Reducing the Pain of Pest Wasps

We need better, effective methods to manage pests

Social wasps as a model system

Emerging Issues | March 2014

Challenges for pest management in New Zealand

the ROYAL SOCIETY of NEW ZEALAND TE APĀRANGI

- ***"Increasing pest resistance is also making some invertebrate pesticides and herbicides ineffective, while others have been phased out".***

*"**The last 50 years of research** into infections in Australia and New Zealand caused by larvae of the sheep blowfly, Lucilia cuprina, **have significantly advanced our understanding of this blowfly** …. However, apart from some highly effective drugs it could be argued that **no new control methodologies have resulted**. …..The use of drugs against this fly species has been very successful but **resistance has developed to almost all current compounds**."*

Sandeman et al. 2014.
International Journal for Parasitology 44: 879-891.

NEW ZEALAND'S BIOLOGICAL HERITAGE

Ngā Koiora Tuku Iho

National Science Challenges

REAL-TIME BIOLOGICAL HERITAGE ASSESSM

Creating solutions to allow biosecurity decision maker comprehensive information

REDUCING RISKS AND THREATS ACROSS LANDSCAPES

Reducing rates of incursion or establishment by foreign invader species; improving efficacy of pest management by scaling-up control operations.

SUSTAINING NATURAL CAPITAL RESILIENT ECOSYSTEMS

restoring the resilience of systems; preventing biodiversity ating the effects of global

Targeting stakeholder priorities

- **(1) Improved tools and strategies for control and eradication of biotic threats**

Contribution to Challenge Mission

- **Mission statement:**
  - *"Socially acceptable, cost-effective and targeted next-generation technologies, tools and strategies are in use at landscape-scale to control invertebrate pests in natural and production ecosystems to protect taonga species and minimize cost and risk to agriculture".*

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VICTORIA
UNIVERSITY OF WELLINGTON

Wasps are a major pest species in NZ

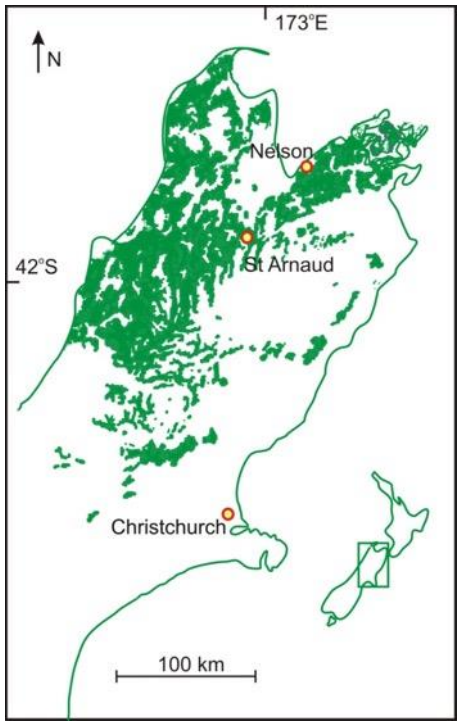
New Zealand Entomologist, 2014
Vol. 37, No. 1, 1–13, http://dx.doi.org/10.1080/00779962.2014.861789

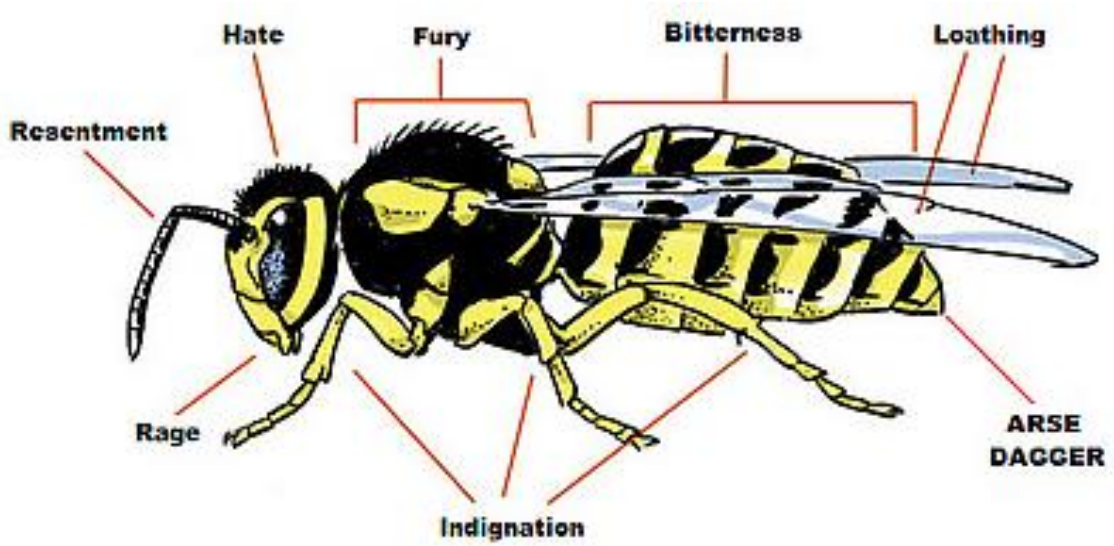
Taylor & Francis
Taylor & Francis Group

Critical issues facing New Zealand entomology

P. J. Lester[a]*, S. D. J. Brown[b], E. D. Edwards[c], G. I. Holwell[d], S. M. Pawson[e], D. F. Ward[f] and C. H. Watts[g]

[a]*School of Biological Sciences, Victoria University of Wellington, PO Box 600, Wellington 6140, New Zealand;*
[b]*Bio-Protection Research Centre, Lincoln University, PO Box 84, Canterbury 7647, New Zealand;* [c]*Department of*





Adapted from Beggs. 2001. Biol. Conserv. 99: 17-28

NEW ZEALAND'S BIOLOGICAL HERITAGE

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Socially acceptable, cost-effective & targeted next-generation technologies:

1. Behavioural manipulation of wasps using pheromones
2. Using Trojan mites to deliver pathogens into wasp nests
3. RNAi as a new technology for wasp control
4. Trojan female technique to regulate wasp populations
5. Gene drives?

