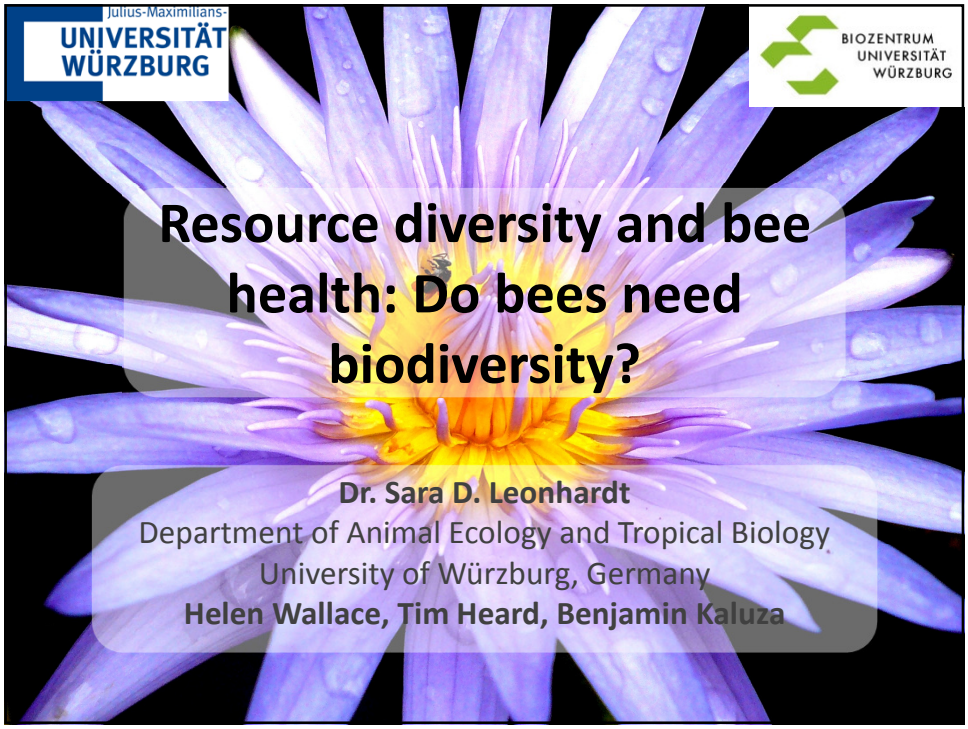
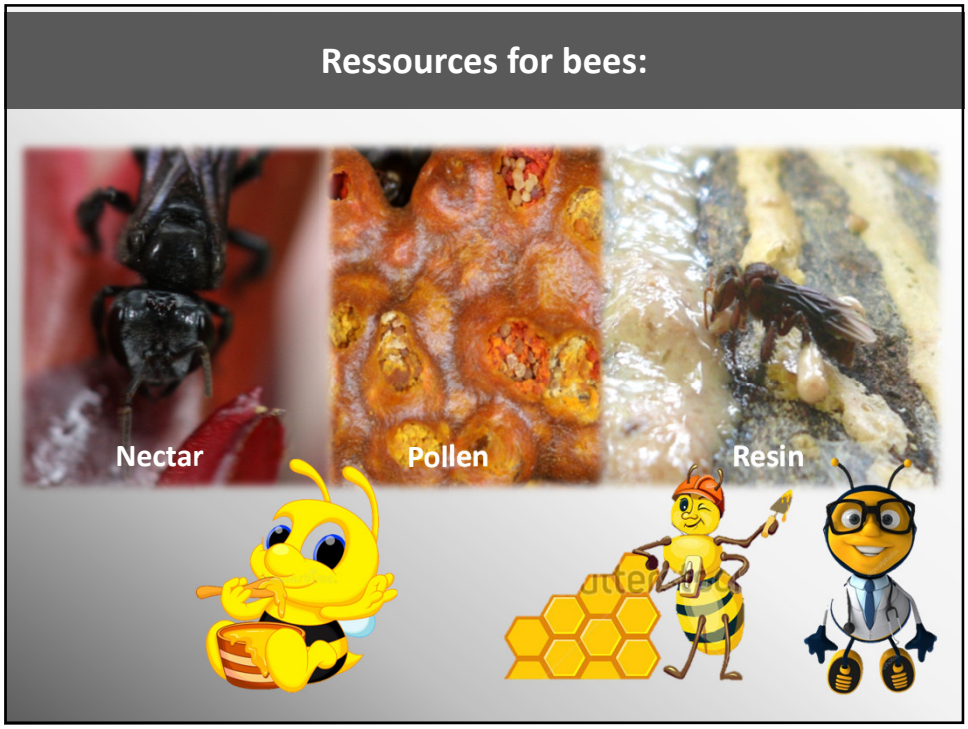
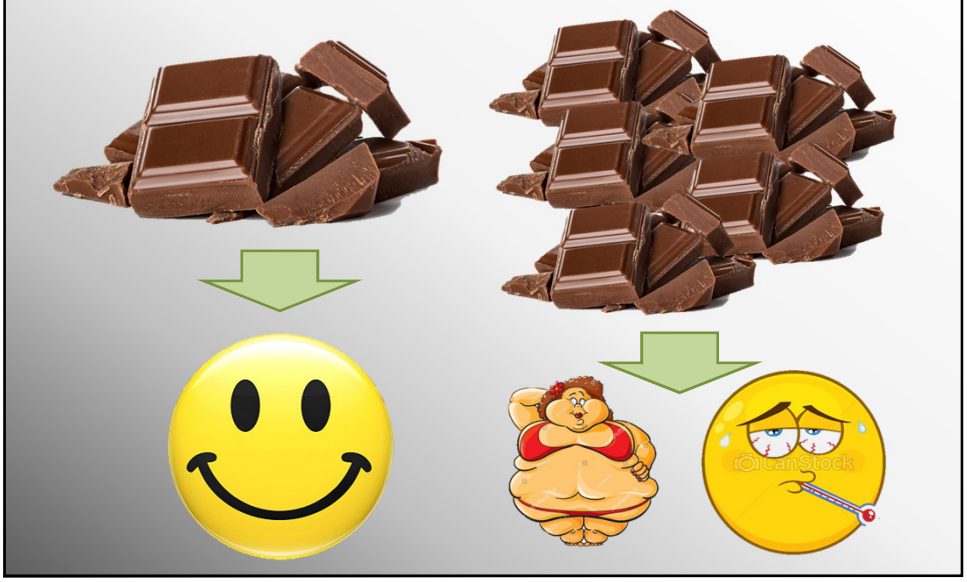
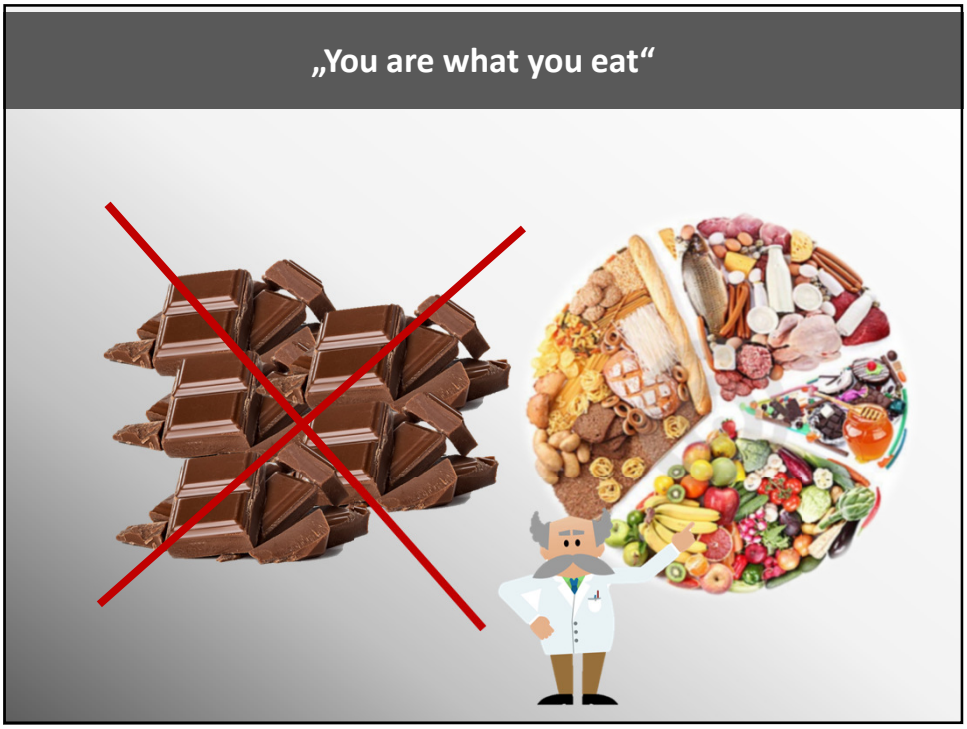

Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG
BIOZENTRUM
UNIVERSITÄT
WÜRZBURG
Resource diversity and bee health: Do bees need biodiversity?
Dr. Sara D. Leonhardt
Department of Animal Ecology and Tropical Biology
University of Würzburg, Germany
Helen Wallace, Tim Heard, Benjamin Kaluza


Ressources for bees:
Nectar
Pollen
Resin

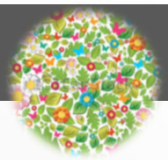
„You are what you eat“



„You are what you eat“



„You are what you eat“



Bees need:

- floral resources (pollen and nectar) with all essential micro- and macronutrients,
- nutritionally balanced diet, i.e. right amounts and ratios of nutrients.

So I need a little bit of everyting to be HAPPY and HEALTHY!

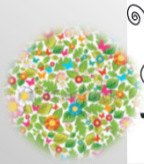
BUT: Different plants strongly vary in resource (nutritional) quality!

e.g. **sugar** in nectar: 2% - 80%

e.g. **protein** in pollen: 2% - 60% of pollen dry mass

e.g. **fat** in pollen: 1% - 30% of pollen dry mass

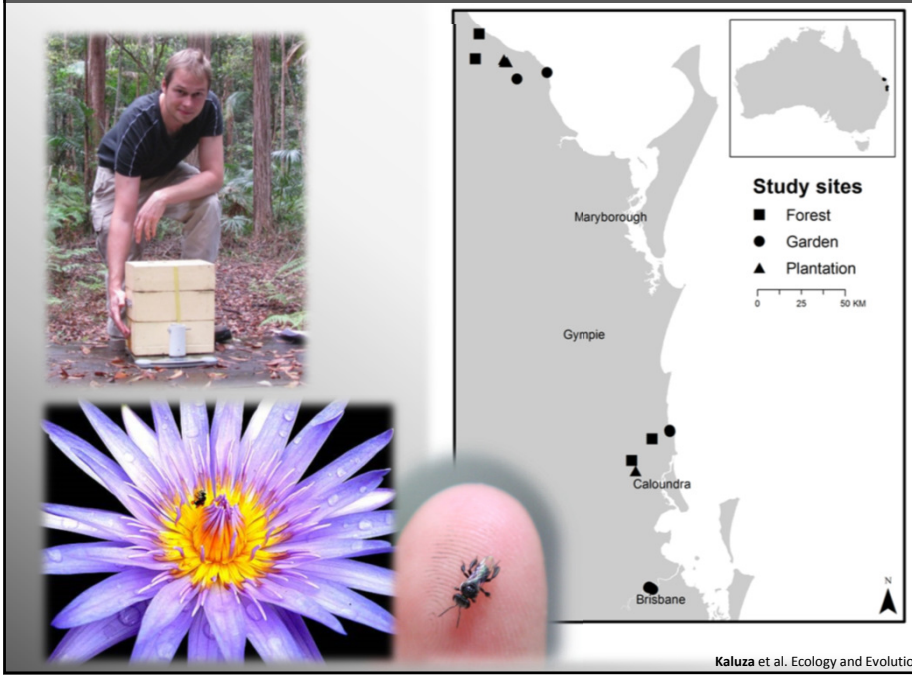
+ variable amounts (e.g. toxic) secundary metabolites!



