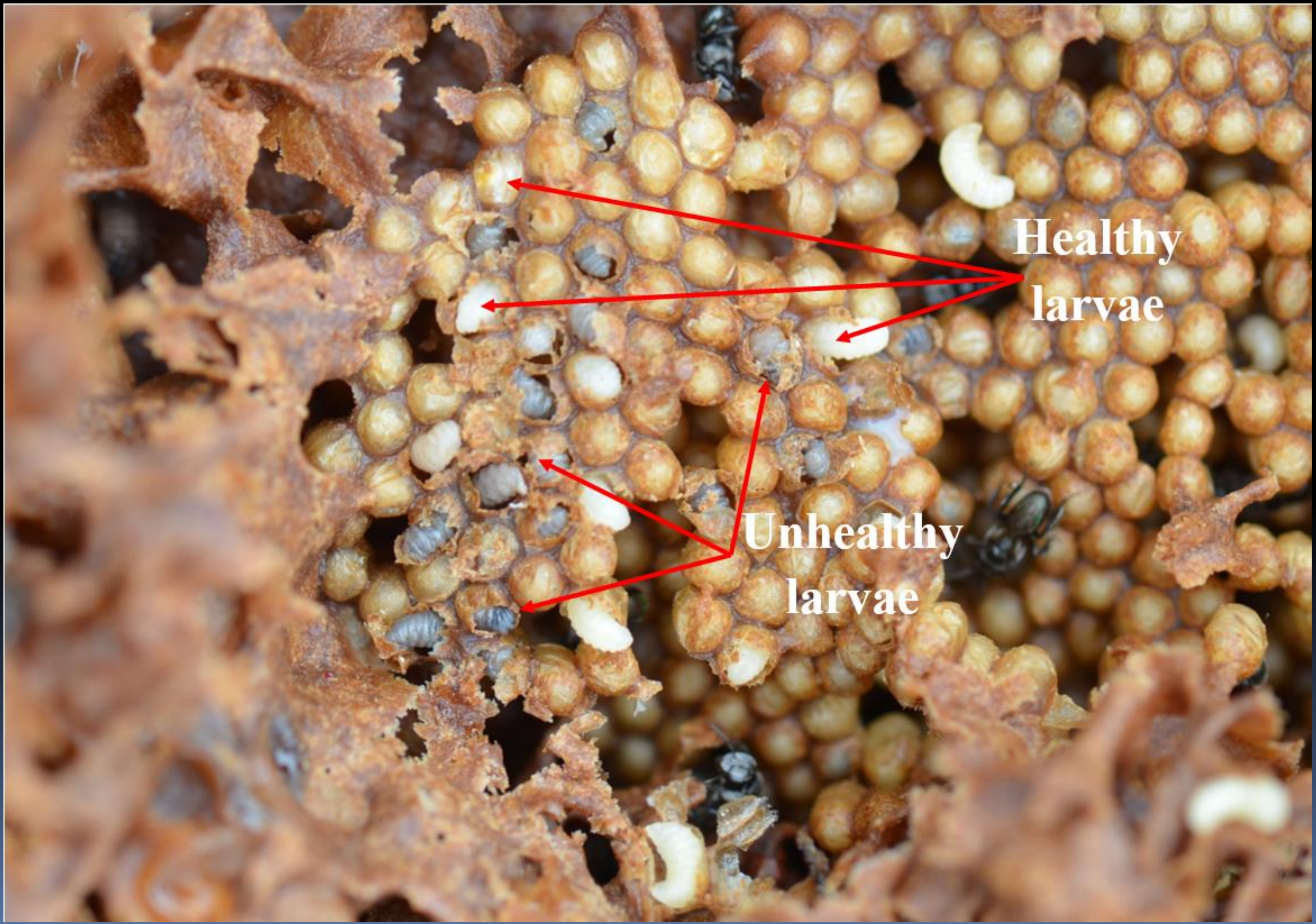
Defence behaviour

- Hygienic behaviour,
- Removal of damaged brood

(Shanks 2014)

Brood pathogen (Shanks disease)

Identification of *Lysinibacillus sphaericus* bacterium as the causative agent (Shanks et al., in press)



Defence behaviour

- Nest wall, Entrance and tube
- Biting
- Resin applying
- Removal of damaged brood
- **Use of plant resins**

Image: Paul Cunningham

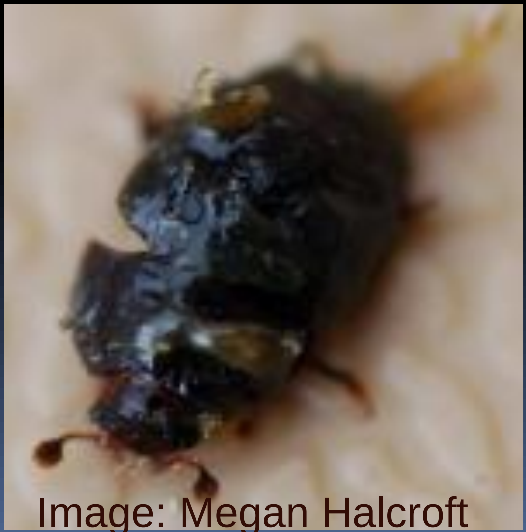


Image: Megan Halcroft

Plant resins are biologically active containing:

- Flavonoids known to be antimicrobial
- Terpenoids known to repel ants and other enemies

Photo: Anne Dollin

Photo: Glenbo Craig

Propolis and stingless bees chemical ecology

- Resin is important in nest recognition (Leonhardt et al .)
- Propolis diversity aids colonies (Drescher et al. 2014)
- Flavonoids are antimicrobial (Massaro et al. 2015)
- Terpenes are repellant (Norton 2016)

Photo: Anne Dollin

Cadaghi tree (*Corymbia torreliana*)