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FOUR POTENTIAL Novel wasp control technologies

1. Behavioural manipulation of wasps using pheromones

- Identify key aspects of wasp foraging or mating behaviours in spring & summer
- Develop and test novel delivery systems for behavioural manipulation of wasps using pheromones
- Develop "Smart" dispensers to enhance lure and kill, or lure and infect, techniques

Max Suckling
Plant & Food Research Ltd
Lincoln

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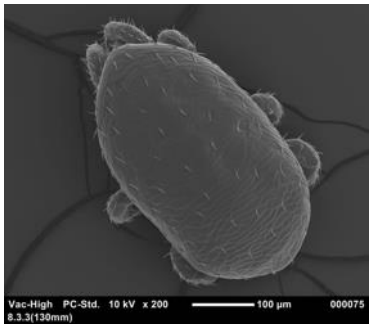
FOUR POTENTIAL Novel wasp control technologies

2. Using Trojan mites to deliver pathogens into wasp nests

- Hygienic behaviour of social insects is a major barrier to delivering pathogens or toxins to nests.
- Mites could operate as a "Trojan horse" for pathogens or toxins, which could then be spread from nest to nest.



A mite species (*Pneumolaelaps* sp.) already present in NZ.

Simon Fowler
Landcare Research Ltd
Lincoln

Landcare Research
Manaaki Whenua

FOUR POTENTIAL Novel wasp control technologies

3. RNAi as a new technology for wasp control

- RNAi, or RNA interference, is a natural biological process wherein small RNA molecules inhibit gene expression.
- RNAi interference is a normal, natural and important part of an organism's immune response to viruses and other foreign genetic material.

(wileyonlinelibrary.com) DOI 10.1002/ps.4056

The next generation of insecticides: dsRNA is stable as a foliar-applied insecticide

Keri San Miguel and Jeffrey G Scott*

Abstract

BACKGROUND: RNAi is a powerful tool used to study gene function. It also has been hypothesized to be a promising new method

Peter Dearden
University of Otago
Dunedin

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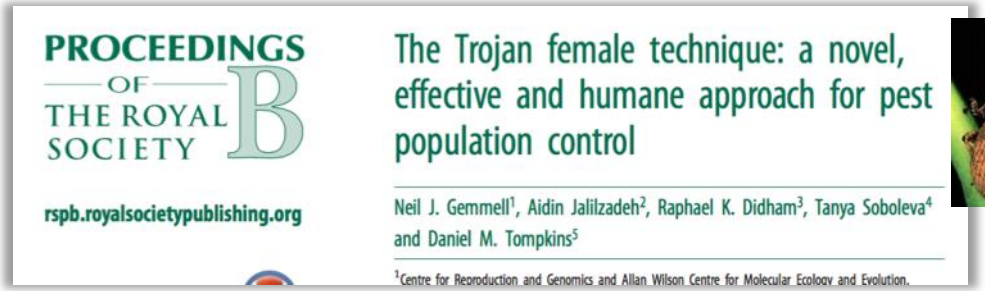
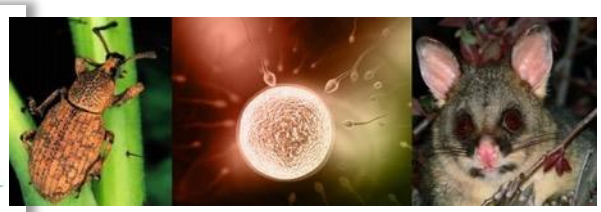
FOUR POTENTIAL Novel wasp control technologies

4. Trojan female technique to regulate wasp populations

- Reproductive management as an effective approach to pest control.
- Utilising **naturally occurring mitochondrial DNA variation** to introduce Trojan Females (TFs) into wild populations where they will continuously produce "sterile males".





Neil Gemmell
University of Otago
Dunedin

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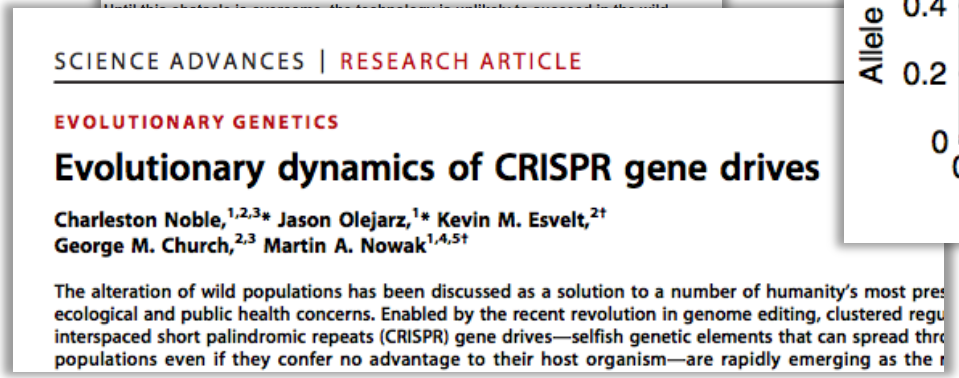
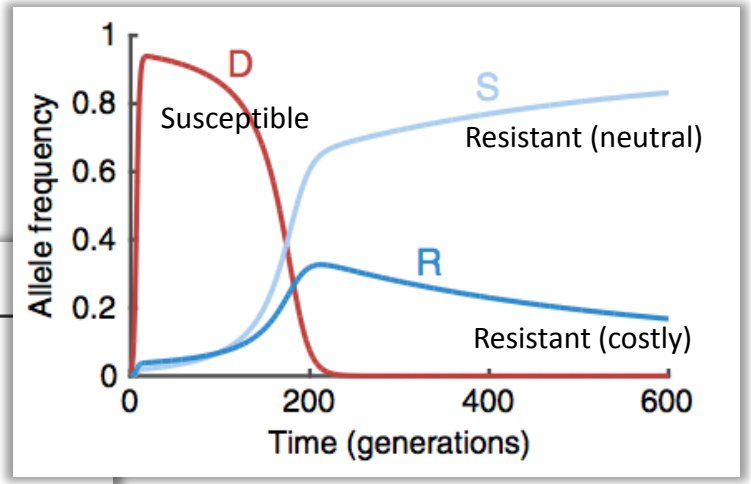
Gene drives?

- A technique that promotes the inheritance of a particular gene to increase its prevalence in a population
- Target genes such as *doublesex,* inhibiting male production
- Issues around guide RNA variation & resistance?





Gene drives?

