# Global Trends in Arthropod Eradication Programs –

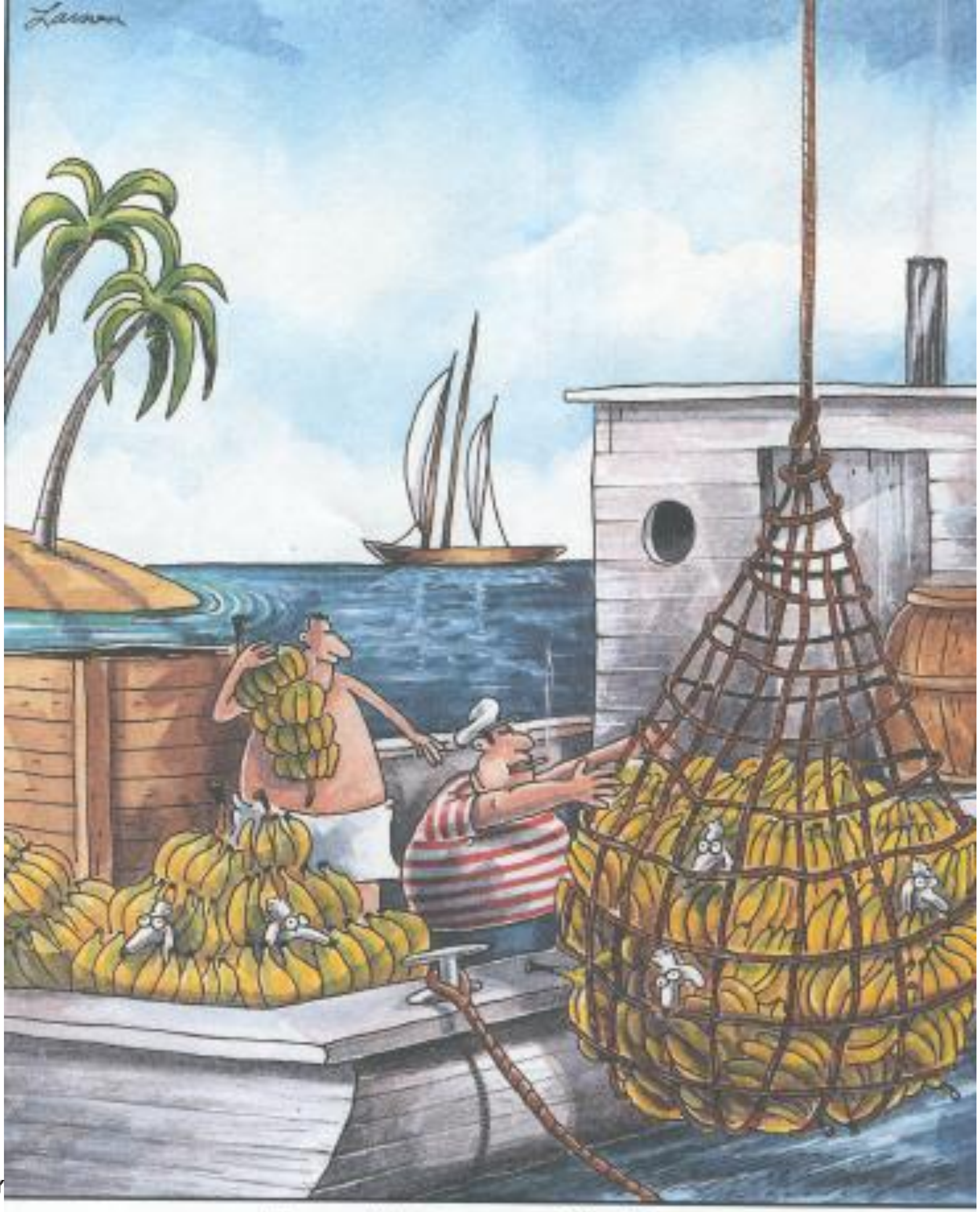
## *Towards Integrated Pest Eradication*

Max Suckling
John Kean (AgResearch)
Lloyd Stringer

More on "*Unloved Biodiversity*"

www.pherobase.com

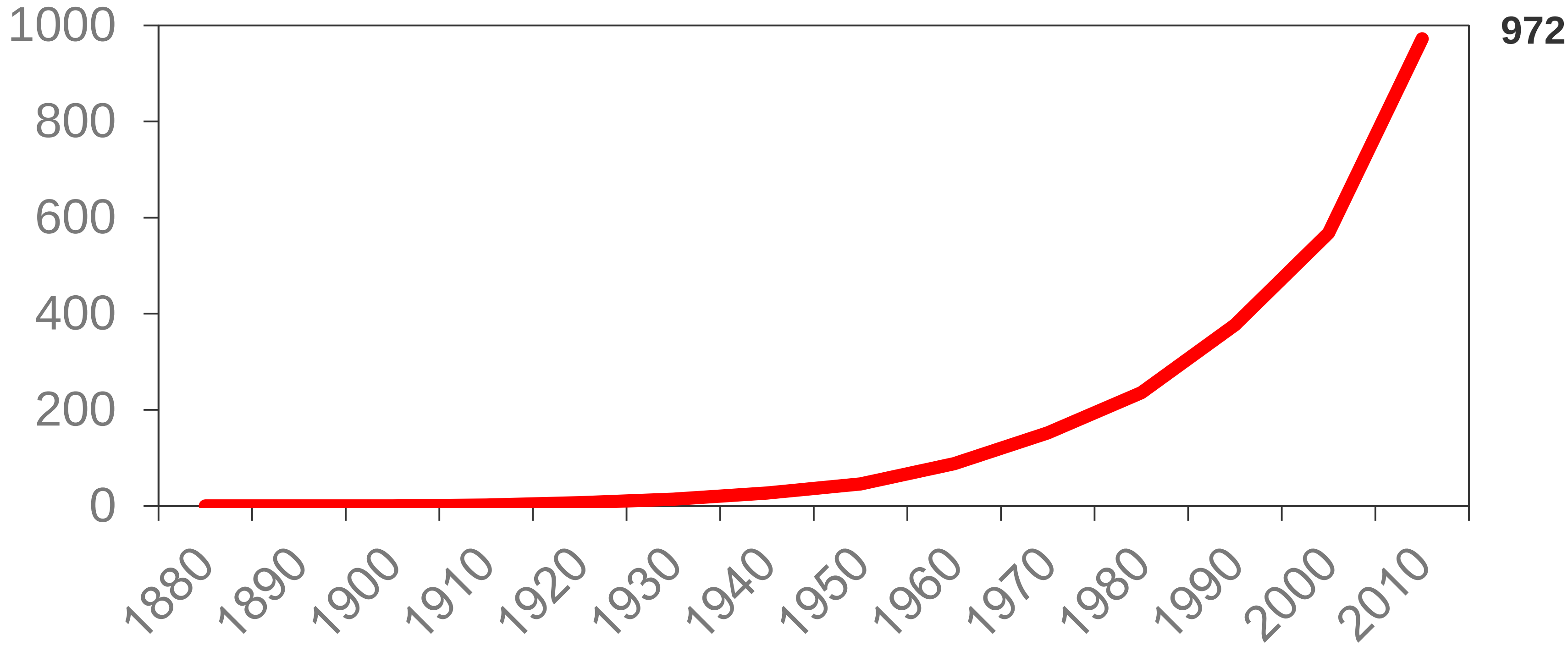
www.b3nz.net/Gerda



How poodles first came to North America

# “How poodles first came to America”

# INSECT RESPONSE PROGRAMMES BY YEAR




**“Eradication” means local extinction**

**Data: http://b3.net.nz/gerda**

# 105 Countries have conducted ≥1 arthropod eradications, so far – **but what is the response**?

| Country | Number of incursions |
|---|---|
| United States | 334 |
| Australia | 219 |
| New Zealand | 80 |
| United Kingdom | 33 |
| Netherlands | 24 |
| Italy | 22 |
| Chile | 20 |
| France | 19 |
| Japan | 19 |
| Canada | 17 |
| Mexico | 14 |
| Argentina | 12 |
| French Polynesia | 12 |
| Spain | 11 |
| Switzerland | 10 |
| Ireland | 9 |
| South Africa | 9 |
| Virgin Islands, U.S. | 8 |
| Austria | 8 |
| Finland | 8 |
| Norway | 7 |
| China | 7 |
| Slovenia | 7 |
| Brazil | 6 |
| Germany | 6 |
| Cook Islands | 5 |
| Nauru | 5 |
| Sweden | 5 |
| US outlying islands | 5 |
| Portugal | 5 |
| Hungary | 4 |
| Honduras | 4 |
| Guatemala | 4 |
| Ecuador | 4 |
| Zimbabwe | 4 |
| Denmark | 4 |
| Czech Republic | 4 |
| Israel | 4 |
| Puerto Rico | 4 |
| Tanzania, United Republic of | 3 |
| Croatia | 3 |
| Latvia | 3 |
| Jamaica | 3 |
| Guam | 3 |
| Uruguay | 3 |
| Nicaragua | 3 |
| Costa Rica | 3 |
| Belize | 3 |
| Cyprus | 3 |
| El Salvador | 2 |
| Papua New Guinea | 2 |
| Bermuda | 2 |
| Panama | 2 |
| Morocco | 2 |
| Pakistan | 2 |
| Peru | 2 |
| Greece | 2 |
| Estonia | 2 |
| Egypt | 2 |
| Fiji | 2 |
| Virgin Islands, British | 2 |
| Paraguay | 2 |
| Botswana | 2 |
| Zambia | 2 |
| Poland | 2 |
| French Guiana | 2 |
| Taiwan, Province of China | 2 |
| Trinidad and Tobago | 2 |
| Jordan | 2 |
| Seychelles | 2 |
| Netherlands Antilles | 2 |
| Guyana | 2 |
| Sudan | 1 |
| Uganda | 1 |
| Antigua and Barbuda | 1 |
| Venezuela | 1 |
| Viet Nam | 1 |
| Samoa | 1 |
| Tunisia | 1 |
| Tokelau | 1 |
| Suriname | 1 |
| Sao Tome and Principe | 1 |
| Thailand | 1 |
| Singapore | 1 |
| Saint Lucia | 1 |
| Ethiopia | 1 |
| Algeria | 1 |
| Burkina Faso | 1 |
| Belgium | 1 |