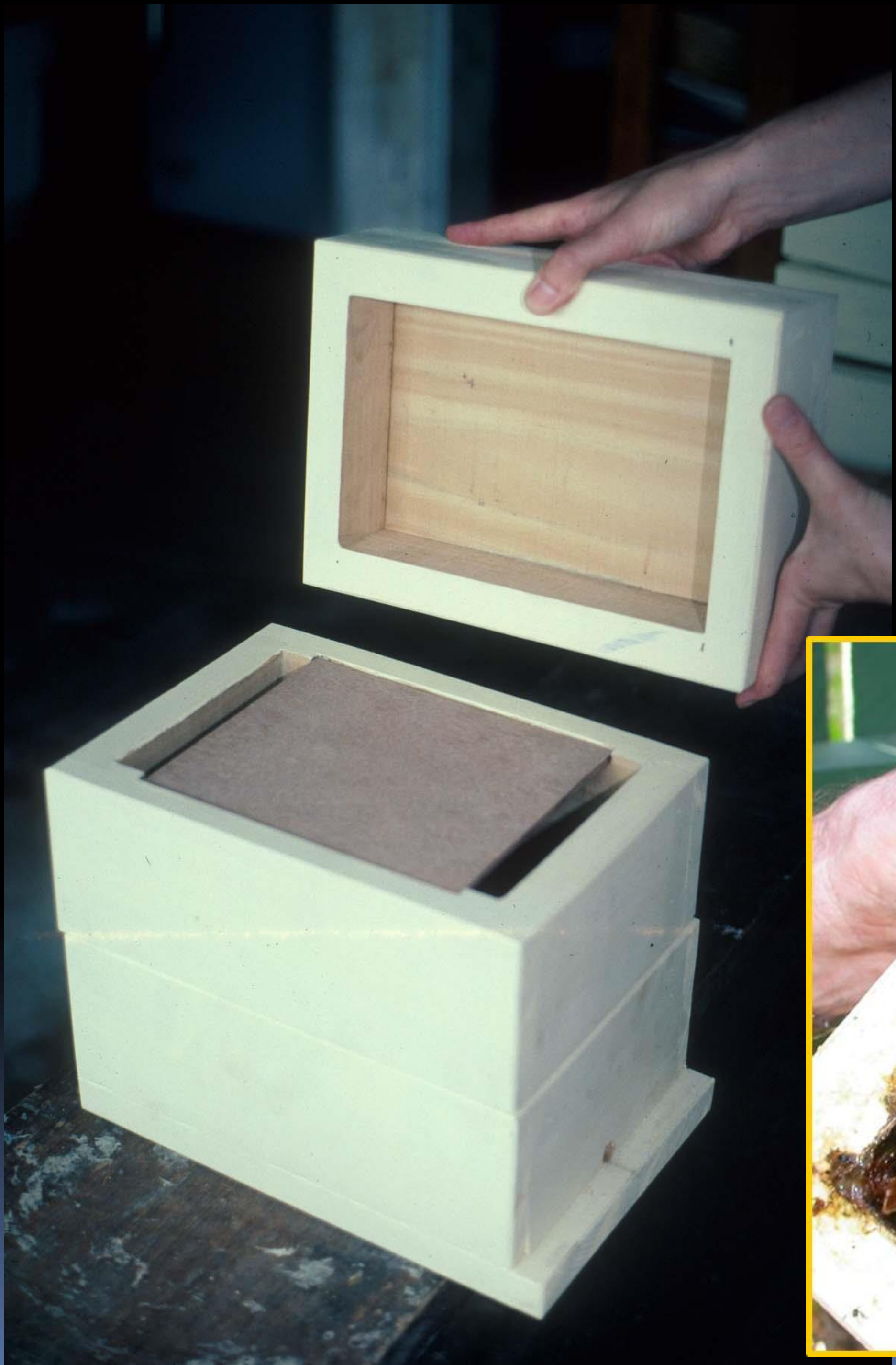
African tulip tree

Poisonous nectar, can kill bees
seems to be a minor problem at worst

Dead bees in flower

Photo: Flavia Massaro

Honey production



Honey

- Commercialisation of a bush tucker
- Composition
  - High water content
  - High acidity
  - Unusual sugars

	Average ± SD
Moisture (g/100 g honey)	26.5 ± 0.8
Electrical conductivity (mS/cm)	1.64 ± 0.12
Ash (g/100 g honey)	0.48 ± 0.06
HMF (mg/kg honey)	1.2 ± 0.6
pH	4.0 ± 0.1
Acidity (milliequivalents/kg honey)	128.9 ± 23.3
Nitrogen (mg/100 g honey)	202.3 ± 191.2
Diastase (DN)	0.4 ± 0.5
Invertase (IN)	5.7 ± 1.5
Fructose	24.5 ± 1.9
Glucose	17.5 ± 2.8
Maltose	20.3 ± 2.9
Sucrose	1.8 ± 0.4
Fructose + glucose	42.0 ± 4.5
Total sugars	64.6 ± [illegible]

JOURNAL OF MEDICINAL FOOD
J Med Food 11 (4) 2008, 789–794

DOI: 10.1089/jmf.2007.0724

Short Communication

Composition and Antioxidant Activity of *Trigona carbonaria* Honey from Australia

Livia Persano Oddo,[1] Tim A. Heard,[2] Antonio Rodríguez-Malaver,[3] Rosa Ana Pérez,[4]
Miguel Fernández-Muiño,[5] María Teresa Sancho,[5] Giulio Sesta,[1] Lorenzo Lusco,[1] and Patricia Vit[6]

Antimicrobial activity of honey

ELSEVIER
International Journal of Antimicrobial Agents 32 (2008) 89–98
International Journal of Antimicrobial Agents
www.ischemo.org

Letters to the Editor

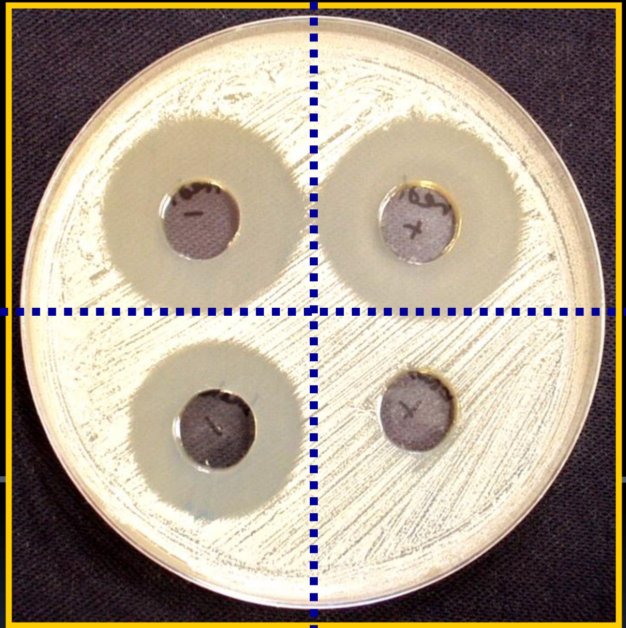
Antibacterial activity of honey from the Australian stingless bee *Trigona carbonaria*