- The limited genetic diversity in the invaded range of an exotic species is a major advantage for gene drives
  - Design guide RNA targets specific to invaded range genotypes
  - Offers a safeguard in their use, against an entire "species extinction"

Diversity and Distributions, (Diversity Distrib.) (2014) **20**, 964–974

BIODIVERSITY RESEARCH

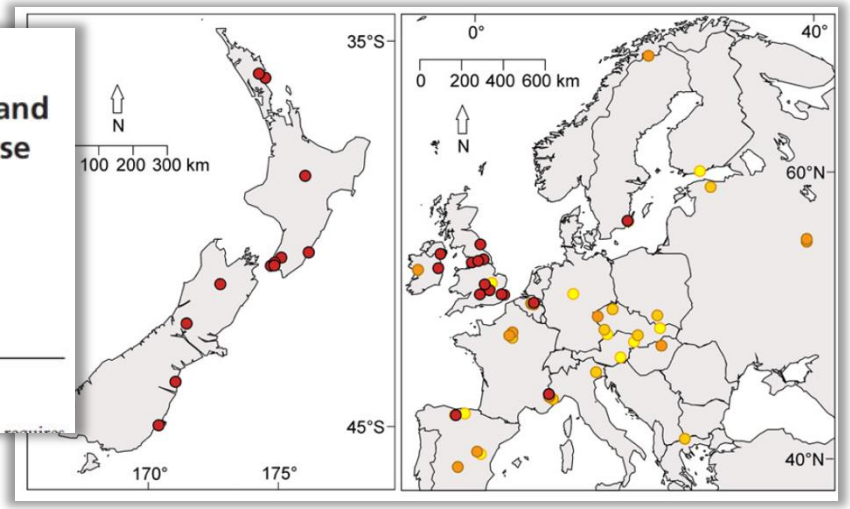
Determining the origin of invasions and demonstrating a lack of enemy release from microsporidian pathogens in common wasps (*Vespula vulgaris*)

P. J. Lester[1]*, M. A. M. Gruber[1], E. C. Brenton-Rule[1], M. Archer[2], J. C. Corley[3], L. Dvořák[4], M. Masciocchi[3] and A. Van Oystaeyen[5]

[1]*Centre for Biodiversity and Restoration Ecology, Victoria University of Wellington,*

ABSTRACT

Haplotypes:



Contribution to Challenge Mission

- Mission statement:
  - "***Socially acceptable***, *cost-effective and targeted next-generation technologies, tools and strategies are in use at landscape-scale to control invertebrate pests in natural and production ecosystems to protect taonga species and minimise cost and risk to agriculture*".

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FOUR POTENTIAL Novel wasp control technologies

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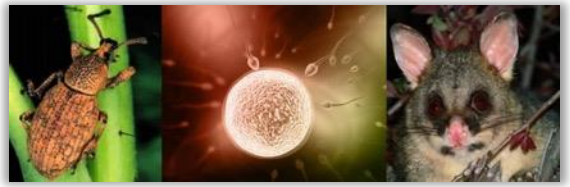
Vision Mātauranga Outcome

5. Perceptions and perspectives on the use of novel pest control strategies

- A cross-cultural analysis of what would and would not be acceptable for pest control, with specific focus on Māori perceptions.



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Victoria University
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FOUR POTENTIAL Novel wasp control technologies

Years 1-3

- Develop the 4 technologies
- Cultural analysis & modelling component

Years 4 (& hopefully 5)

- In year 3 determine which of the 4 technologies has the highest chance of "step-changing" wasp management
  - including which of the technologies is likely to be culturally acceptable
- Fund (1-2?) of those technologies for 2 additional years for further work & pilot studies
  - Develop then the technology transfer, specific pathways, etc
  - Continue with Vision Mātauranga work

Intermediate (5-year) Outcome

- *New Zealand production and conservation sectors, iwi and communities have access to an array of improved tools, methodologies and strategies for the eradication and control of biotic threats*

- *Socially acceptable, cost-effective and targeted next-generation technologies are piloted with the aim of mitigating the impact of invertebrate pests in natural/production ecosystems*

National Science Challenges

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National SCIENCE Challenges

Biological control of Vespula: new options available

Bob Brown

Ronny Groenteman

Funded by Sustainable Farming Fund

Ministry for Primary Industries
Manatū Ahu Matua

Why are wasps so invasive?

- Life cycle
- Biology/behaviour –super organism
- NZ environmental conditions
- No natural enemies
- Open niche

Classical biological control

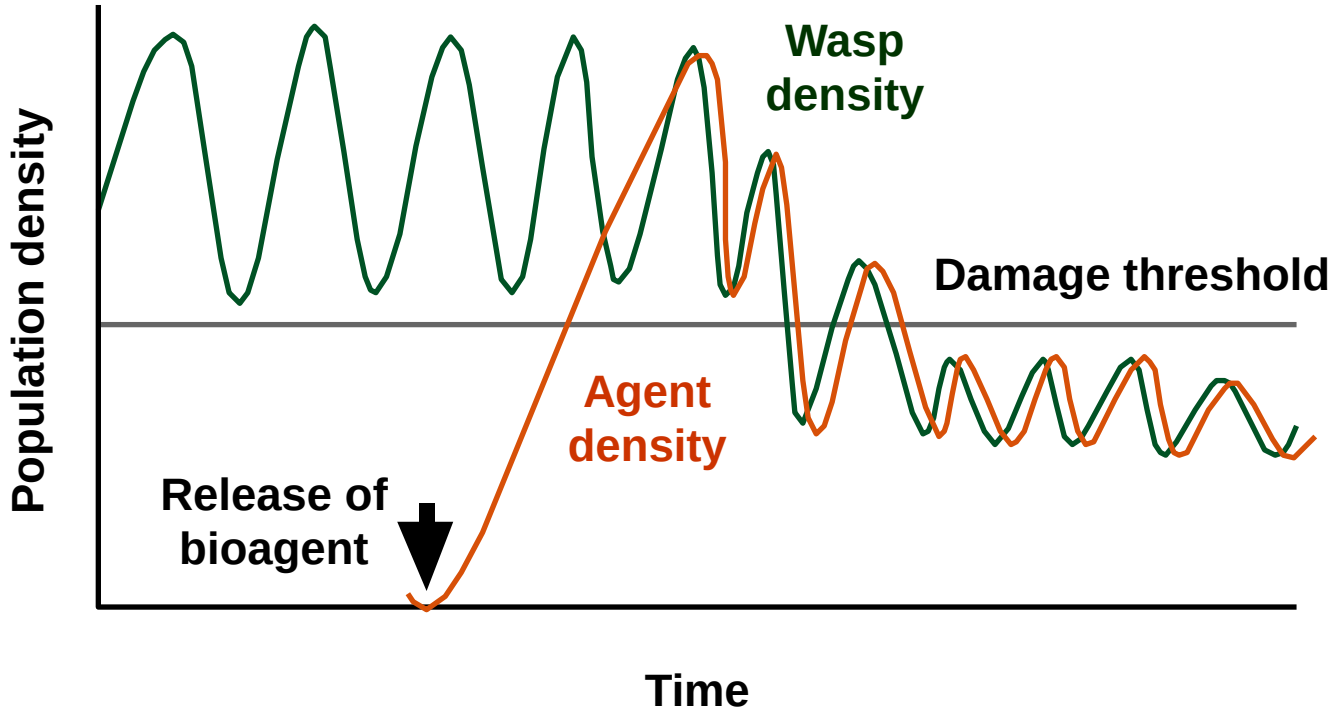
Advantages

- Long term
- Species specific
- Self sustaining and spreading
- Cost effective – no recurring costs

Disadvantages

- Slow
- Can be difficult to establish (climate/habitat)
- Target not usually eradicated

A successful programme should progress like this:



(adapted from Briese 2000)

Who are the candidates?