# Pesticides

# We can fight back but ...
# can we avoid pesticides ?

gerda
global eradication and response database

# b3.net.nz/gerda



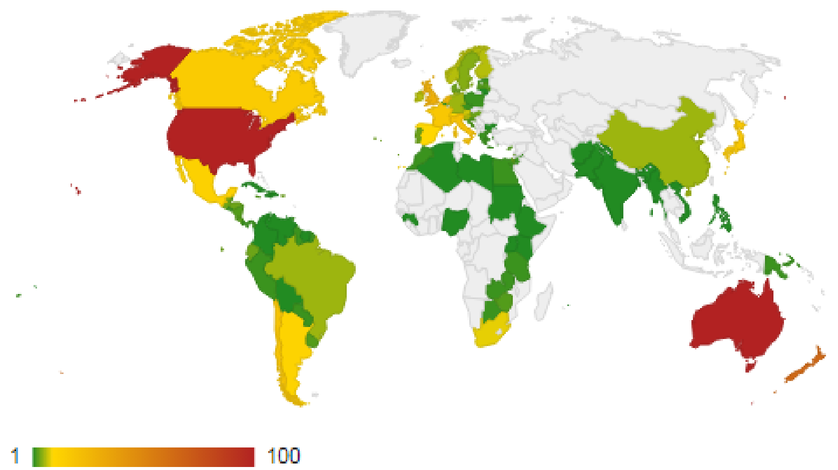
## Gerda · global eradication and response database

This database summarises incursion response and eradication programmes from around the world.

The scope of the database is terrestrial arthropod pests and plant pathogens. Weeds, vertebrate pests, aquatic pests, and animal diseases are not currently included. Read more about the scope and purposes of the database in the frequently asked questions (FAQ) section.

The database currently contains:

- 1096 incursion responses
- including 972 eradication programmes
- in 105 countries
- against 310 target taxa
  - · 167 arthropods
  - · 10 nematodes
  - · 3 molluscs
  - · 13 bacteria/phytoplasmas
  - · 47 fungi/oomycetes
  - · 70 viruses/viroids
- documented in 740 references



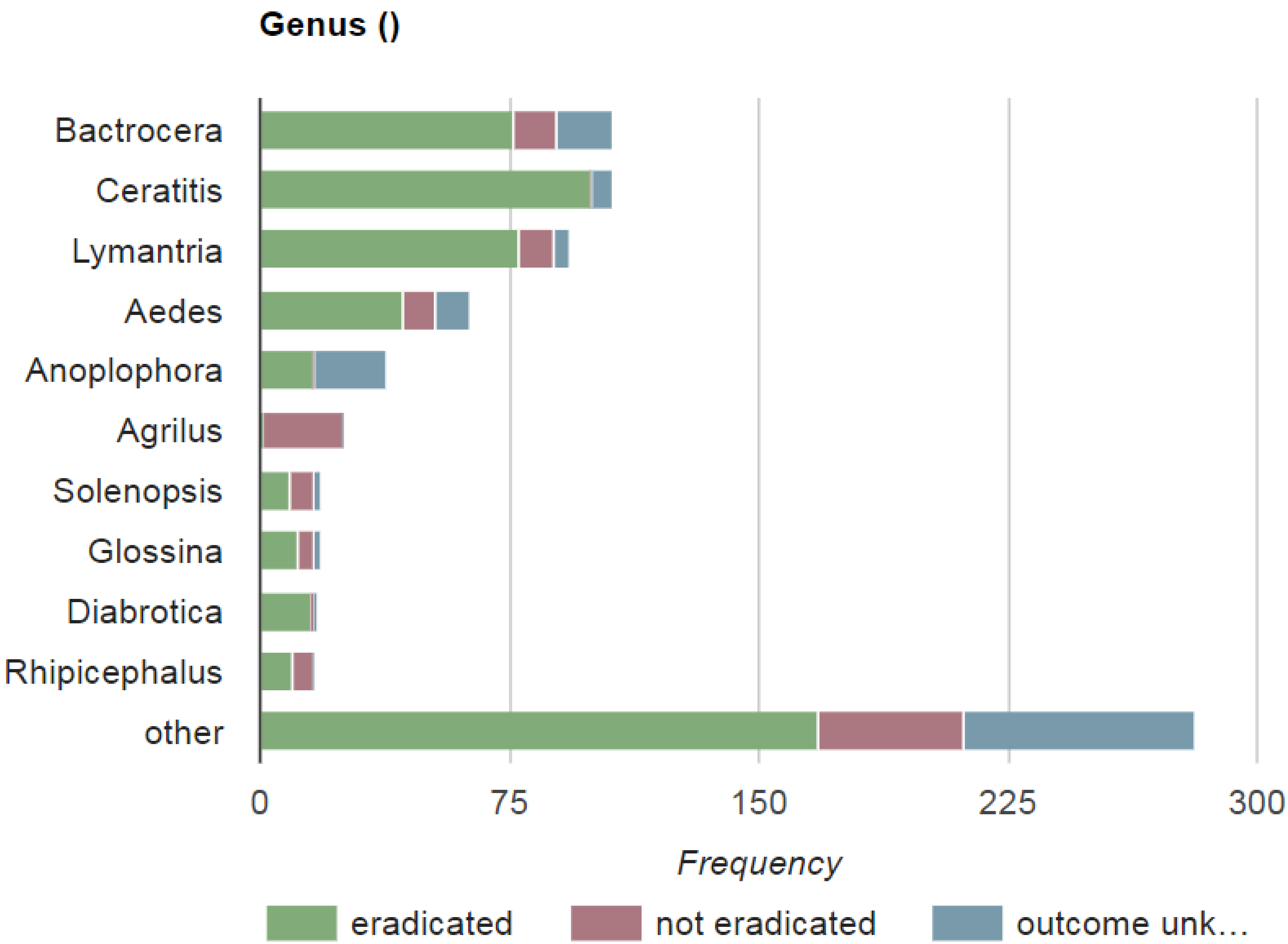

Number of eradication programmes per country

Please cite this resource as:

**Kean JM, Suckling DM, Sullivan NJ, Tobin PC, Stringer LD, Smith GR, Lee DC, Flores Vargas R, Fletcher J, Macbeth F, McCullough DG, Herms DA et al. 2017.** Global eradication and response database. http://b3.net.nz/gerda (accessed 12 May 2017).

Authors are listed in decreasing order of the number of database entries made. Only contributers who have edited at least 50 programmes are listed.

# Increase in biodiversity of unwanted targets



# Target taxa

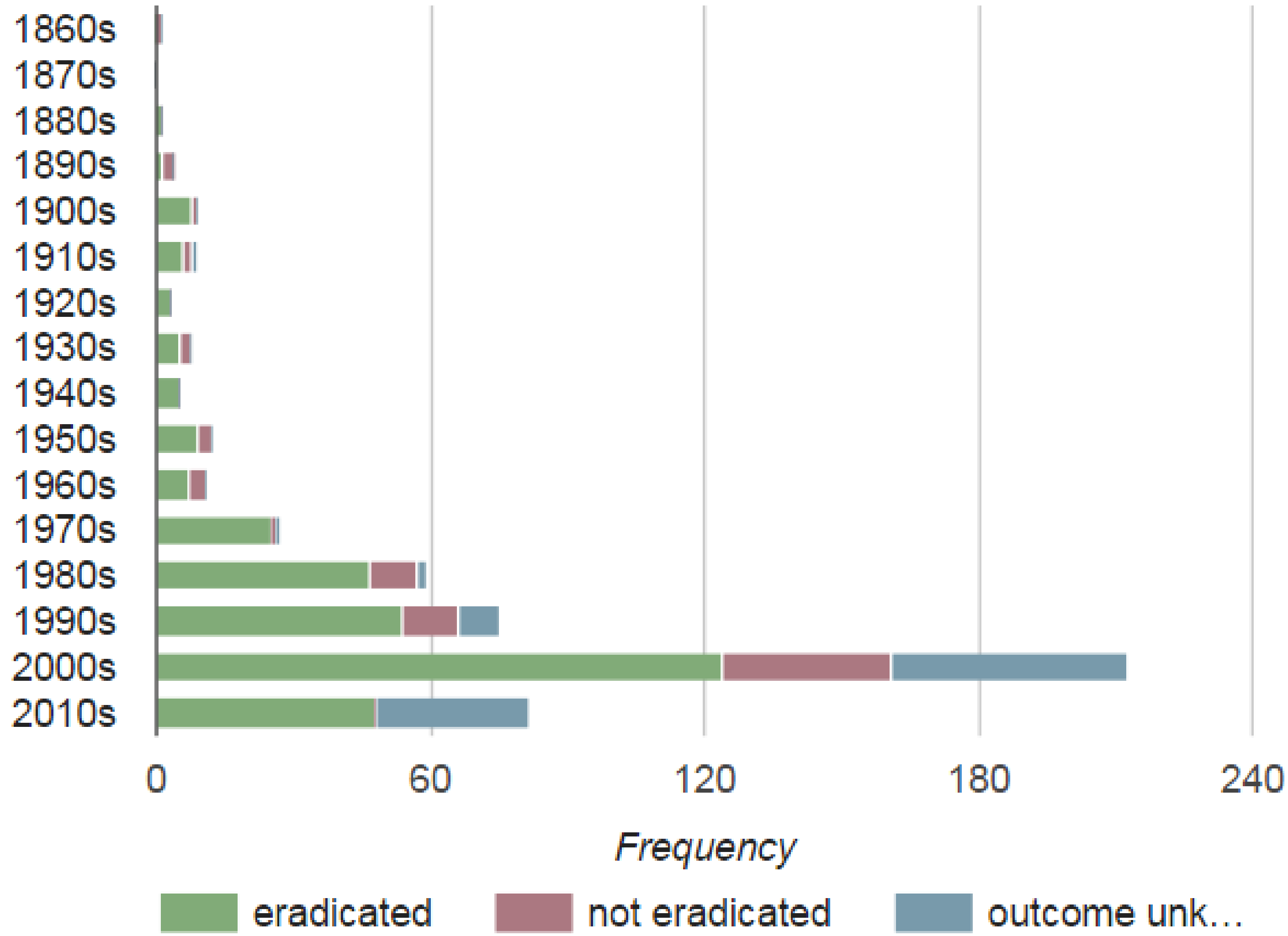
Data filter Culicidae ▼ Manage filters

Showing: **Eradication programmes** WHERE **Family** contains '*Culicidae*'

| Species | Common name | Order: Family | Cases |
|---|---|---|---|
| *Aedes aegypti* | yellow fever mosquito | Diptera: Culicidae | 38 |
| *Aedes albopictus* | Asian tiger mosquito | Diptera: Culicidae | 11 |
| *Aedes atropalpus* | American rock pool mosquito | Diptera: Culicidae | 4 |
| *Aedes camptorhynchus* | southern saltmarsh mosquito | Diptera: Culicidae | 10 |
| *Anopheles gambiae* | African malaria mosquito (complex) | Diptera: Culicidae | 2 |
| *Culex quinquefasciatus* | southern house mosquito | Diptera: Culicidae | 1 |