Wright et al. 2017, Simpson & Raubenheimer 2012, Keller et al. 2005

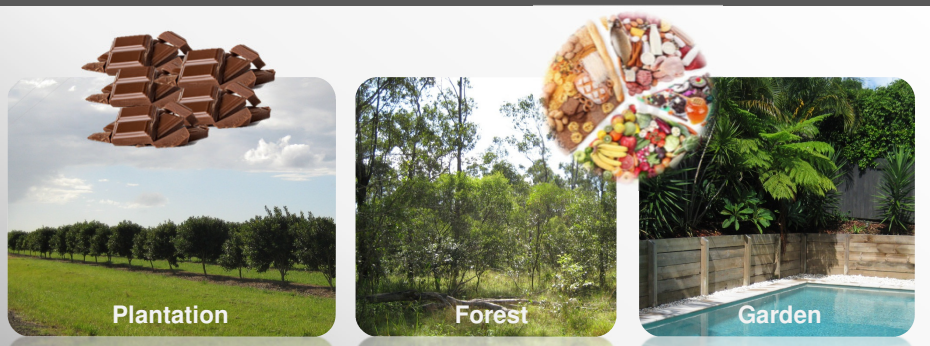
Do bees really collect diverse?
And how does it affect their health and fitness?

Experiment: sugarbag bee (*Tetragonula carbonaria*) in Queensland!



Kaluza et al. Ecology and Evolution 2016

Experiment: placing colonies in three different landscapes!



4 sites each with 4 hives → 16 hives

4 sites each with 4 hives → 16 hives

4 sites each with 4 hives → 16 hives

Start condition (2011):

48 hives

Kaluza et al. Ecology and Evolution 2016

Experiment: placing colonies in three different landscapes!

48 hived colonies of *Tetragonula carbonaria*

Foraging activity, patterns and resource intake (pollen, nectar, resin) recorded across seasons

→ **Resource quantity and diversity**

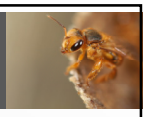
Chemical analyses of nectar (sucrose content), pollen (protein content) & resin (antimicrobial activity) storages and larval food

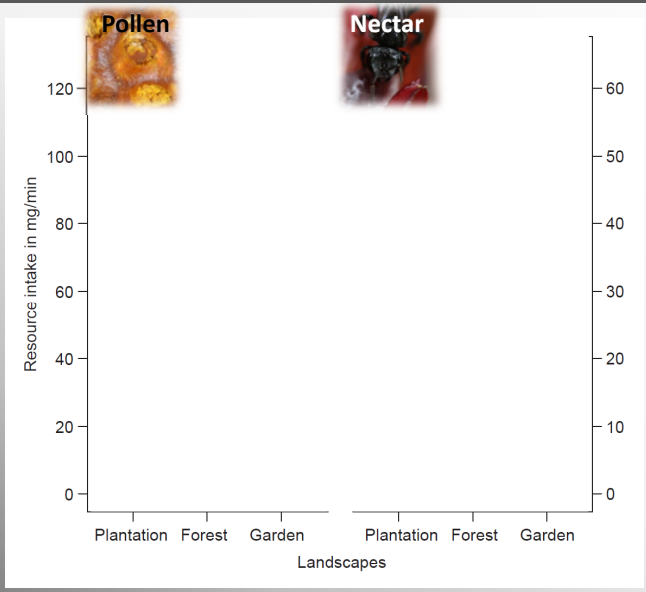
→ **Resource quality**

Colonies propagated when split weight was reached

→ **Health/fitness**

Results: Ressource quantity increases with increasing resource diversity in the landscape.

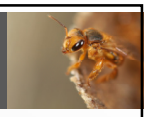


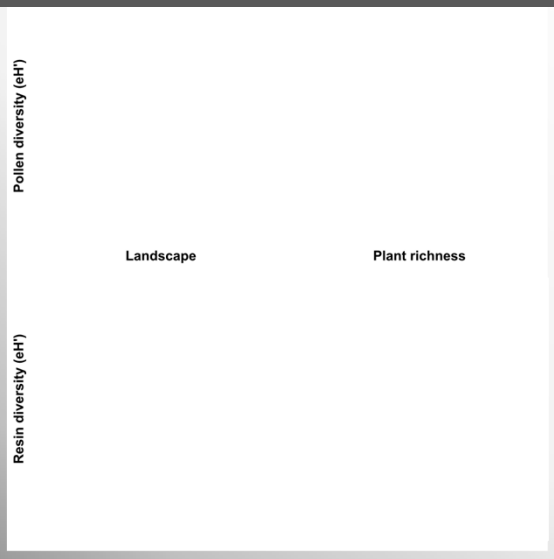


GLMM: *** $p < 0.001$, - - - significant correlations

Kaluza et al. 2016, *Ecology & Evolution*

Results: Ressource diversity collected increases with increasing resource diversity in the landscape.