Photo by B Brown

Photo by Peter Traub

Photo by B Brown

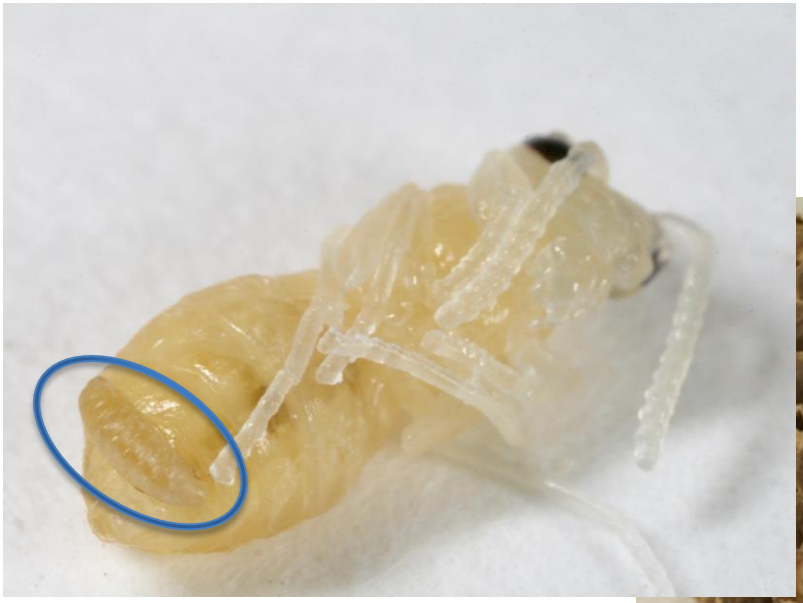
Borrowed from: http://faluke.blogspot.co.nz/2015/06/leopoldius-coronatus.html

#1 Sphecophaga vesparum

- 3 spp introduced to NZ 1980s – 1990s
  - One established
- Specific to social wasps
- New genetic stock collected in UK
- Also opportunity to survey for other enemies