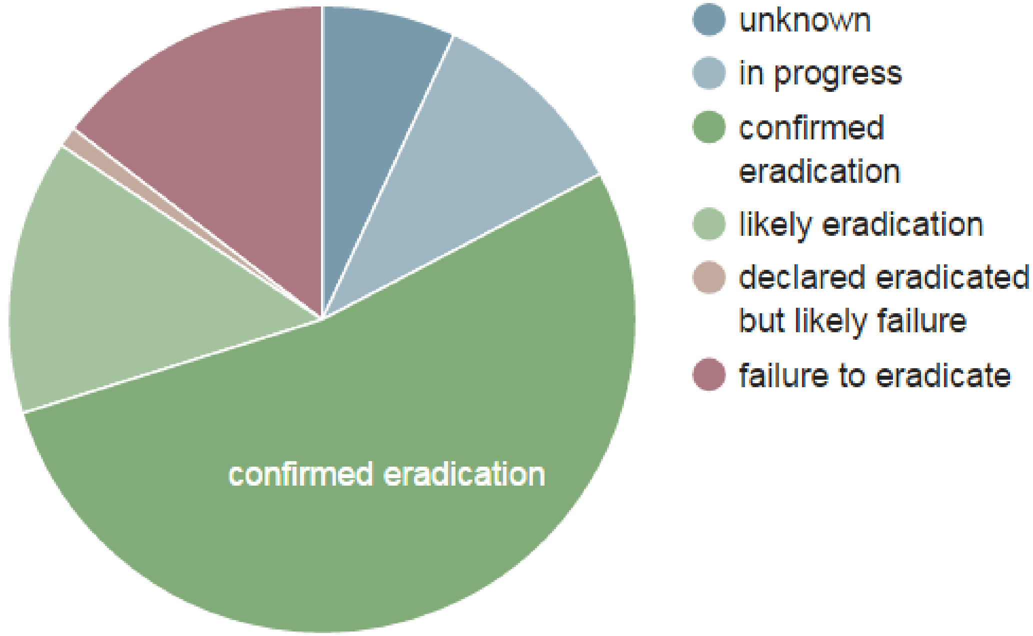
To add a new species, first check it is not already present in the full target list

# Detection date ()



# Outcomes from arthropod eradication programs

**81% success on average (=B Grade?)**




Of the 635 programmes for which the outcome is known:

- 515 (81%) were successful and
- 120 (19%) failed.

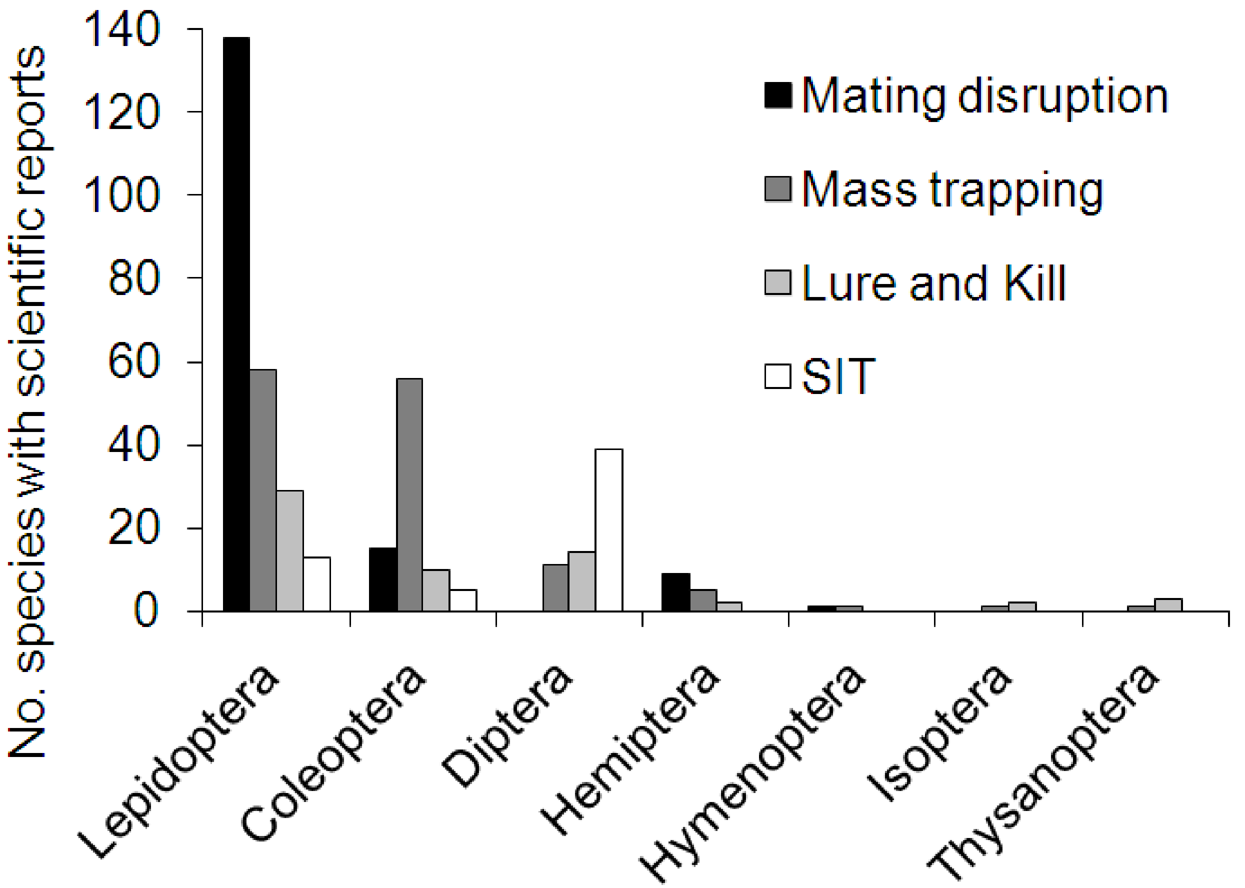
 SCI

Received: 3 May 2012 Revised: 14 October 2013 Accepted article published: 23 October 2013 Published online in Wiley Online Library:

(wileyonlinelibrary.com) DOI 10.1002/ps.3670

# From integrated pest management to integrated pest eradication: technologies and future needs

David M Suckling,[a,b,c*] Lloyd D Stringer,[a,b,c] Andrea EA Stephens,[a,d] Bill Woods,[c,e] David G Williams,[c,f] Greg Baker[c,g] and Ashraf M El-Sayed[a,b]




Plant & Food RESEARCH RANGAHAU AHUMĀRA KAI

**Table 1.** Potential issues, constraints and considerations for the use of eradication technologies either on their own or in conjunction with other technologies

| Technology | Registration and approvals | Range of targets | Suitability for an eradication | Compatibility with other tactics | Perceived social acceptance | Potential use in an eradication | |
|---|---|---|---|---|---|---|---|
| Surveillance technologies | Few issues, vandalism risk | Certain types of species | Essential | Baseline tactic | High | Delimitation and monitoring progress | |
| Broad-spectrum insecticides | Essential | Wide | Highly effective, limited by nontarget impacts | Low compatibility, impacts on biocontrol, SIT | Low | Effective, though generally unwanted in populated areas | |
| 'Lower risk' insecticides/green chemistry | Essential | Variable | Highly effective, limited by nontarget impacts | Low compatibility, impacts on biocontrol and SIT | Moderate | Effective, though generally unwanted in populated areas | |
| Biopesticides (Bt, fungi, baculovirus and nematodes) | Essential | Some life-stage specific | Moderate to low, depends on target | Low compatibility, impacts on biocontrol, SIT | Moderate | Valuable for initial knockdown. More socially acceptable than broad-spectrum sprays | |
| Mass trapping | Few issues | 133 species | Moderate to low | Compatible, impacts SIT | High | Valuable for initial reduction in population size | |
| Lure and kill/male-annihilation | Essential for toxicant | 60 species | Moderate to low | Compatible, impacts SIT | Moderate | Valuable for initial reduction in population size | |
| Mating disruption | Few issues, low hazard | 160 species | Moderate to low | Conflict with pheromone delimitation and SIT | High | Species with a long-range pheromone | |
| Sterile insect technique | Few issues | 57 species | Low to high, depends on target and fitness of sterilized insects | Compatible, needs marking system to distinguish releases | High | Generates scarcity of viable individuals; allows for calibration of sampling efficiency | 74,76 |
| Biological control (BCA) | Not if existing, essential for introduction of exotic agents | Variable, differs for each BCA | Moderate to low, depends on target | Not compatible with insecticides | Moderate to high | Valuable additional tool impacting on population size | |
| Tree/plant destruction | Owner compensation | High | High | Compatible | Moderate | Good where insect has limited range and for sanitation | 6 |
| Mechanical/physical | Owner compensation | High | Moderate | Compatible | High | Labour intensive | |