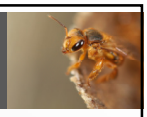


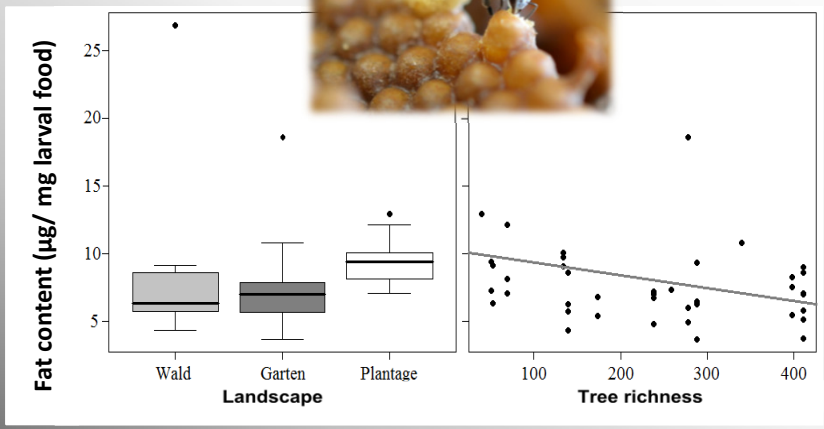


GLMM: (pollen) R^2 = 0.33/ (resin) R^2 = 0.29, ** p < 0.01, *** p < 0.001, - - - significant correlations

Kaluza et al. 2016, *Ecosphere*

Results: Resource quality of larval food increases with resource diversity in a landscape (i.e. fat content decreases).





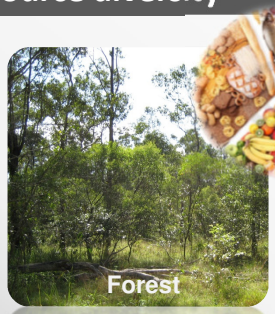
GLMM: (pollen) R^2 = 0.33/ (resin) R^2 = 0.29, ** p < 0.01, *** p < 0.001, - - - significant correlations

Kaluza et al. 2016, *Ecosphere*

Results: Colony fitness.. increases exponentially with plant resource diversity

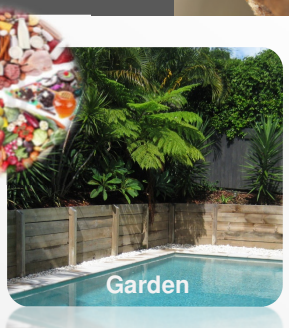
† 5 colonies

2013: 16 colonies



† 1 colony

2013: 24 colonies

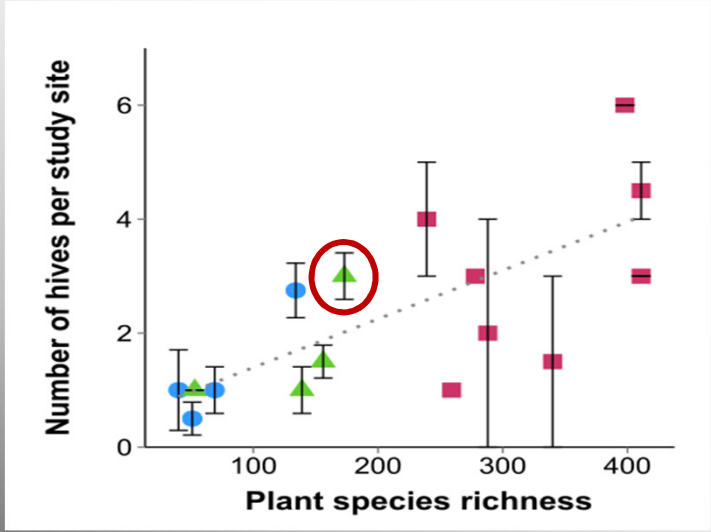


† 2 colonies

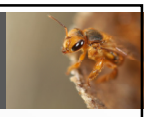
2013: 33 colonies

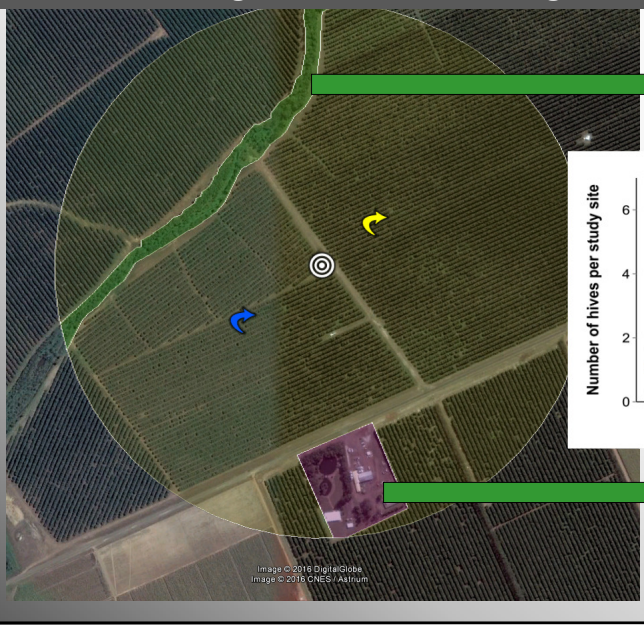
Kaluza *et al.*, under review

Even in plantations: little remnants of diverse vegetation can be enough!