The antibacterial activities of the 22 samples of *Trigona* honey are shown in Table 1. The initial total antibacte-

Peroxide vs Non-peroxide activity

Leptospermum honey

Leptospermum honey + catalase



Brush box honey

Brush box honey + catalase

cus aureus

Journal of Applied Microbiology
Journal of Applied Microbiology ISSN

ORIGINAL ARTICLE

Antimicrobial activity of honey from the stingless bee *Trigona carbonaria* determined by agar diffusion, agar dilution, broth microdilution and time-kill methodology

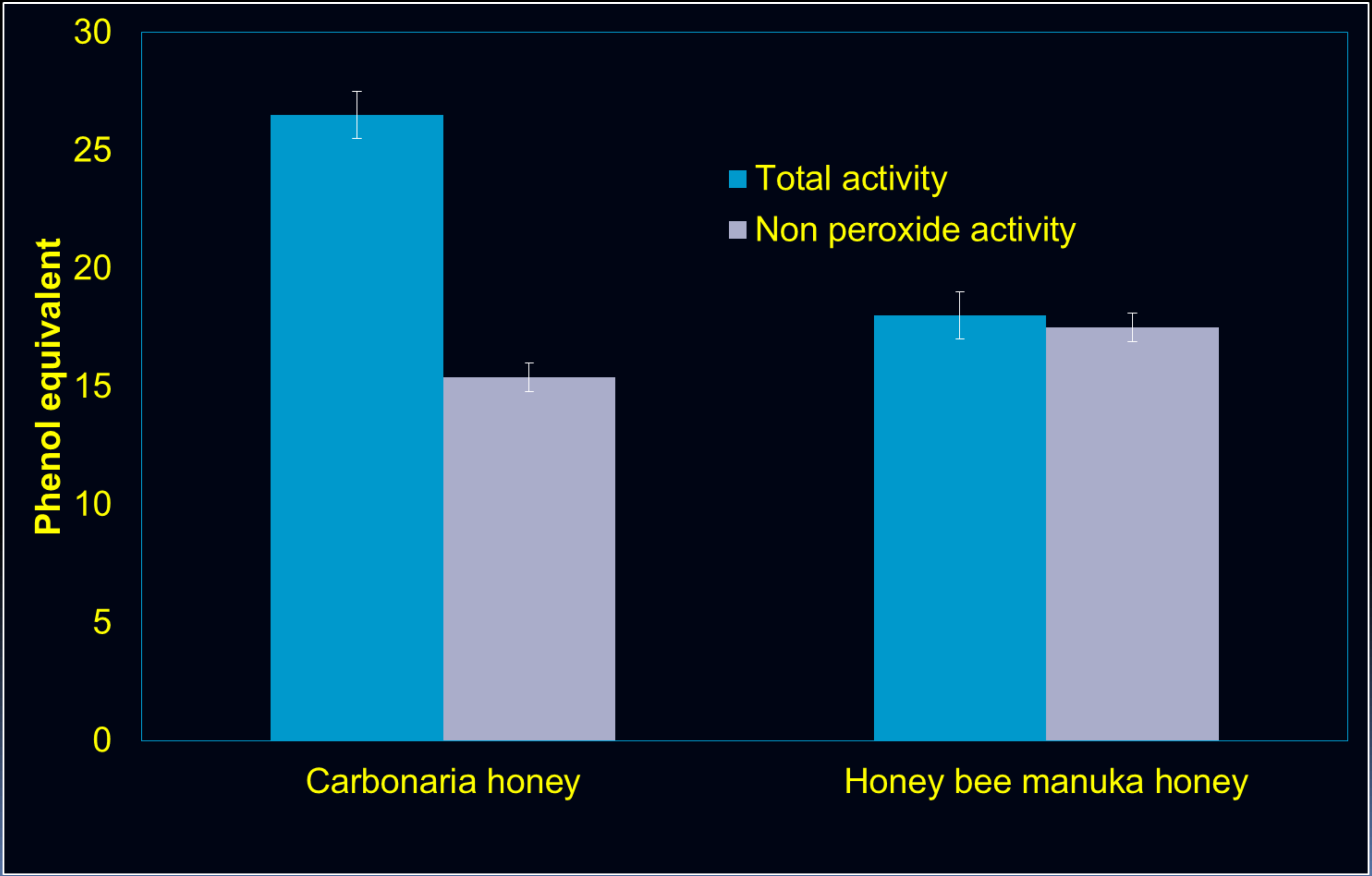
K.L. Boorn[1], Y.-Y. Khor[2], E. Sweetman[2], F. Tan[2], T.A. Heard[3] and K.A. Hammer[2]

JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY
Article
pubs.acs.org/JAFC

In Vitro Antibacterial Phenolic Extracts from "Sugarbag" Pot-Honeys of Australian Stingless Bees (*Tetragonula carbonaria*)

C. Flavia Massaro,*[,†] Daniel Shelley,[†] Tim A. Heard,[§] and Peter Brooks[†]

Antimicrobial activity of honey



Antimicrobial activity of honey –where is it from?

Honey comb of

Apis mellifera

Made of WAX

Honey pots of

Tetragonula carbonaria

Made of PROPOLIS

Propolis

Propolis can be collected and sold as a valuable product

Fighting swarms

Peculiar behaviour
of ***Tetragonula***

Bees hovering in circular motion

Fighting swarms

Bees hovering facing the entrance

Photo: Tobias Smith

Fighting swarms

Bees fighting to the death

Photo: Paul Cunningham

Fighting swarms are caused by an attacking colony attempting to usurp the nest of the defending colony

Fighting swarms are caused by an attacking colony attempting to usurp the nest of the defending colony

Nest defence in a stingless bee: What causes fighting swarms in *Trigona carbonaria* (Hymenoptera, Meliponini)?