## Technology vs acceptance for use ?

frontiers in
ECOLOGY AND EVOLUTION
PERSPECTIVE ARTICLE
published: 02 March 2015
doi: 10.3389/fevo.2015.00017

# Can we replace toxicants, achieve biosecurity, and generate market position with semiochemicals?

***David M. Suckling*** [1,2,3]*

[1] *Better Border Biosecurity, The New Zealand Institute for Plant and Food Research Ltd., Christchurch, New Zealand*
[2] *Joint Graduate School in Plant and Food Science, School of Biological Sciences, The University of Auckland, Auckland, New Zealand*
[3] *Plant Biosecurity Cooperative Research Centre, Canberra, ACT, Australia*


***www.b3nz.net/gerda***

***www.Pherobase.com***

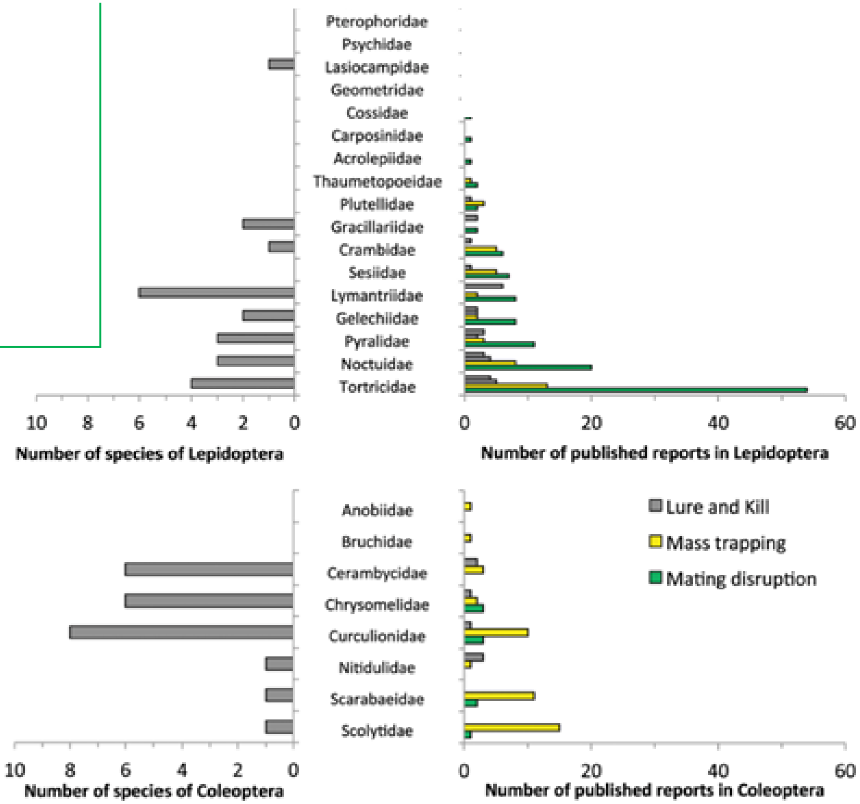




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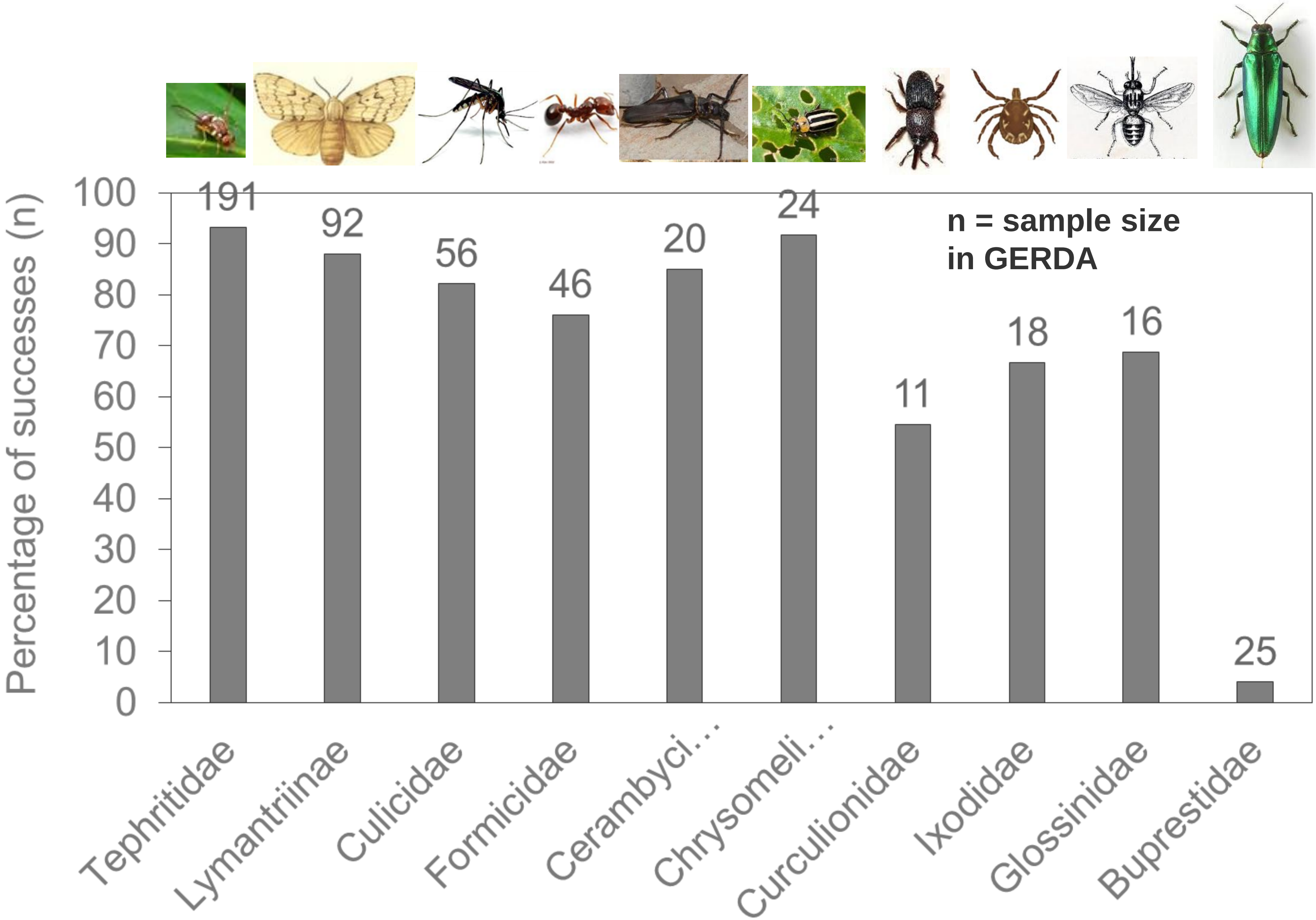
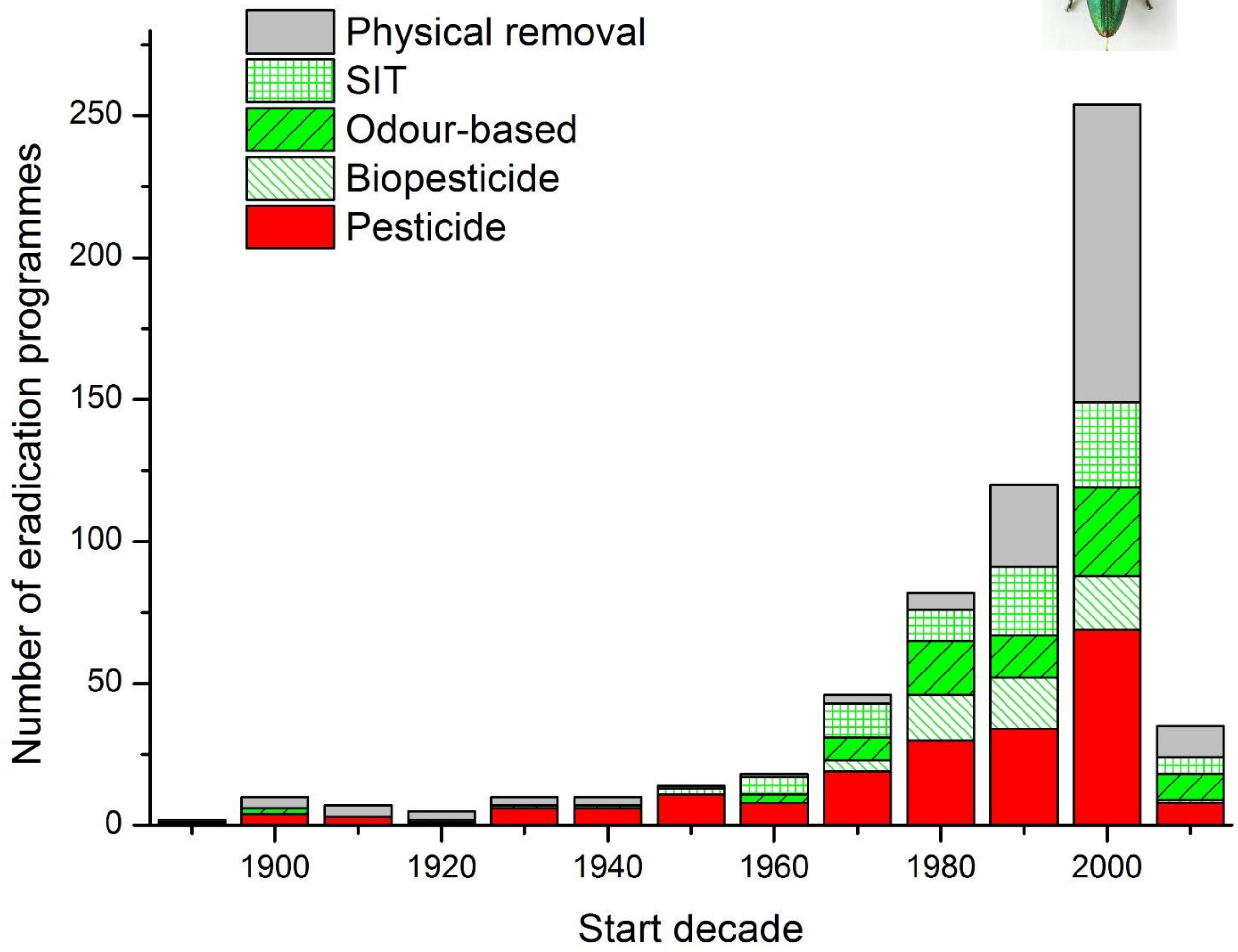
**FIGURE 1 | Reported tactical tests of pheromones for pest** indication of the number of species in each family with