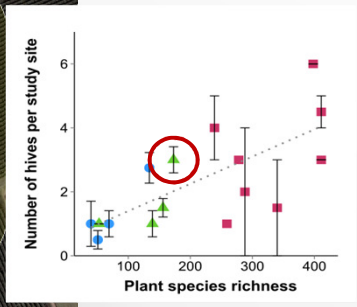


Even in plantations: little remnants of diverse vegetation can be enough!





gully with **diverse** plant species



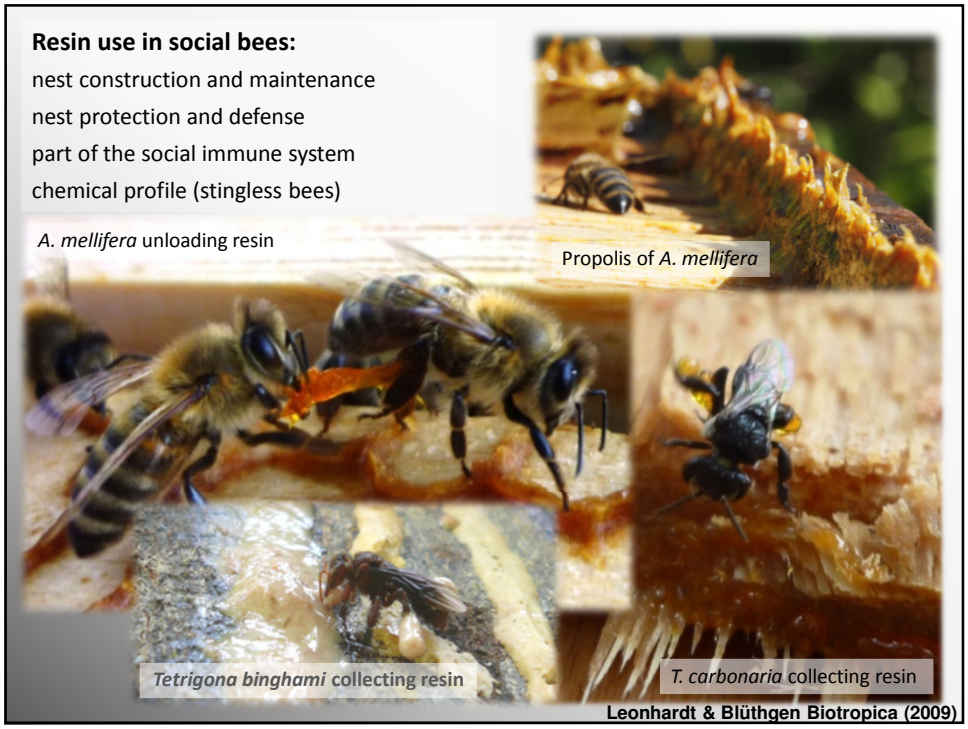
garden with **diverse** plant species

Access to diverse resources increases bee health and fitness!

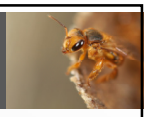

Acknowledgements
DFG Deutsche Forschungsgemeinschaft
DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service
University of the Sunshine Coast
LEUPHANA UNIVERSITÄT LÜNEBURG
Julius-Maximilians-UNIVERSITÄT WÜRZBURG
Graduate School Life Sciences


So far and thanks for all the bees..

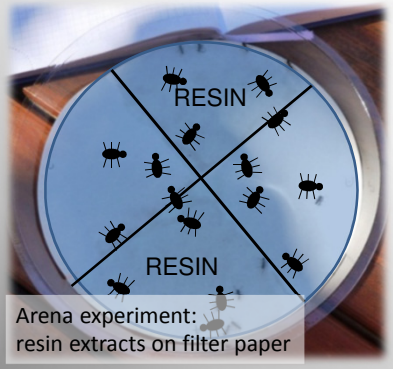

Do bees benefit from diverse resources?
Resin as example


Resin use in social bees:
nest construction and maintenance
nest protection and defense
part of the social immune system
chemical profile (stingless bees)
A. mellifera unloading resin
Propolis of A. mellifera
Tetrigona binghami collecting resin
T. carbonaria collecting resin
Leonhardt & Blüthgen Biotropica (2009)

Methods: How does resin diversity influence defensive properties?



- Single resins against resin mixtures

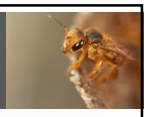


Arena experiment: resin extracts on filter paper

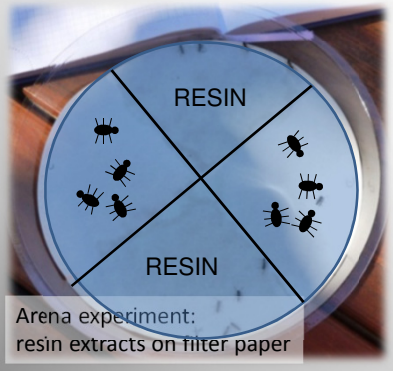
→ repellent properties against predators (small hive beetle, two ant species)

Drescher *et al.* Oecologia (2014)

Methods: How does resin diversity influence defensive properties?