R. Gloag[1], T.A. Heard[2], M. Beekman[1] and B.P. Oldroyd[1]

1

2

VOL. 184, NO. 6 THE AMERICAN NATURALIST DECEMBER 2014

NATURAL HISTORY NOTE

Bees at War: Interspecific Battles and Nest Usurpation in Stingless Bees

John Paul Cunningham,[1,*] James P. Hereward,[2] Tim A. Heard,[3] Paul J. De Barro,[4] and Stuart A. West[5]

Inter-specific colony usurption

- Tetragonula hockingsi usurps nests of T. carbonaria

Flight range

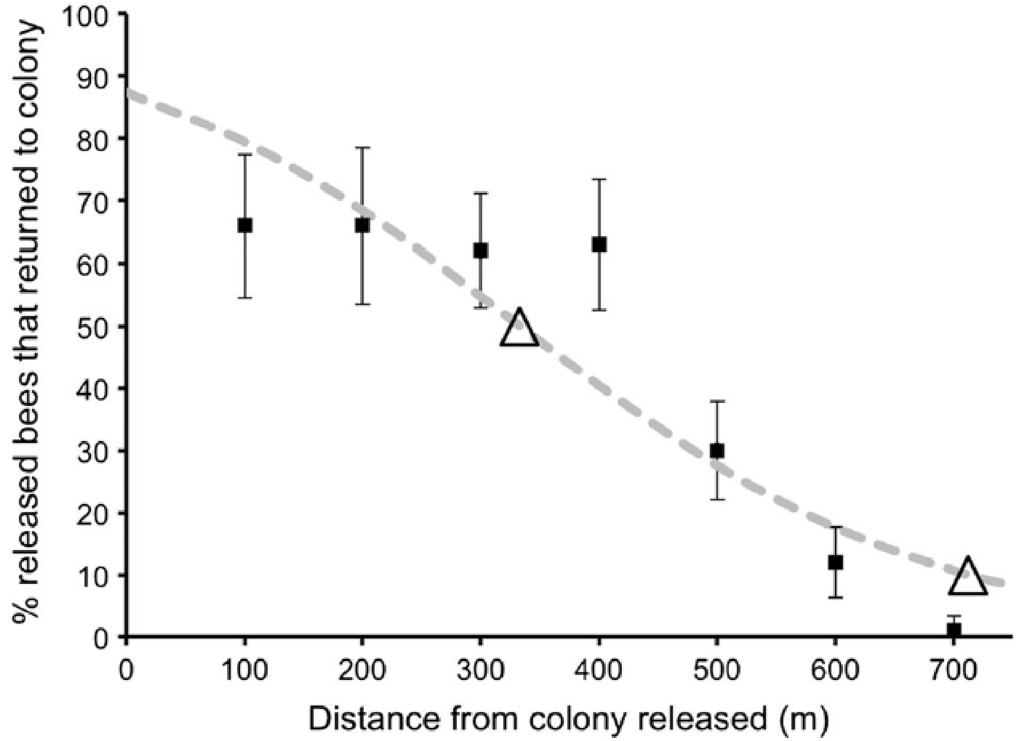


Fig. 3. Mean percentage of bees ($n = 100$ bees per distance) that returned to the colony when released between 100 and 700 m from the colony (error bars indicate ± one standard deviation).

Austral Entomology (2016) ••, ••–••

Flight range of the Australian stingless bee *Tetragonula carbonaria* (Hymenoptera: Apidae)

Jordan P. Smith,[1] Tim A. Heard,[2] Madeleine Beekman[1] and Ros Gloag[1]*

Flight range (500m radius around nest)