# Percentage success by insect family (n >10)




Physical removal
SIT
Odour-based
Biopesticide
Pesticide
Number of eradication programmes
0
50
100
150
200
250
1900
1920
1940
1960
1980
2000
Start decade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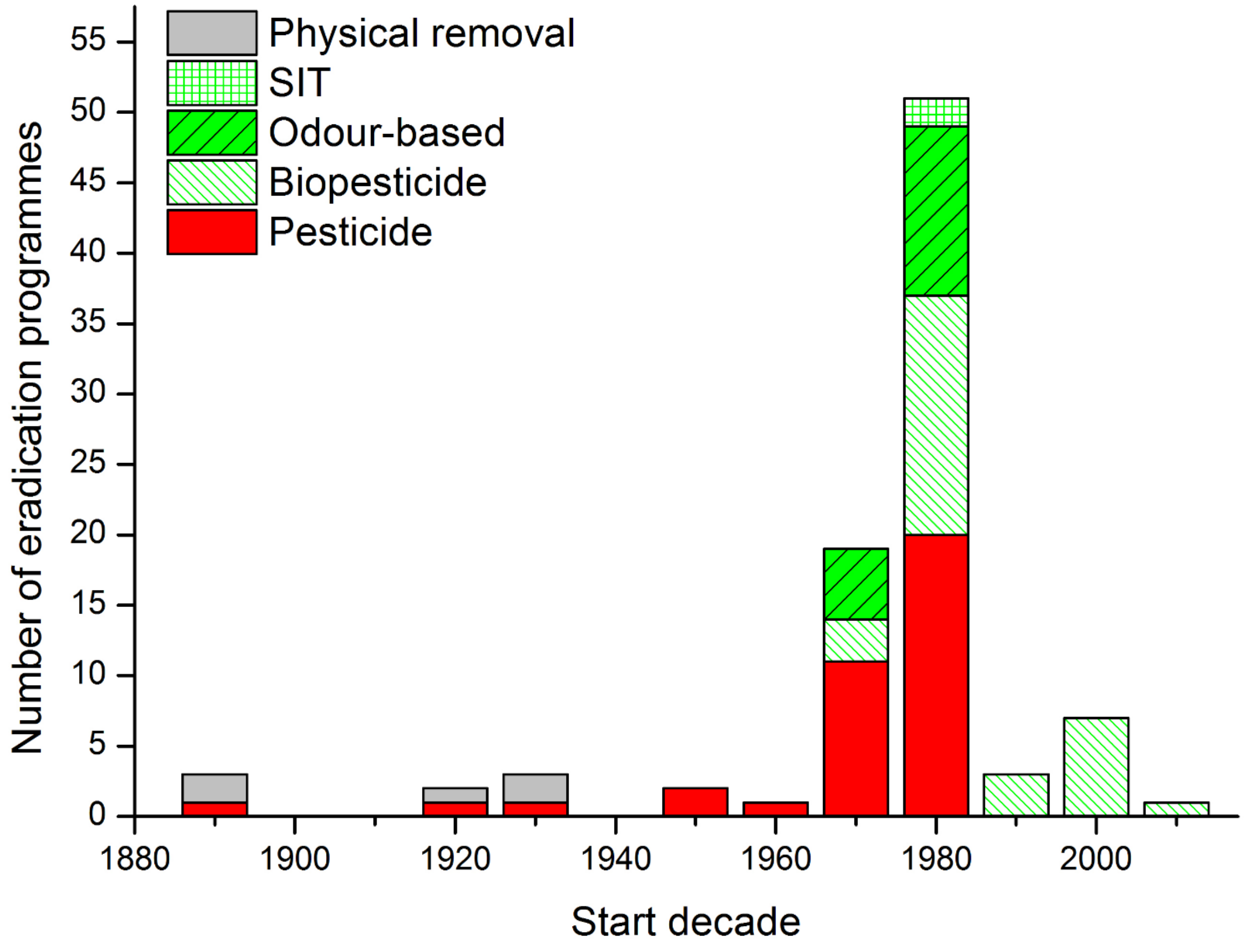
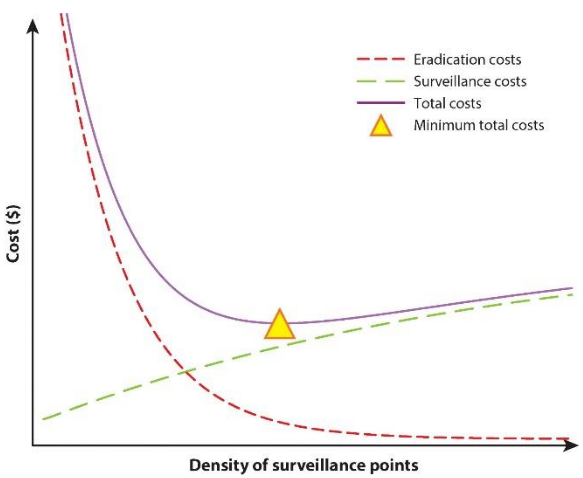
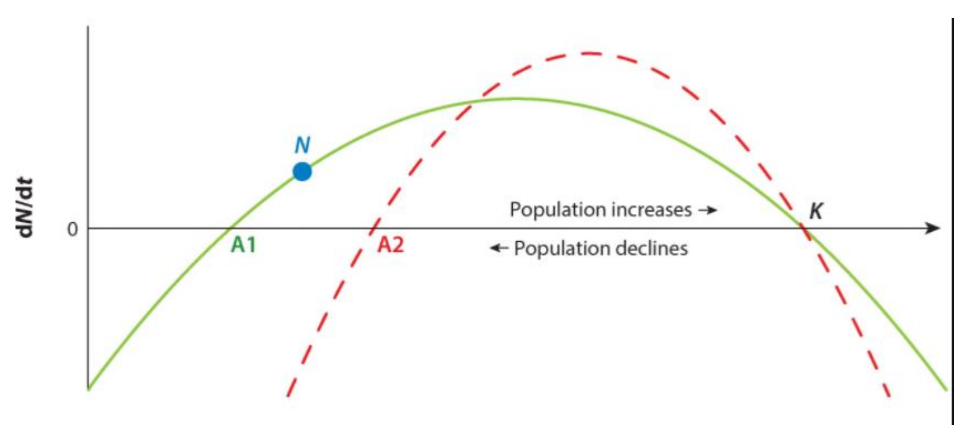


# Eradication of Invading Insect Populations: From Concepts to Applications

**Annual Review of Entomology**
Vol. 61:335-352 (Volume publication date March 2016)
First published online as a Review in Advance on December 14, 2015
DOI: 10.1146/annurev-ento-010715-023809

**Andrew M. Liebhold,[1,*] Ludek Berec,[2] Eckehard G. Brockerhoff,[3] Rebecca S. Epanchin-Niell,[4] Alan Hastings,[5] Daniel A. Herms,[6] John M. Kean,[7] Deborah G. McCullough,[8] David M. Suckling,[9] Patrick C. Tobin,[10] and Takehiko Yamanaka[11]**



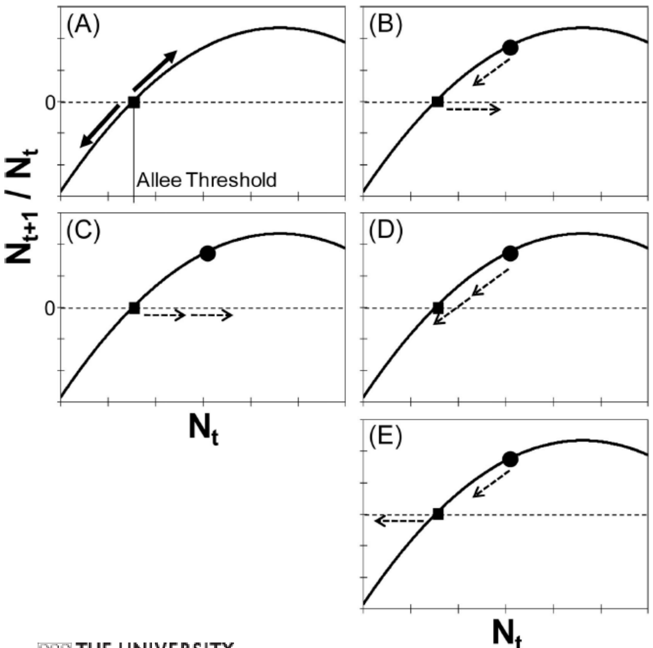



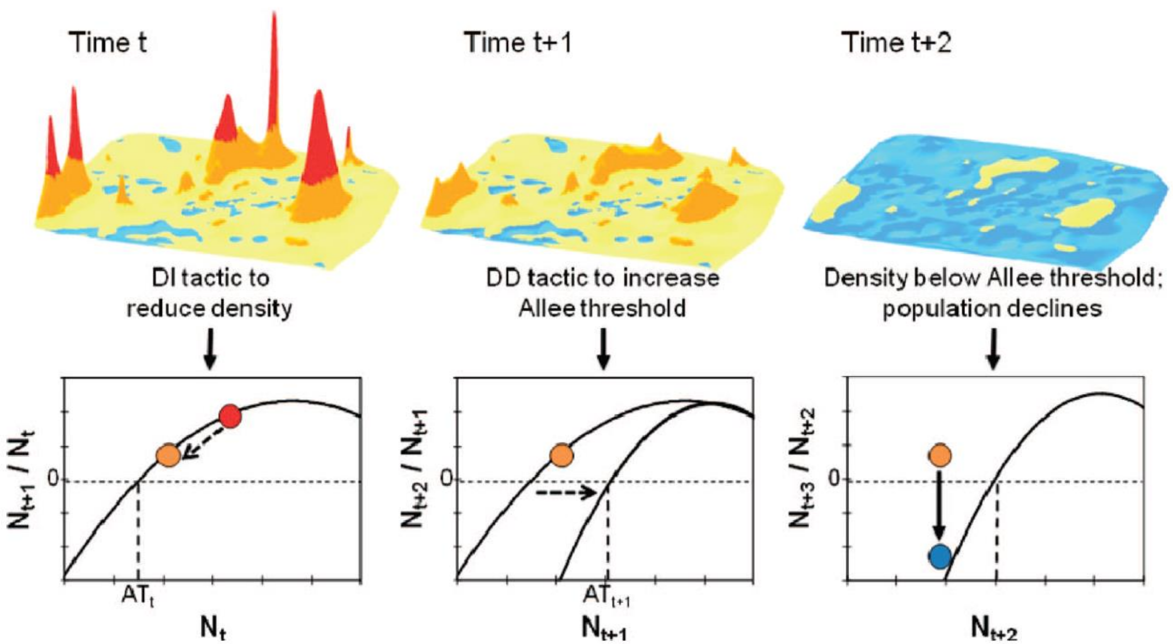
Forum

# Combining Tactics to Exploit Allee Effects for Eradication of Alien Insect Populations

David Maxwell Suckling,[1] Patrick C. Tobin,[2] Deborah G. McCullough,[3] and Daniel A. Herms[4]