- Single resins and resin mixtures



Arena experiment: resin extracts on filter paper

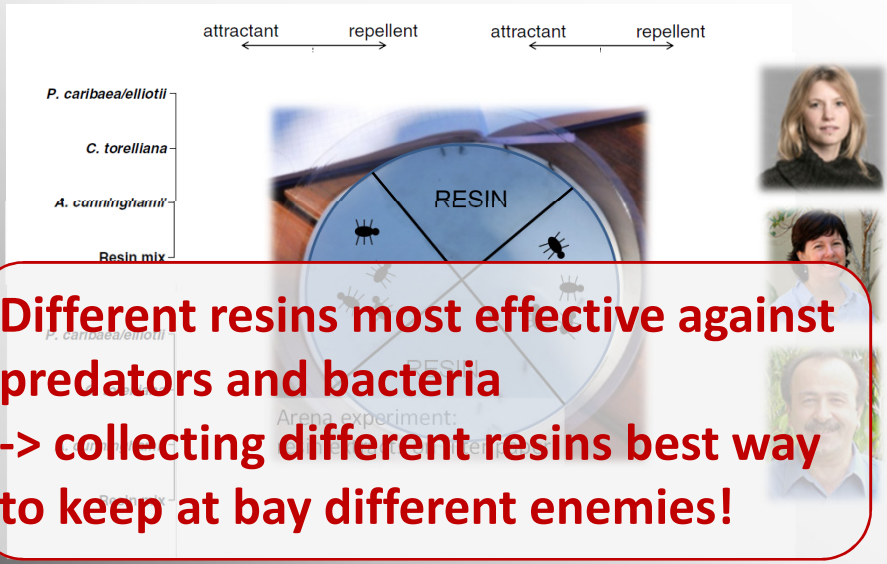
Agar diffusion assay

→ repellent properties against predators (small hive beetle, two ant species)

→ antimicrobial properties against bacteria (4) and fungi (1)

Drescher *et al.* Oecologia (2014)

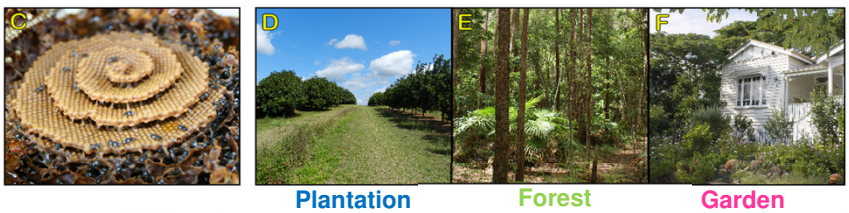
Repellent properties against predators/parasites.. vary with predator type and can be strongest for resin mix



Different resins most effective against predators and bacteria
-> collecting different resins best way to keep at bay different enemies!

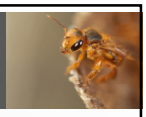
Drescher *et al.* Oecologia (2014)

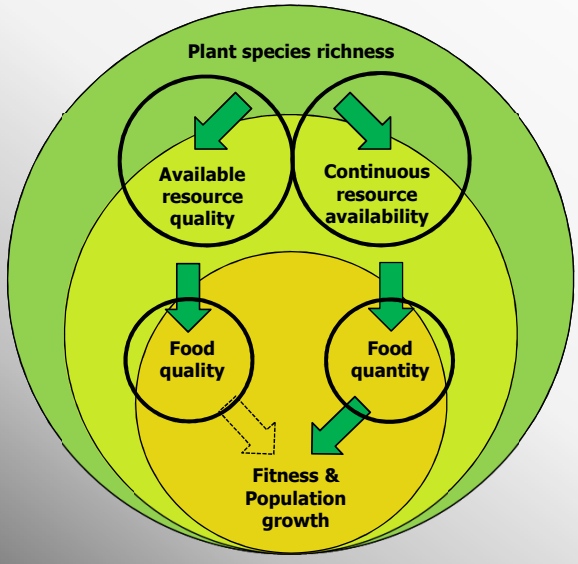
Colony fitness.. increases exponentially with plant species richness/ resource diversity



Kaluza *et al.*, under review

Colony fitness.. increases exponentially with plant species richness/ resource diversity





Kaluza *et al.*, under review

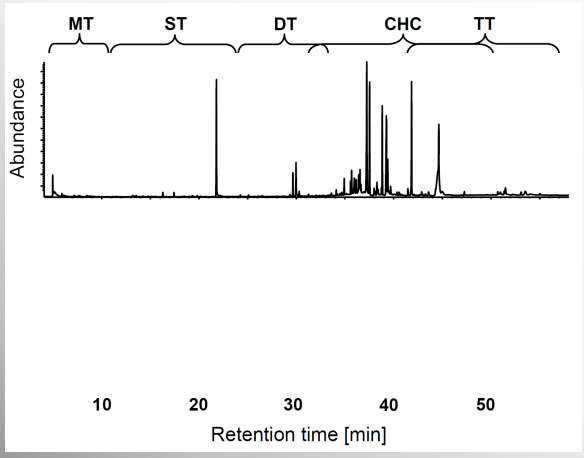
Plant sources!

- Tree wounds
- Seed capsules
- Flowers
- Flower buds

Chemical profiles: One bee with, one without resin derived compounds!

Cuticular terpenes!

T. carbonaria



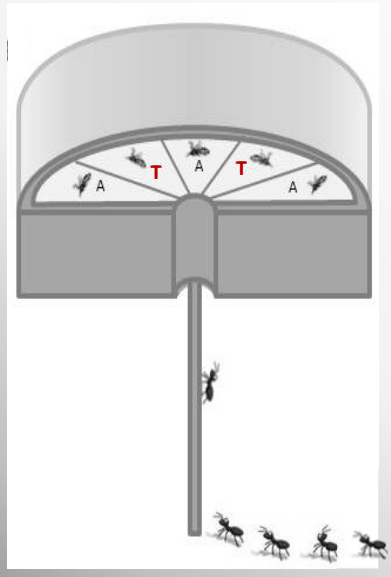
+

A. australis

–

Leonhardt et al. Austral Ecology (2010)

Resin against predatory ants!