Sub-urban area

Natural area

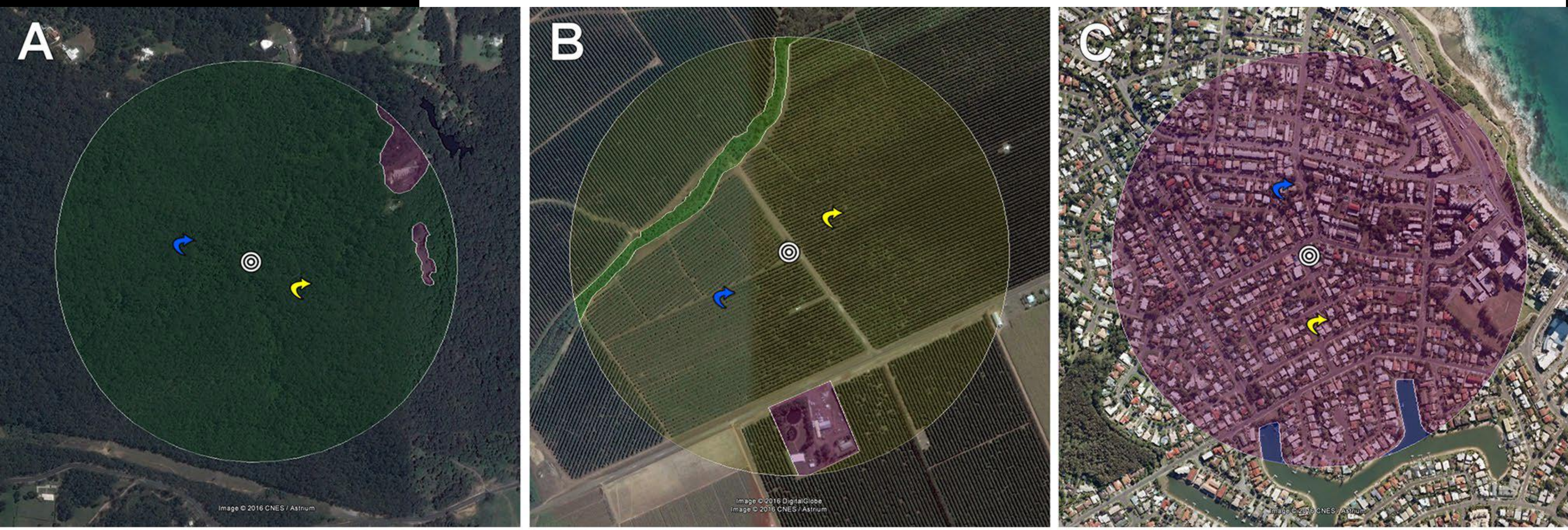
Homing behaviour

J Comp Physiol A
DOI 10.1007/s00359-016-1100-5

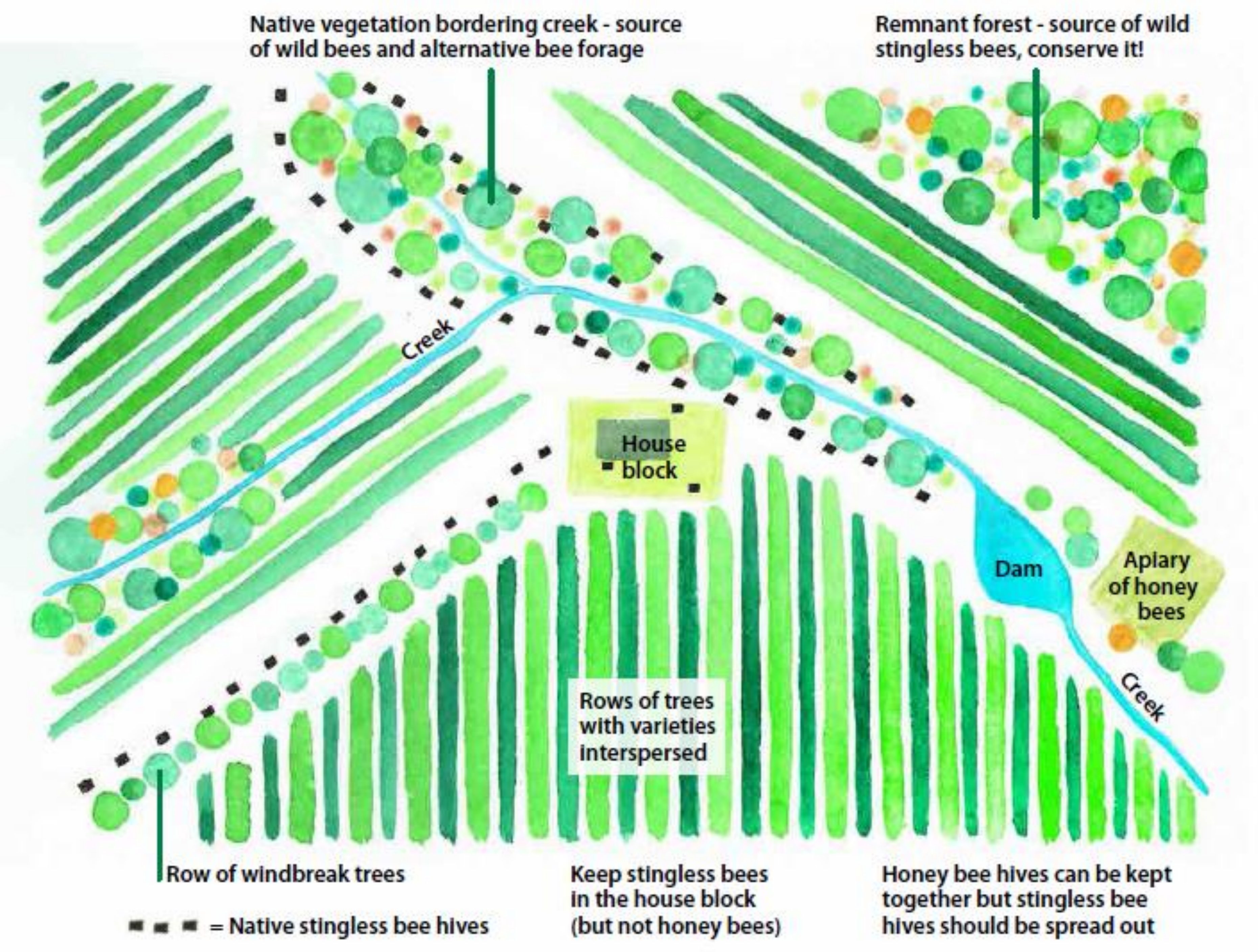
ORIGINAL PAPER

Resources or landmarks: which factors drive homing success in *Tetragonula carbonaria* foraging in natural and disturbed landscapes?

Sara D. Leonhardt[1] · Benjamin F. Kaluza[1,2,3] · Helen Wallace[2] · Tim A. Heard[4]



Most bees returned in the natural forests and gardens, but in farm landscapes many never made it home. This information gives us insight into how stingless bees navigate. Their ability to get home in natural, seemingly homogeneous habitats surprised us. Perhaps they use complex combinations of visual objects or olfactory landmarks?