J. Econ. Entomol. 105(1): 1–13 (2012); DOI: http://dx.doi.org/10.1603/EC11293

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# Additive or synergistic ?

| Combination type | Quality of interaction | |
|---|---|---|
| Synergistic | AB > A + B | |
| Additive | AB = A + B | |
| Redundant | AB = A or B | X |
| Antagonistic | AB < A + B | X |

**Released sterile female moths lay sterile eggs, providing food for egg parasitoids and yielding a numerical response**

PLOS | ONE

RESEARCH ARTICLE

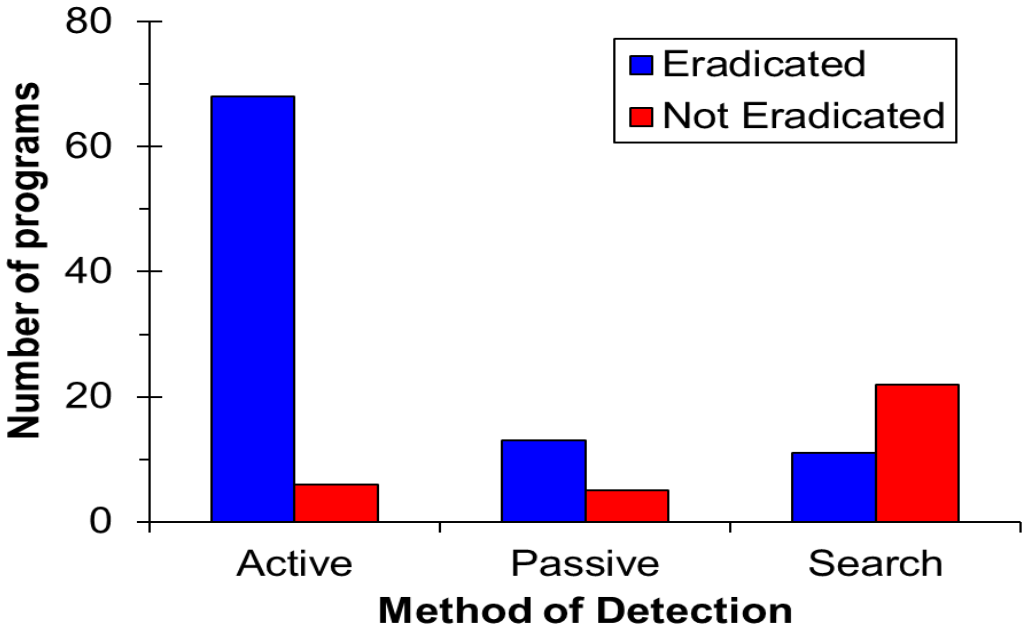
Is the Combination of Insecticide and Mating Disruption Synergistic or Additive in Lightbrown Apple Moth, *Epiphyas postvittana*?

David M. Suckling[1,2,5]*, Greg Baker[2,3], Latif Salehi[2,3], Bill Woods[2,4]

**What are the requirements for synergistic combinations ?**

**The key may be two inversely density dependent tactics**

# Method of detection makes a big difference




**Active = lures**

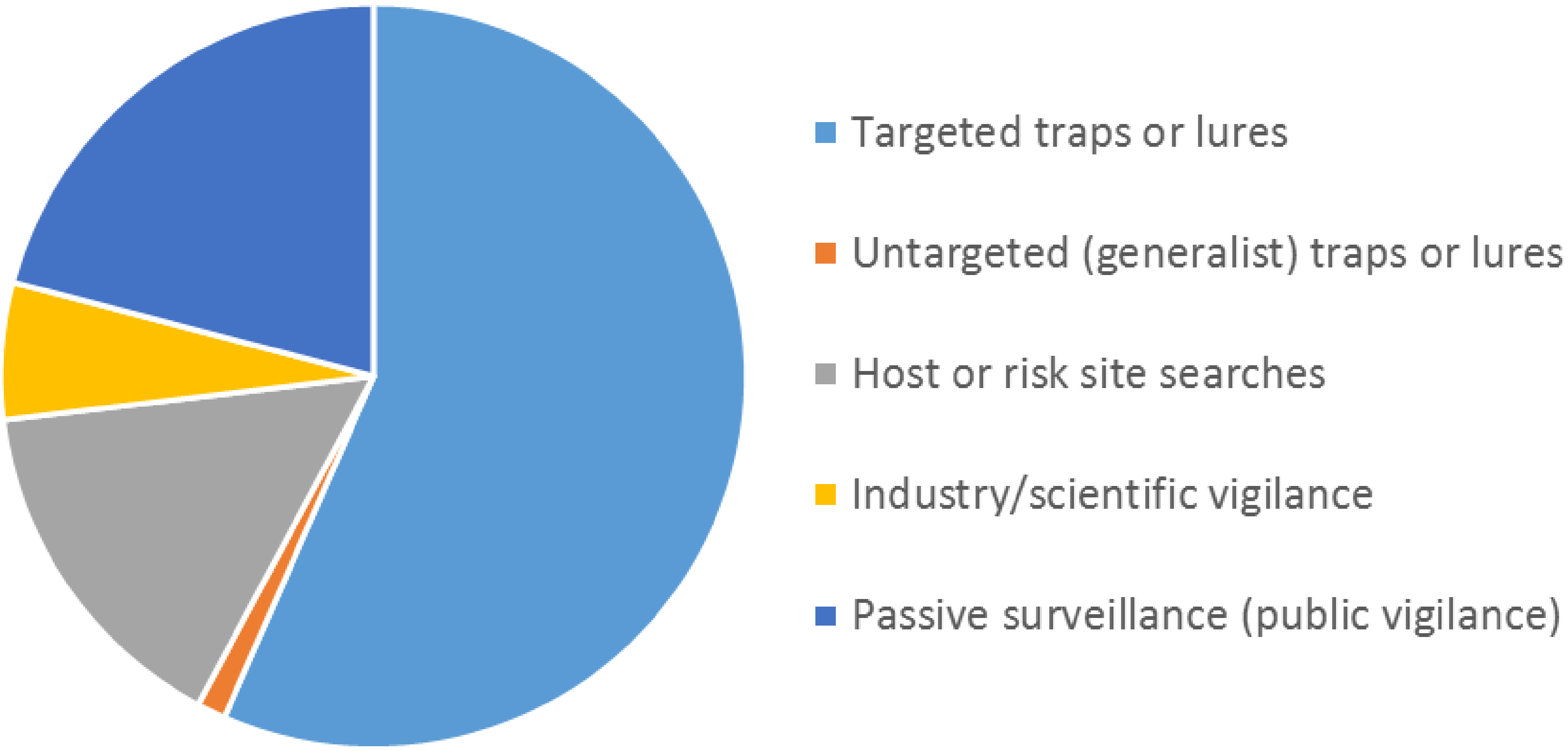
**Passive = public reporting, untargeted (light trap with LBAM in California)**