Photo by B Brown

Sphecophaga vesparum

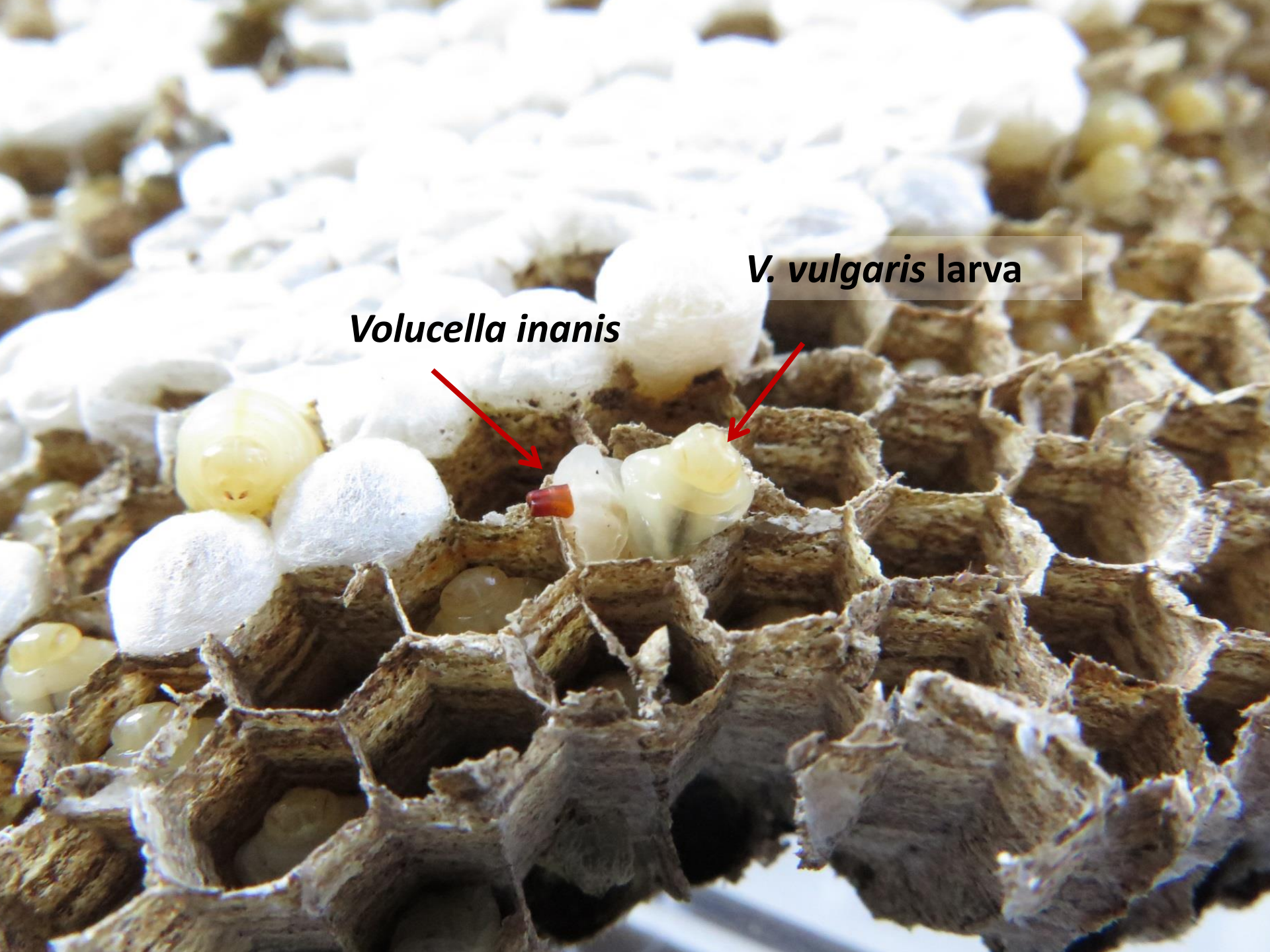


Photos by B Brown

#2 *Volucella inanis*

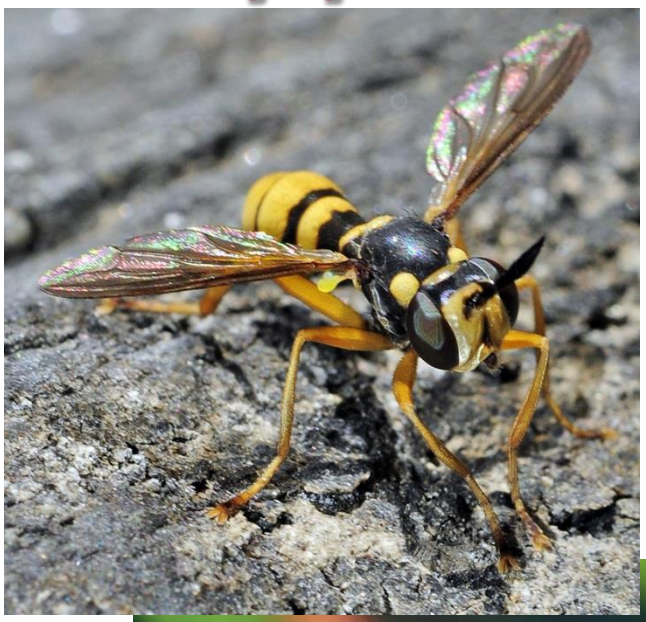
- Brood parasite of *Vespula* & *Vespa*…pre-emptive biocontrol???
- Likely consumes more than one larva
- Found in most nests in 2016 UK survey

Photo by Peter Traub


V. vulgaris larva
Volucella inanis

#3 Leopoldius spp

- Parasitises adult Vespids. Another pre-emptive biocontrol???
- Could be released from hyper-parasitism
- Species active at different times



Top photo: borrowed from:
http://faluke.blogspot.co.nz/2015/06/leopoldius-coronatus.html
Bottom photo: borrowed from
https://www.facebook.com/groups/british.conopids/ posted by Chris Sellen 2016

#4 *Metoecus paradoxus*

- Brood parasite of *Vespula*
- Also found in many nests in 2016 UK survey
- Complex life history

Photo by B Brown

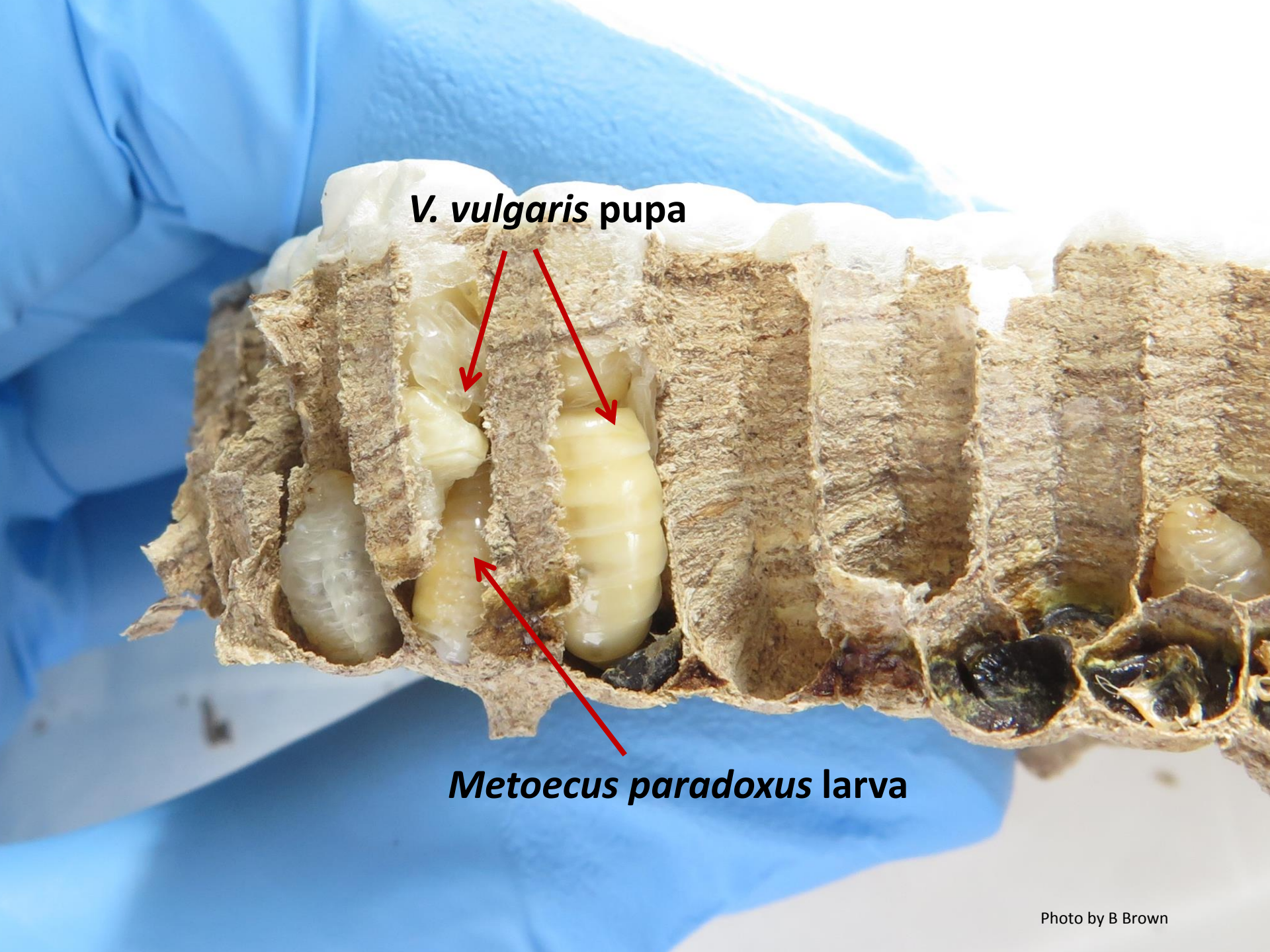


Photo by B Brown

Time line for current biocontrol project

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- We aim to have at least one new agent in the final stages of release (if not actually released!) by the end of 2020 financial year.
- Releases of new genetic stock of Sphecophaga through the course of the project.