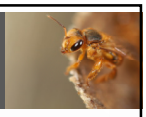


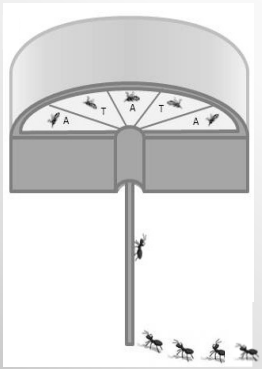
T

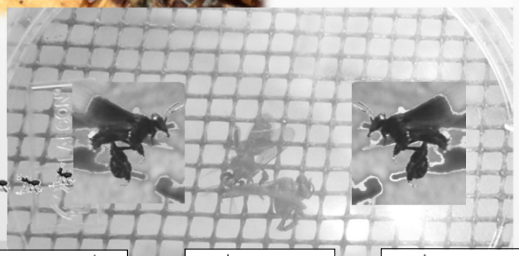
A

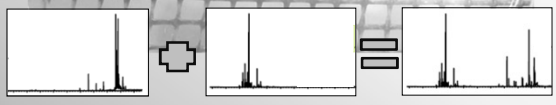
Leonhardt *et al.* Chemoecology (2015)

Methods: Functional role of increased chemical diversity?



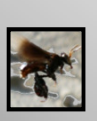


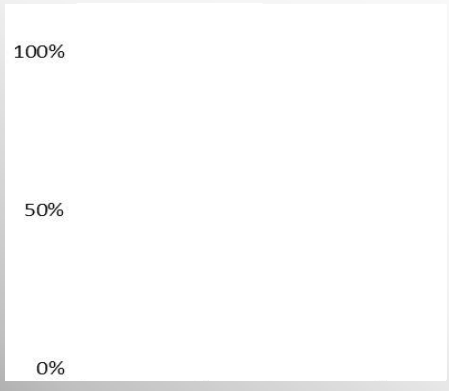




Leonhardt *et al.* Behavioral Ecology & Sociobiology (2010),
Leonhardt *et al.* Chemoecology (2015)

Resin against predatory ants?





T. carbonaria

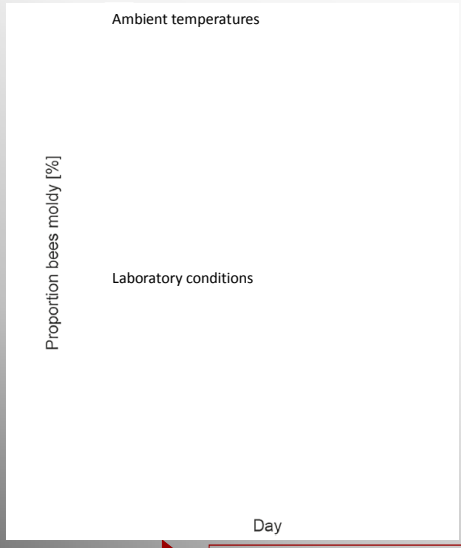
A. australis

Resin coat can protect against predators!

Fisher's exact test: * $p < 0.05$

Leonhardt *et al.* Chemoecology (2015)

Resin against mold?



T. carbonaria

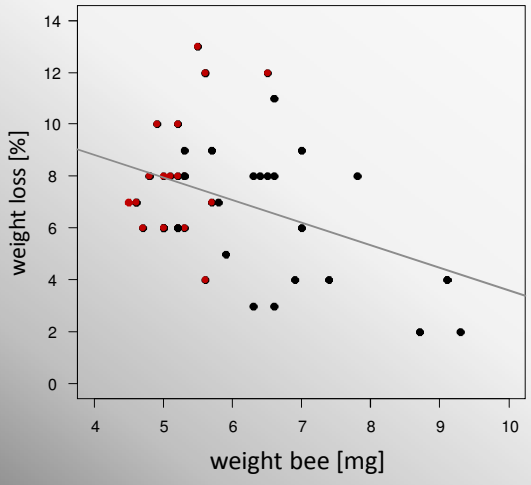
A. australis

Resin coat does not protect against mold!

Survival test: $p > 0.05$

Leonhardt *et al.* Chemoecology (2015)

Resin against desiccation?



T. carbonaria

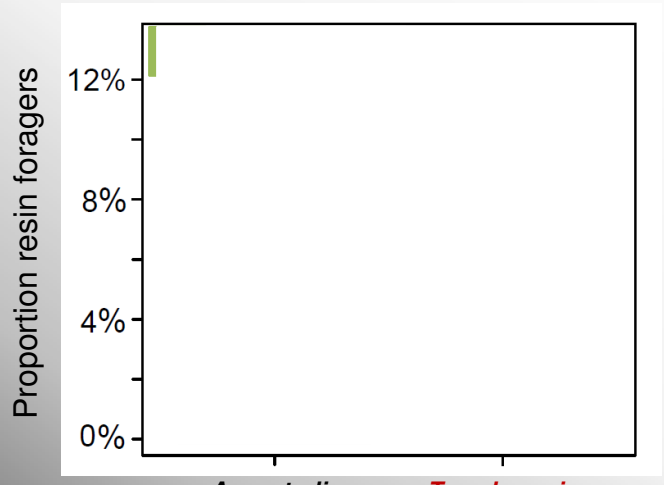
A. australis

Desiccation rate depends on bee weight/size, but not on presence of resin-derived compounds!