**Search = host/site and industry searching (vested interest)**

**Significant effect of detection method on the success/failure to eradicate (*P*<0.001, N=125)**

## 22.7 times more likely to succeed with active instead of search

# Effect of lures is huge, it's a good investment



**Research Article**

SCI

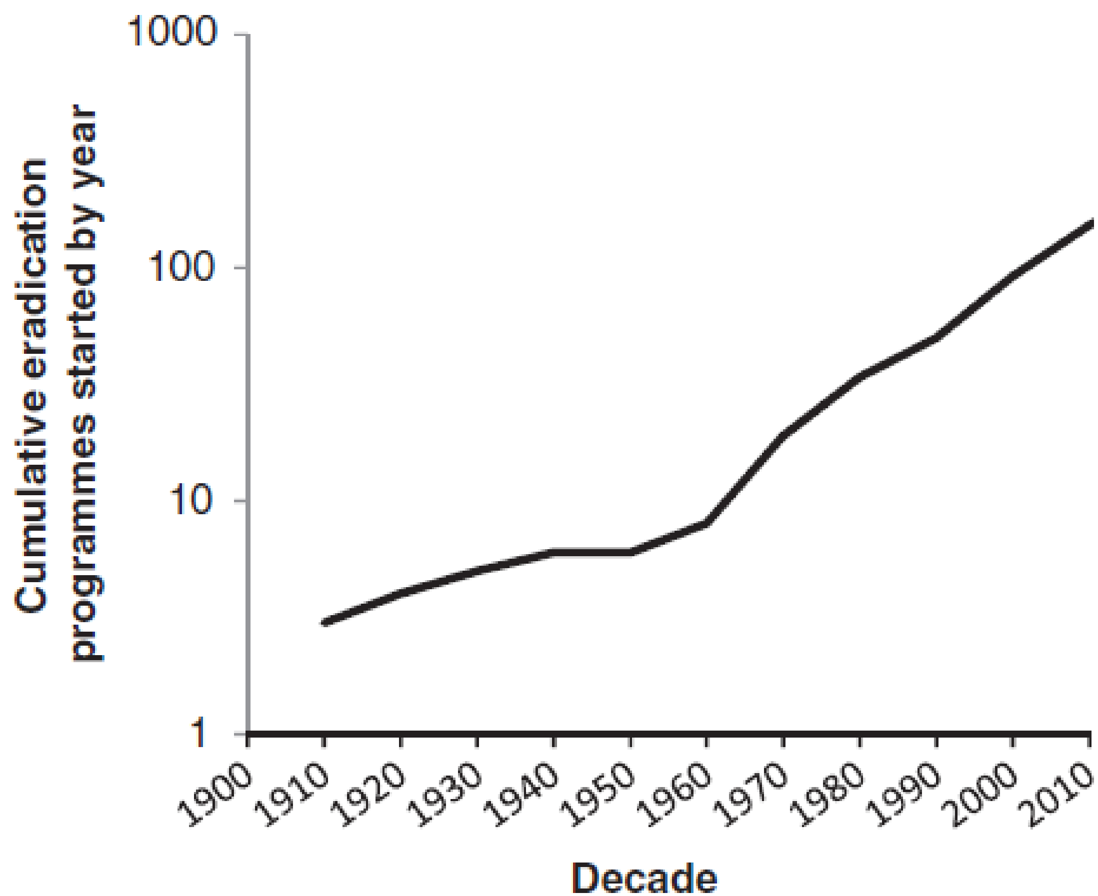
Received: 17 July 2014 Accepted article published: 10 September 2014 Published online in Wiley Online Library: 8 October 2014

(wileyonlinelibrary.com) DOI 10.1002/ps.3905

global eradication and response database

# Eradication of tephritid fruit fly pest populations: outcomes and prospects

David Maxwell Suckling,[a,b,c*] John M Kean,[c,d] Lloyd D Stringer,[a,b,c,e] Carlos Cáceres-Barrios,[f] Jorge Hendrichs,[g] Jesus Reyes-Flores[g] and Bernard C. Dominiak[h]

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The New Zealand Institute for Plant & Food Research Limited

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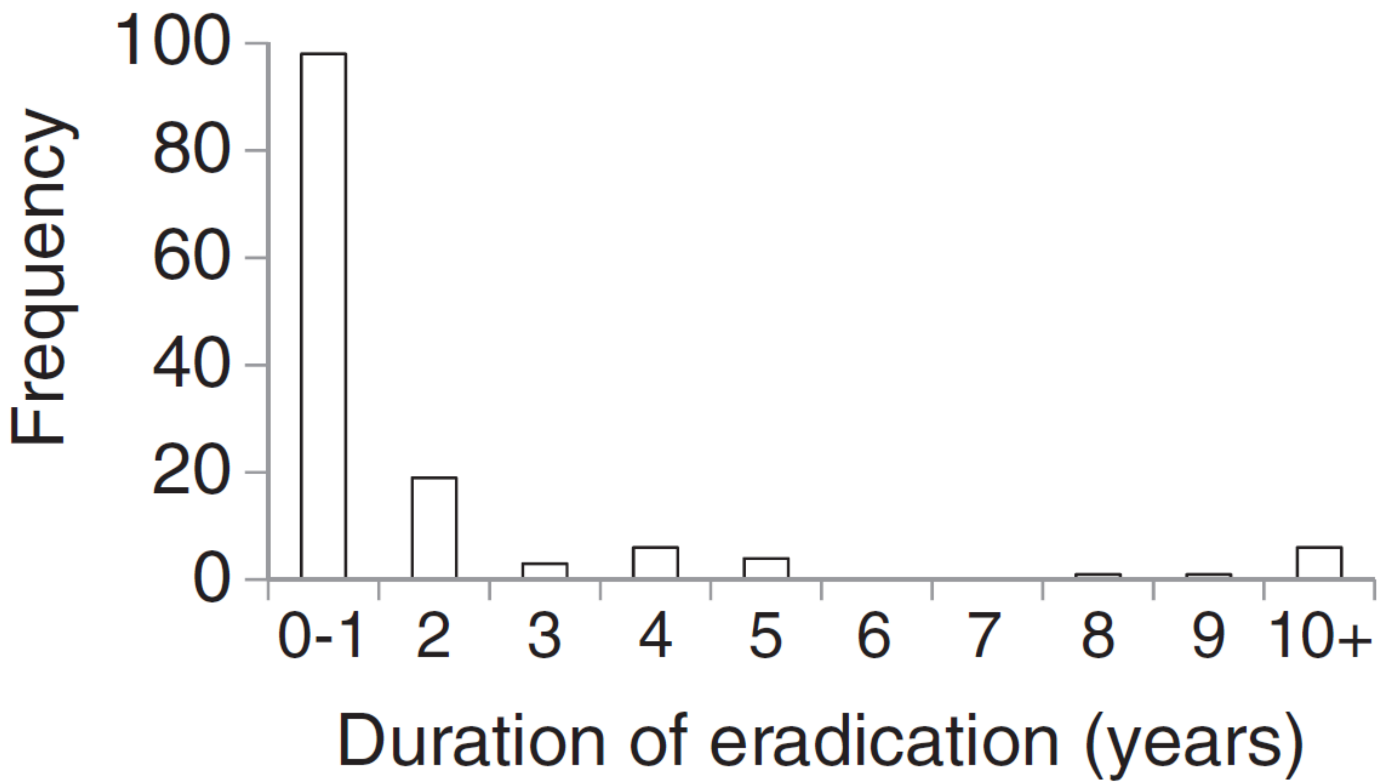
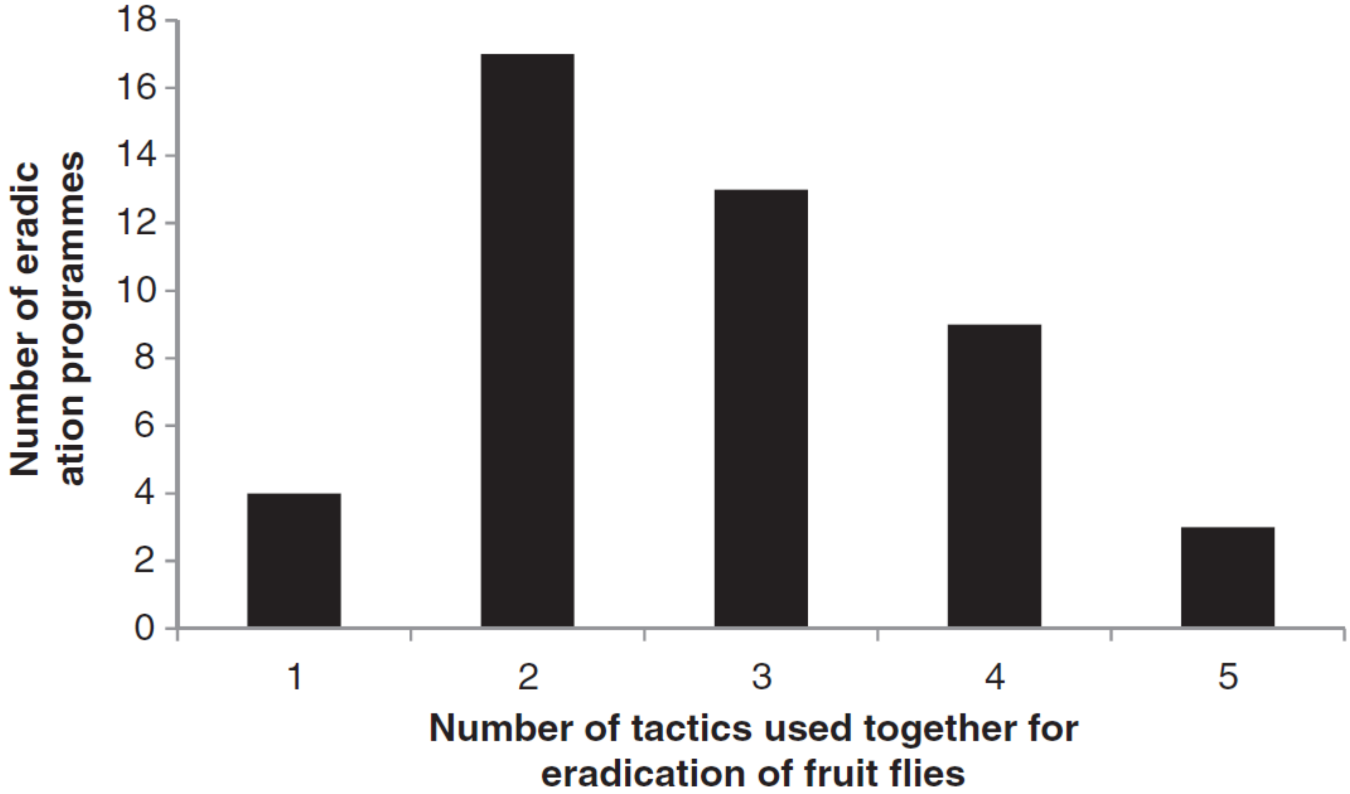
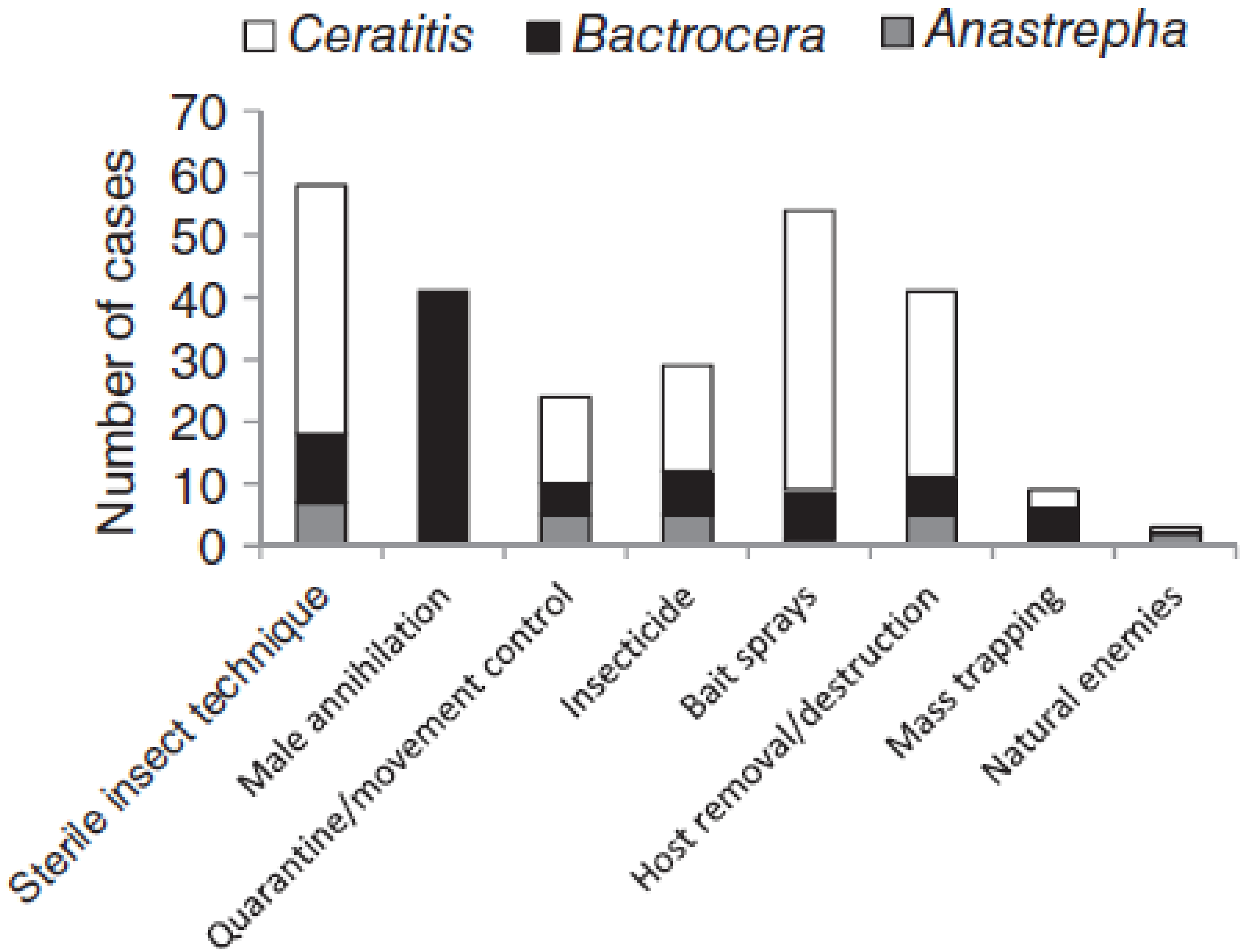
# Fruit fly eradication program duration