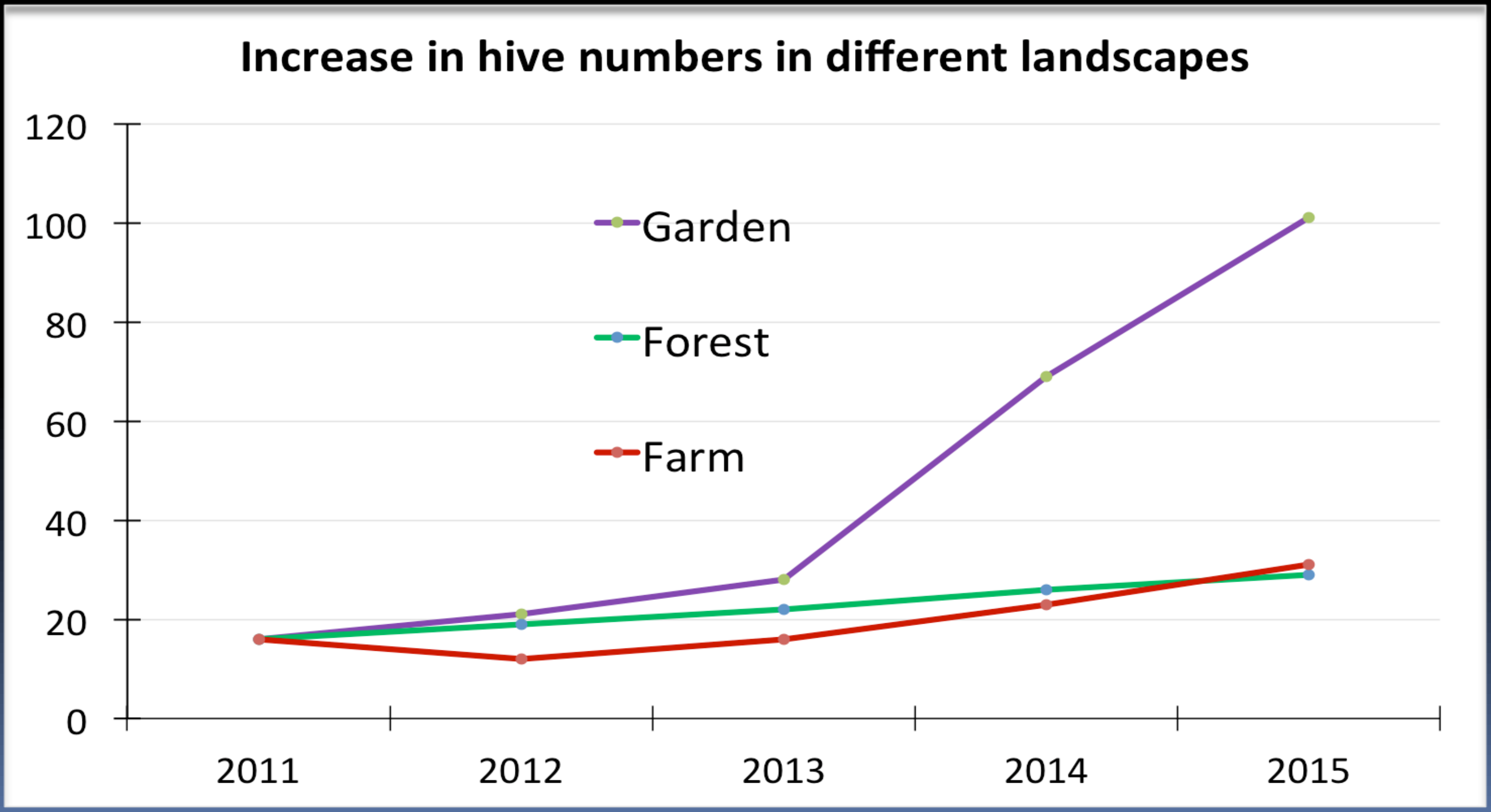

Native vegetation bordering creek - source of wild bees and alternative bee forage
Remnant forest - source of wild stingless bees, conserve it!
Creek
House block
Dam
Apiary of honey bees
Creek
Rows of trees with varieties interspersed
Row of windbreak trees
= Native stingless bee hives
Keep stingless bees in the house block (but not honey bees)
Honey bee hives can be kept together but stingless bee hives should be spread out