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National SCIENCE Challenges

Funded by Sustainable Farming Fund

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National SCIENCE Challenges

It's our pain too: Exploring New Zealanders' attitudes, beliefs, and acceptance of novel pest controls

Eric Edwards & Edy MacDonald

Department of Conservation
Te Papa Atawhai

Landcare Research
Manaaki Whenua

New Zealand Government

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National SCIENCE Challenges

The team

Edy MacDonald – DOC (project lead)
Eric Edwards – DOC
Dan Tompkins– Landcare Research
Bob Frame – Landcare Research
Robyn Kannemeyer - Landcare Research
Alison Greenaway - Landcare Research
Taciano Milfont - VUW
Wokje Abrahamse - VUW
Fabien Medvecky – University of Otago
James Russell – University of Auckland

NSC Biological Heritage Programme 2:
Reducing Risks and Threats

Nationally what is at stake?

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1. Pest wasps are a key agent of biodiversity decline

2. Upscaling pest control nationally with *novel tech* is in the future but we must start the conversation now

What causes people to engage and take/support sustainable behaviour?

- Information
- Economic impact
- Emotions

Most people developing the programmes are too close to the issue:

- Skewed perception of the community (often polar views are expressed the loudest)
- People are not rationale

Aim 1: develop a segmentation model of NZers

Audience segmentation

Demographics are out

Psychographics are in

Understand underlying values of people

Aim 1: develop a segmentation model of NZers

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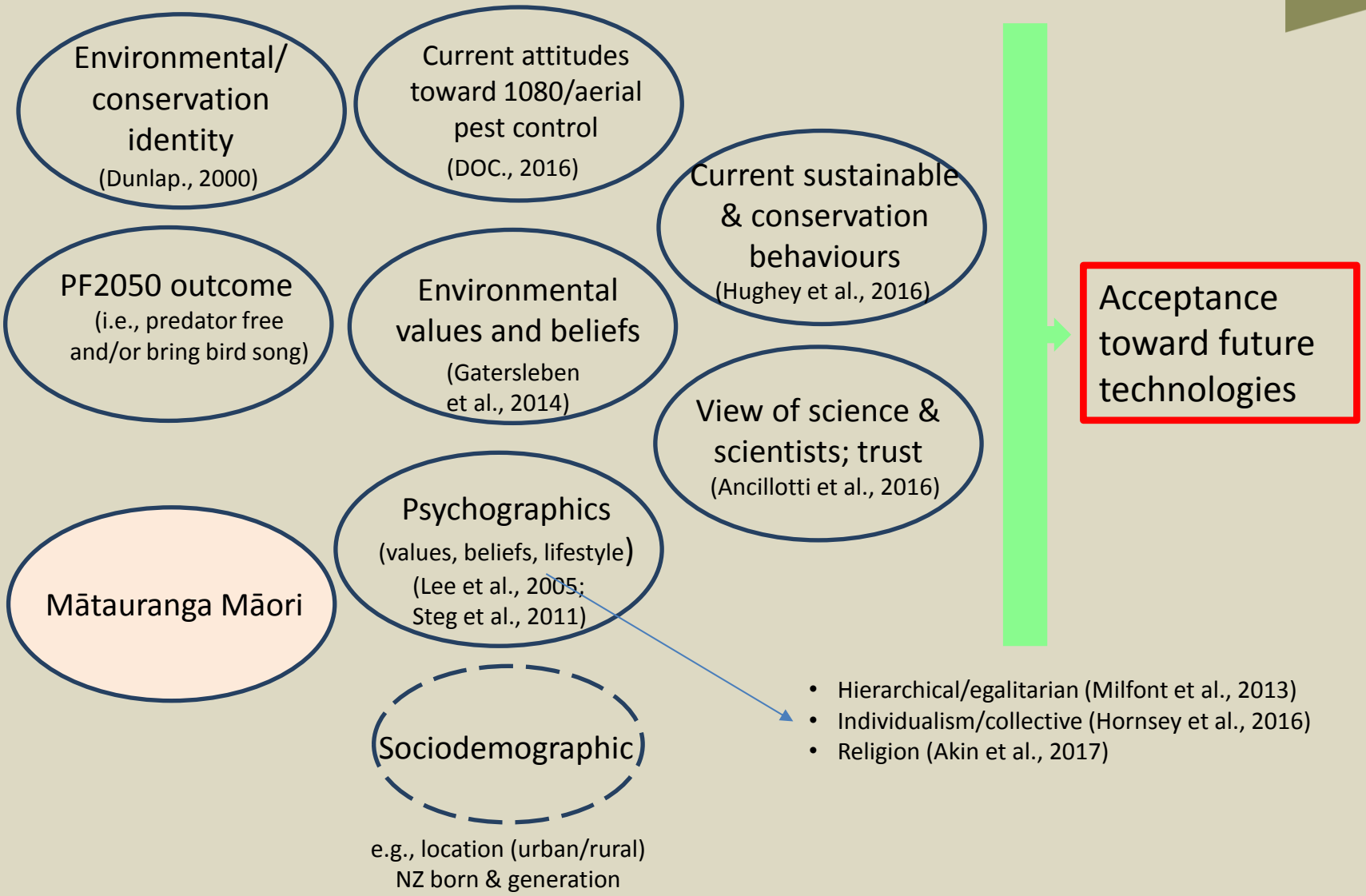


Social acceptance using choice modeling

- Rats vs wasp
- New toxin vs selective breeding vs genetic
- Infertility vs death
- Ground vs aerial distribution

Choice A	Choice B
Question 1	
 1	 2
▶Target species is a wasp ▶Control via selective breeding that results in sterile male offspring ▶Aerial distibution	▶Target species is a rat ▶Control via poison resulting in death ▶Ground based bait stations