GLMM: $p > 0.05$

Leonhardt *et al.* Chemoecology (2015)

T. carbonaria collect more resin than *A. australis*



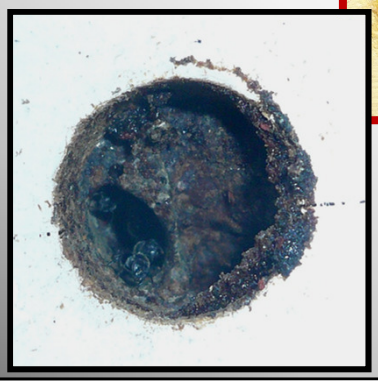
Leonhardt *et al.* Apidologie (2014)

4 nests per species; generalized mixed model (binomial distribution): * $p < 0.05$

Resin use: Nest entrance!

T. carbonaria

Homing in on sticky resin barrier!

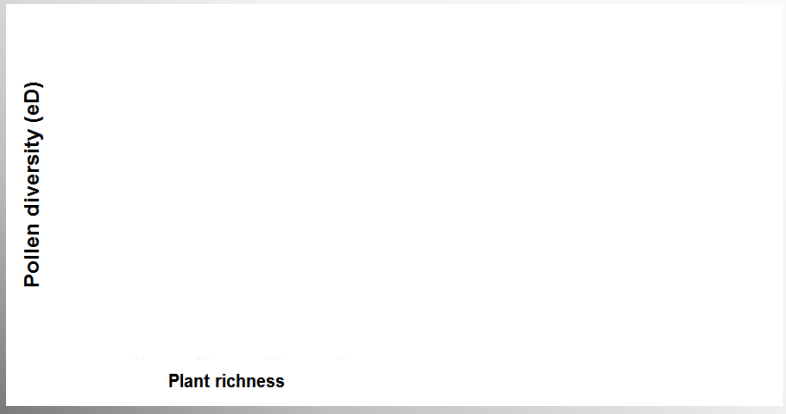


A. australis

Little resin, narrow entrance!

Resin marks and protects entrance!

Resource diversity … increases with plant (source) biodiversity



GLMM: (pollen) $R^2 = 0.18$, $P < 0.001$ / (resin) $R^2 = 0.03$, $P = 0.037$, log-linear relationship

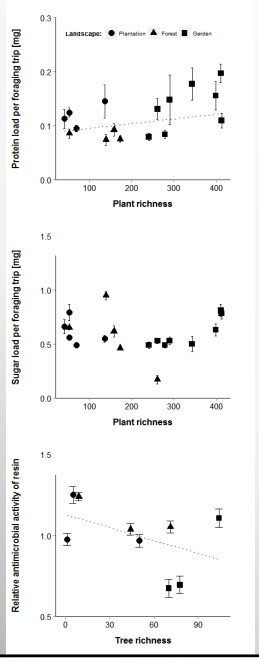
Kaluza et al. 2015, *in prep.*

Resource quality … depends on plant biodiversity & community composition

Sugar load/ forager

Protein load/ forager

Antimicrobial activity



Kaluza et al. 2015, *in prep.*

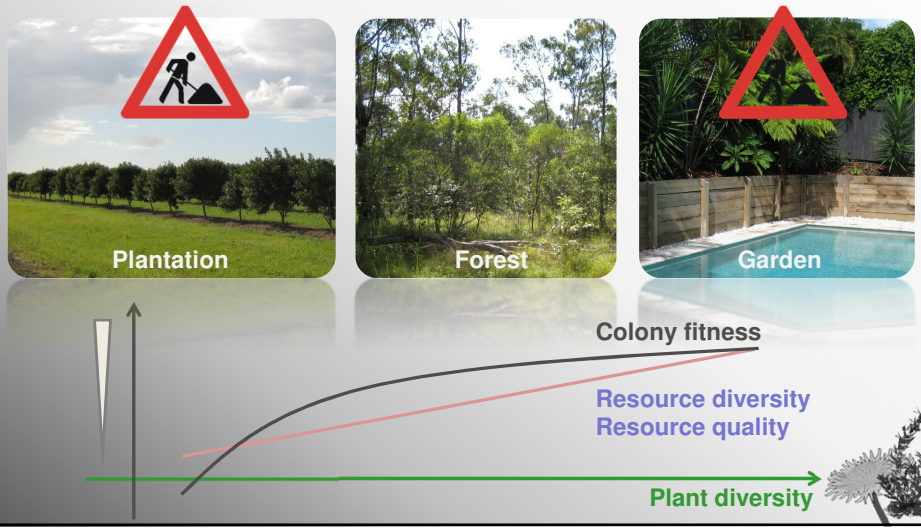
Hypotheses:

Resource diversity gradient: diversity increases from plantations to gardens

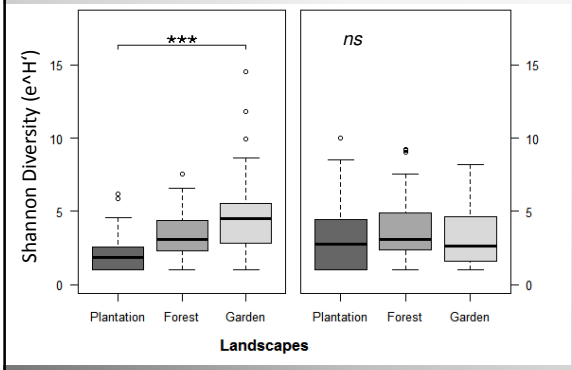
→ higher resource diversity (intake)

→ higher resource quality

→ increased fitness



Results: Resource diversity … increases with plant (source) diversity



Pollen

- highest in gardens, low in plantations

Resin

- similar across landscapes

→ No correlation between tree richness and landscape

GLMM: (pollen) $\chi 2$ = 19.41 / (resin) $\chi 2$ = 1.01

Kaluza et al. 2015, *in prep.*