Performance of colonies in diverse environments

Ecology and Evolution
Open Access

Urban gardens promote bee foraging over natural habitats and plantations

Benjamin F. Kaluza[1,2,3], Helen Wallace[2], Tim A. Heard[4], Alexandra-Maria Klein[5] & Sara D. Leonhardt[3]



Communication of food sources -honey bees

- The “waggle dance”
- Workers follow the scout and feel her movement

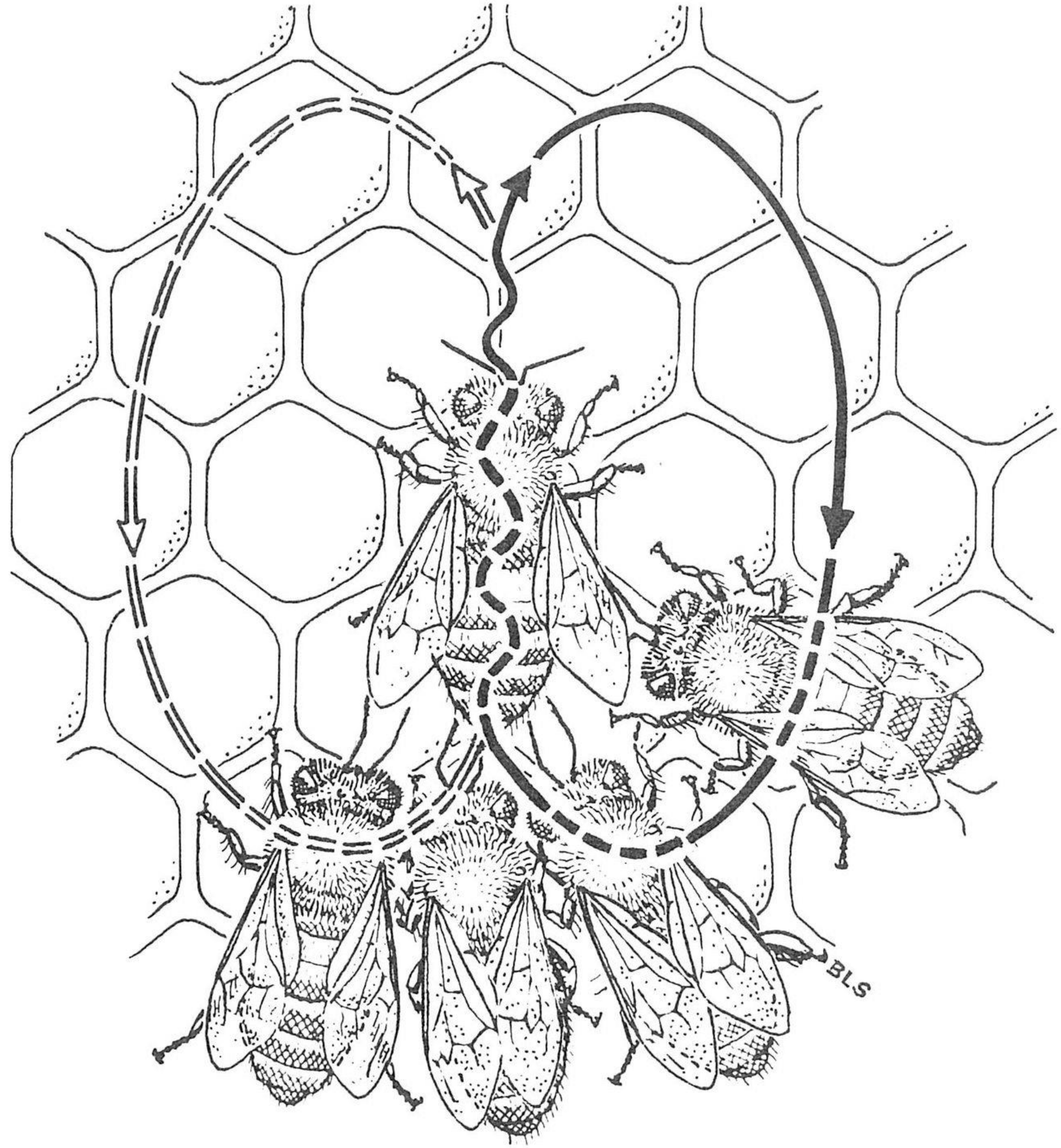
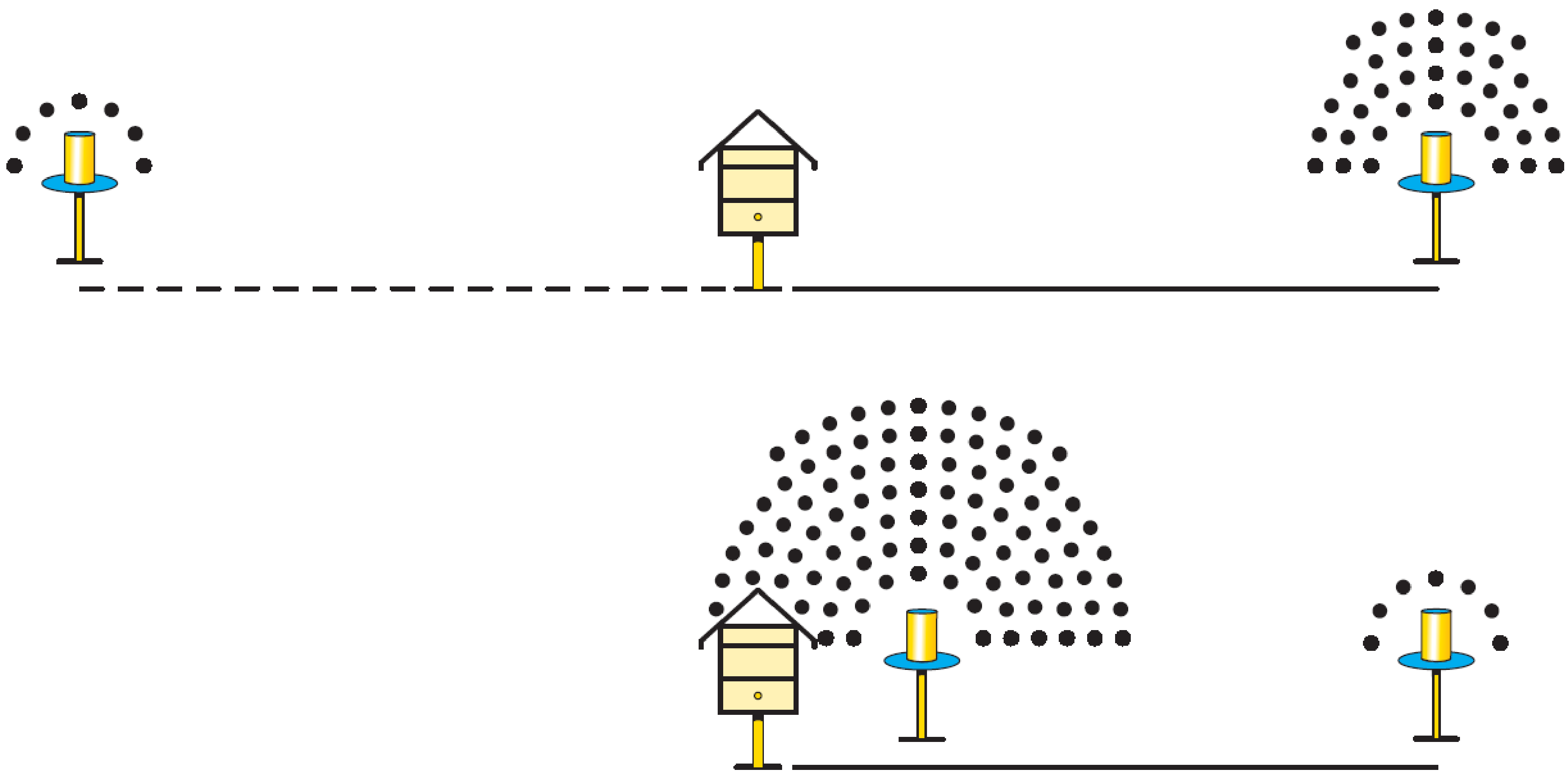