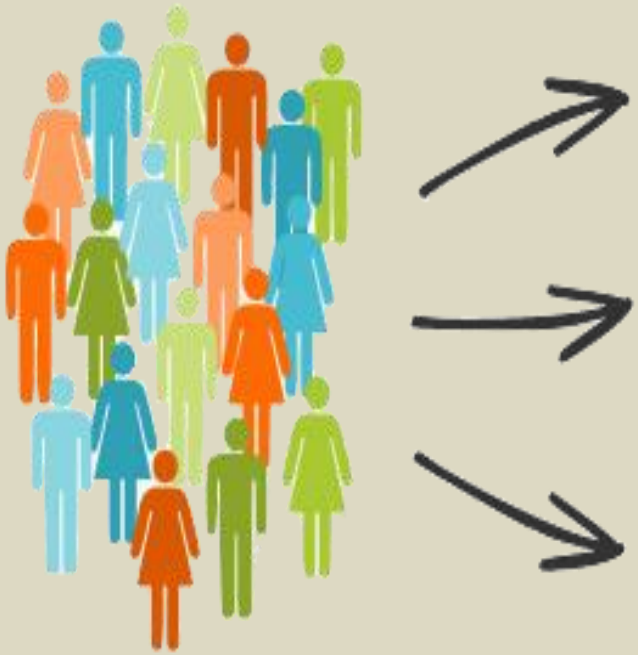
Question 2	
▶Target species is a wasp ▶Control via poison resulting in death ▶Ground based bait stations	▶Target species is a rat ▶Control via selective breeding that results in sterile male offspring ▶Aerial distibution

Attributes linked to acceptance

Wasp
Ground base
One-off
Poison
Death
Selective breeding
Fertility control
Rat
On going
Biological control
Genetic modification
Aerial

Greater acceptance

Lesser acceptance



- Value Y & Z
- Belief A & B
- Lifestyle 1 & 2
- Social acceptance wasps

- Value V & X
- Belief C & D
- Lifestyle 3 & 4
- Social acceptance ground

- Value V & Z
- Belief E & F
- Lifestyle 3 & 5
- Low Social acceptance of genetic

Segmentation model shared with councils, government agencies, and other stakeholders

Aim 2: explore complexity of social acceptance with key partners & stakeholders

- Focus groups to test:
  - How support or resistance is manifested
  - Nuances of different world views
  - Perceptions of trust

Aim 3: test the impact of persuasive communication theory on social acceptance

- Taking the salient beliefs, develop messages and test for 'nudge' (behavioural insights)

- Test different framing:
  - Positive vs. negative
  - Loss vs. gain
  - Individual vs collective good
  - Economic, moral, social outcomes

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Cats are a problem!

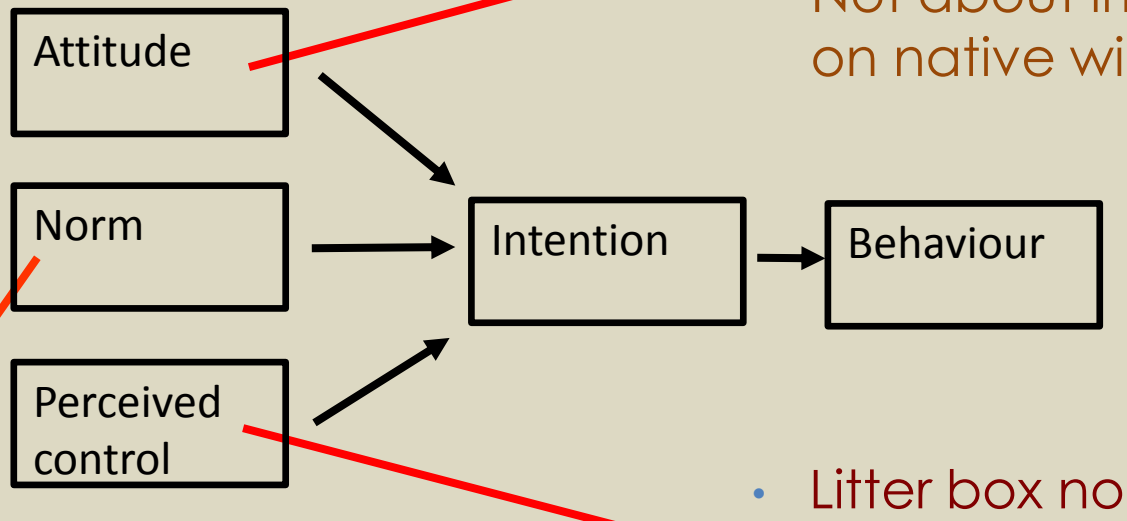
- Target cat owners visiting veterinarian clinics
- Funded by NZ Animal Companion Trust
- Supported by NZ Vet Association
- 40 vet clinics in 5 cities participated

The cat team

- Edy MacDonald
- Wayne Linklater, VUW
- Kevin Stafford, Massey
- Yolanda van Heezik, Otago
- Mark Farnworth, Plymouth University

Cats inside at night

Theory of Planned Behaviour

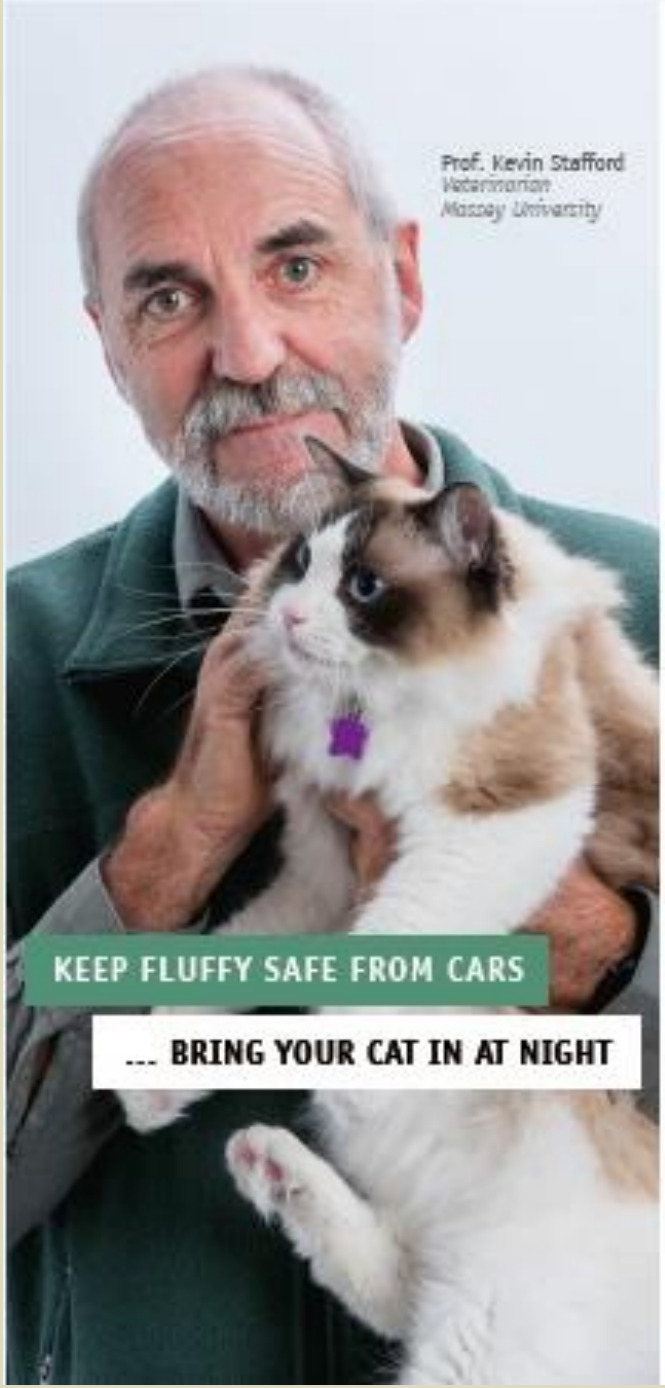


- Cat safety/cars
- Good thing
- Not about impact on native wildlife

- Veterinarians
- Not SPCA
- Not DOC, F&B, G Morgan
- Family members

- Litter box not an issue
- Cat flap not an issue

#18. Keeping my cat inside all night will protect native wildlife.



- Cats have a greater risk of being hit by a car at night when they are less visible to drivers
- 74% of veterinarians treat a cat that was hit by a car at least once a month. A quarter of veterinarians see car-injured cats every week.
- Three out of four cat owners visiting veterinarians said having their cat in at night is safer

This research about cat welfare for cat owners is a cooperative effort by researchers at Victoria University of Wellington, Massey University, Otago University and University of Plymouth (UK) and is supported by funding from the New Zealand Companion Animals Trust.

If you would like to know more about this study contact Wayne Linklater at Victoria University: (04) 463 5233 ext. 8575 or wayne.linklater@vuw.ac.nz.

- 75% of cat owners agree, having their cat in at night is beneficial
- A cat's company at night is great for reducing stress
- 2 out of 3 cat-owning families think having their cat inside at night is the right thing to do

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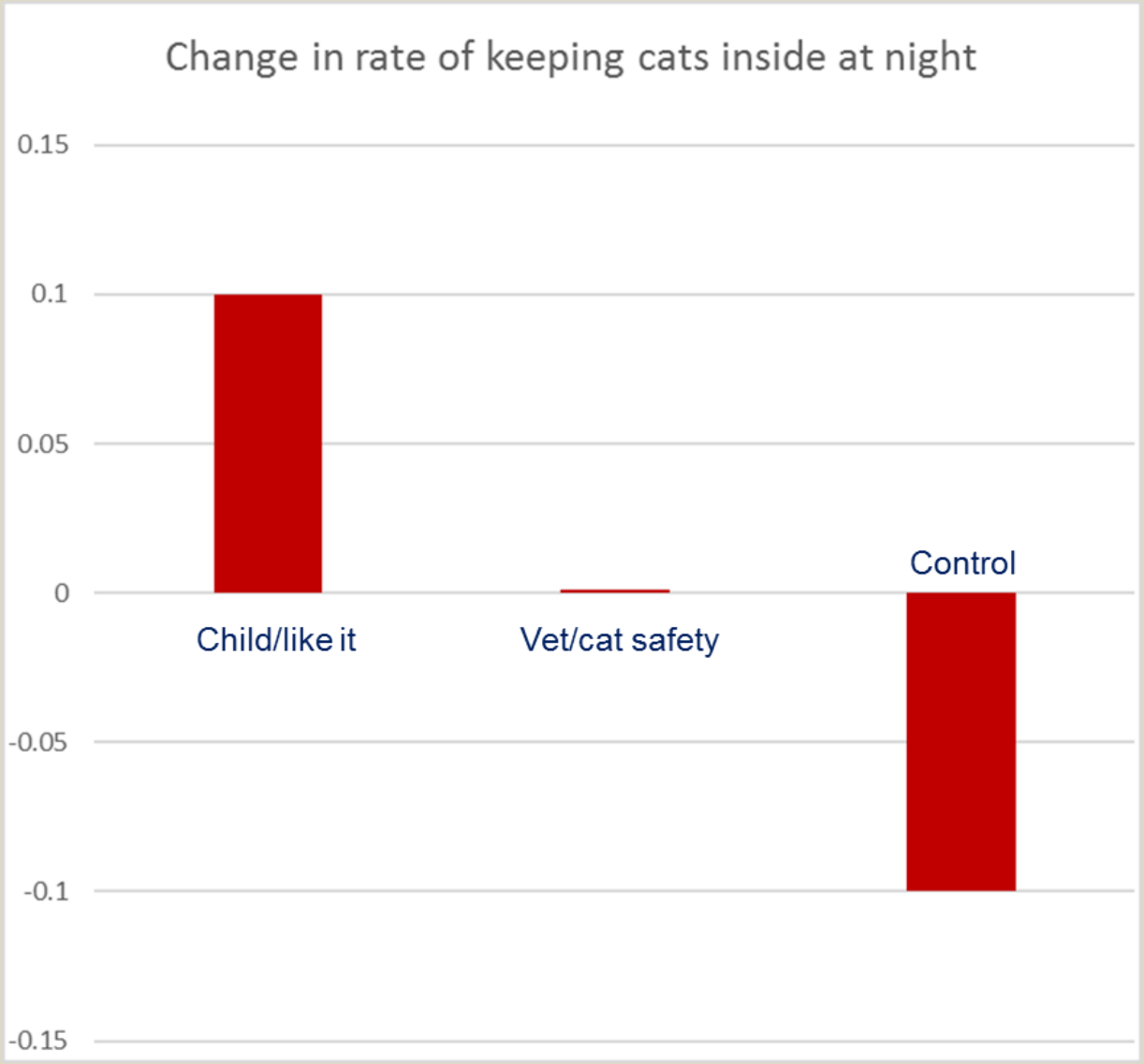
Change in rate of keeping cats inside at night
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
Child/like it
Vet/cat safety
Control

Wider applications

- Across all aspects of biosecurity
- Social license to operate
  - Who will the nation listen to and trust?
    - Avoid the climate change set backs
- Longitudinal study – changes over time
- Science communication
  - Role of scientists
  - Proactive approach

National
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Department of Conservation
Te Papa Atawhai

Landcare Research
Manaaki Whenua