FIGURE 15.11. The tail-wagging dance of *Apis mellifera*. The upper worker is dancing in the pattern indicated; she is followed and antennated by other workers. (From Frisch, 1967a.)

Communication of food sources -stingless bees

- *Tetragonula carbonaria* can communicate direction but not distance (Neih et al 1995)



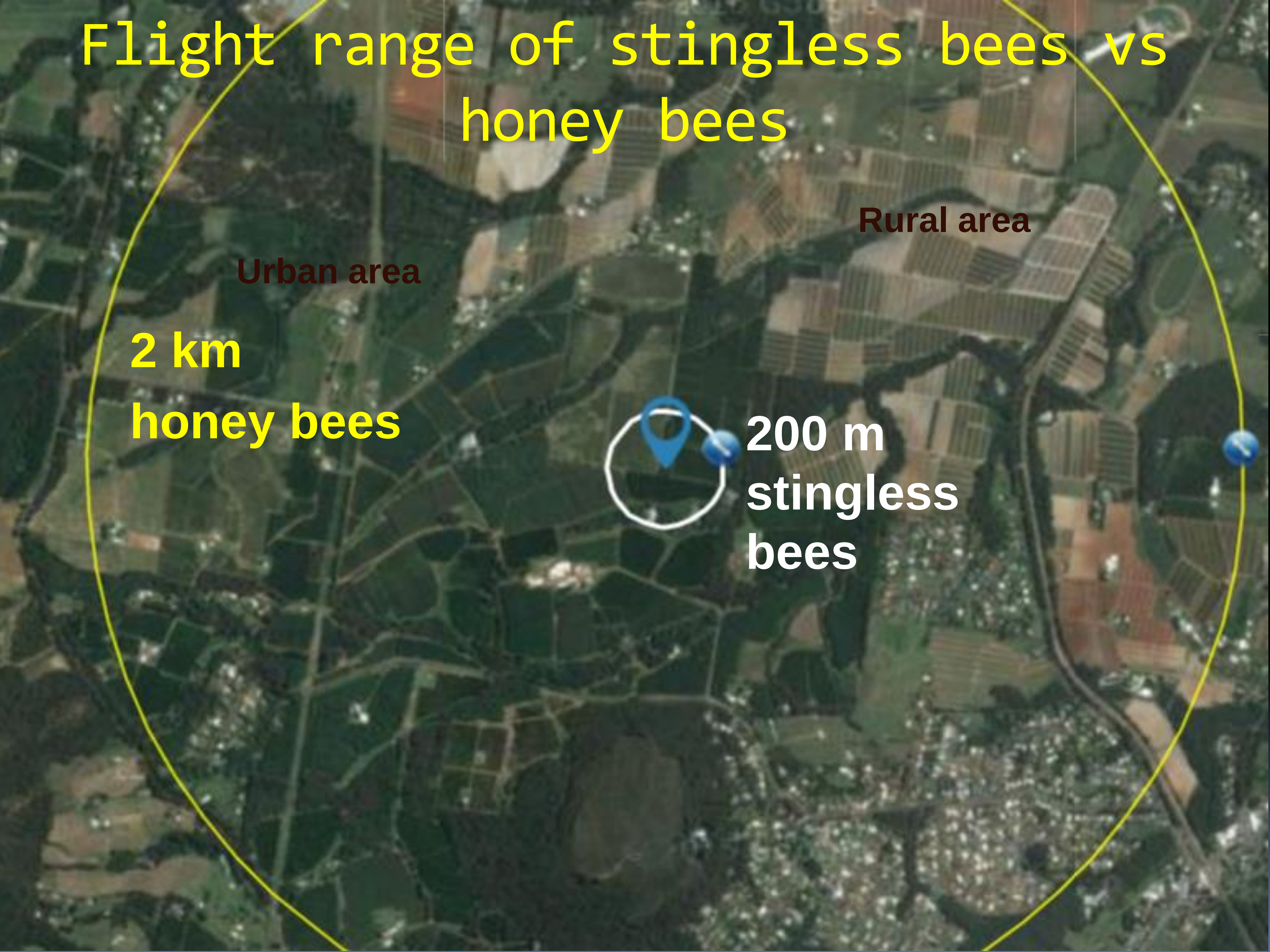
Pollination of crop plants

Macadamia

Unlike honey bees, stingless bees have the following advantages:

- Generally harmless to humans and domesticated animals
- Preservation of biodiversity
- Colonies are unable to abscond as the old queen is flightless
- They are resistant to the diseases and parasites of honey bees
- Short flight ranges (typically 500 m) keeps them in crops

Flight range of stingless bees vs honey bees

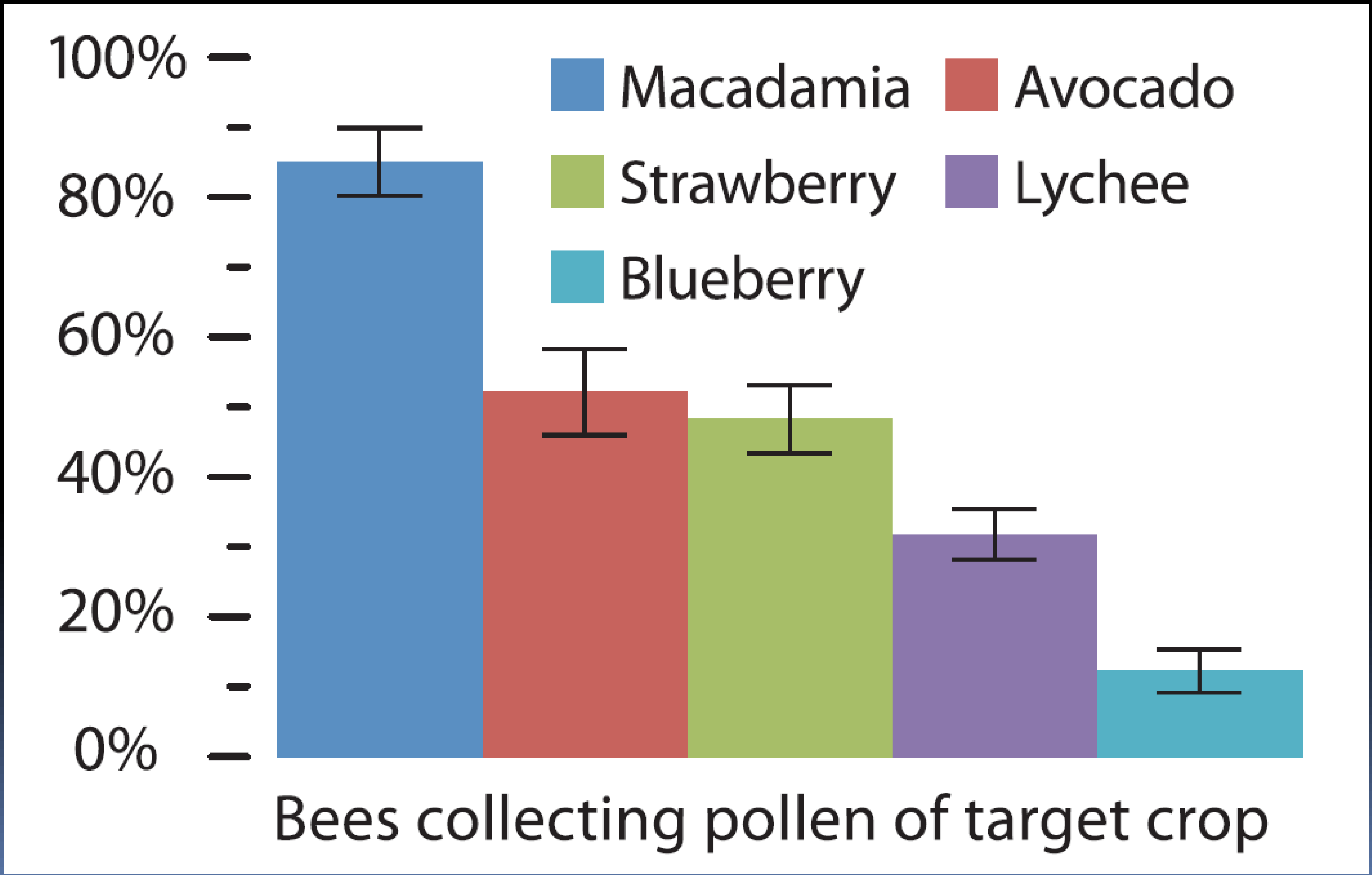


Disadvantages of stingless bees for crop pollination include:

- Lack of availability of large numbers of hives
- Limited to warmer part of the globe
- Some species fight when placed in close proximity

Positioning hives

The proportion of bees collecting pollen of the target crop for five crop species



Competition between crops: Strawberry vs macadamia

Summary

- Introduction to Stingless bees
- Stingless beekeeping in Australia
- Recent research that has supported the practice of Stingless beekeeping
  - Taxonomy
  - Domestication
  - Natural enemies and defence mechanisms
  - Studies on the products of hives: propolis and honey,
  - Queen replacement
  - Fighting swarms
  - The flight range and homing behaviour
  - Effect of habitat type on colony success
  - Use of these bees as crop pollinators.

Thank you!

tim@sugarbag.net

www.sugarbag.net

Facebook:
Sugarbag Bees

Sugarbag Bees

New book available at
www.NativeBeeBook.com.au