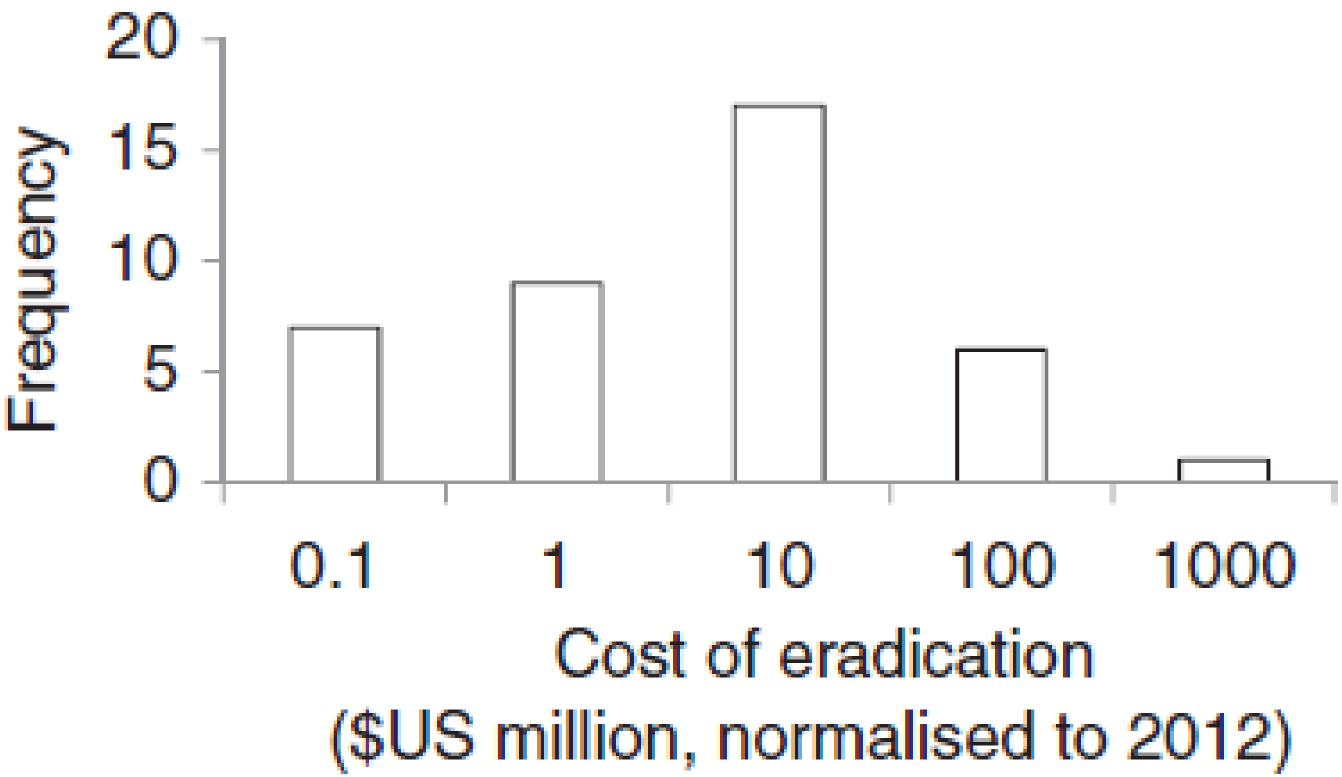
# Integrated Pest Eradication of FF



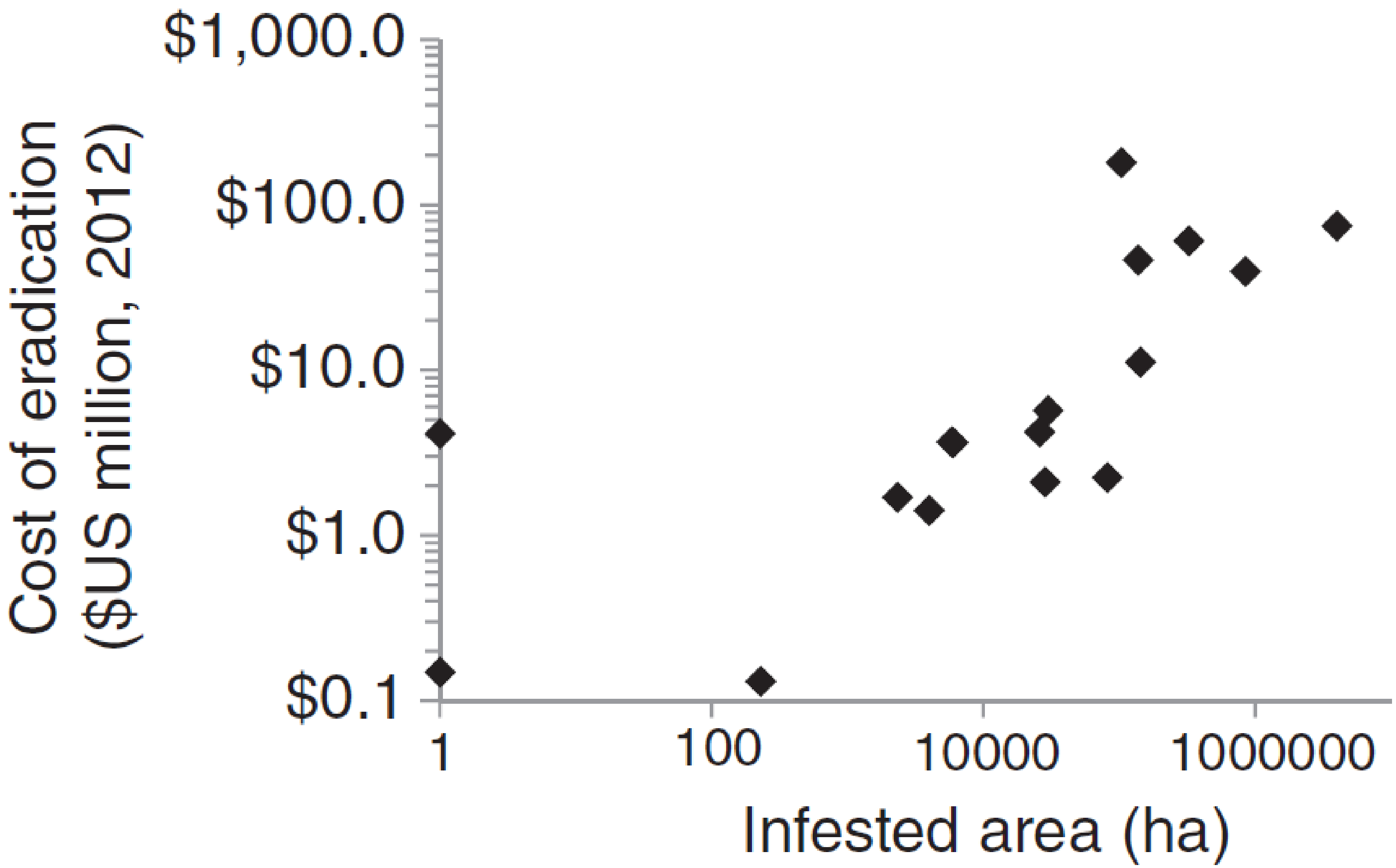



Tactics used during fruit fly eradications

# Fruit fly eradication costs in USD



# Cost vs area – get it early

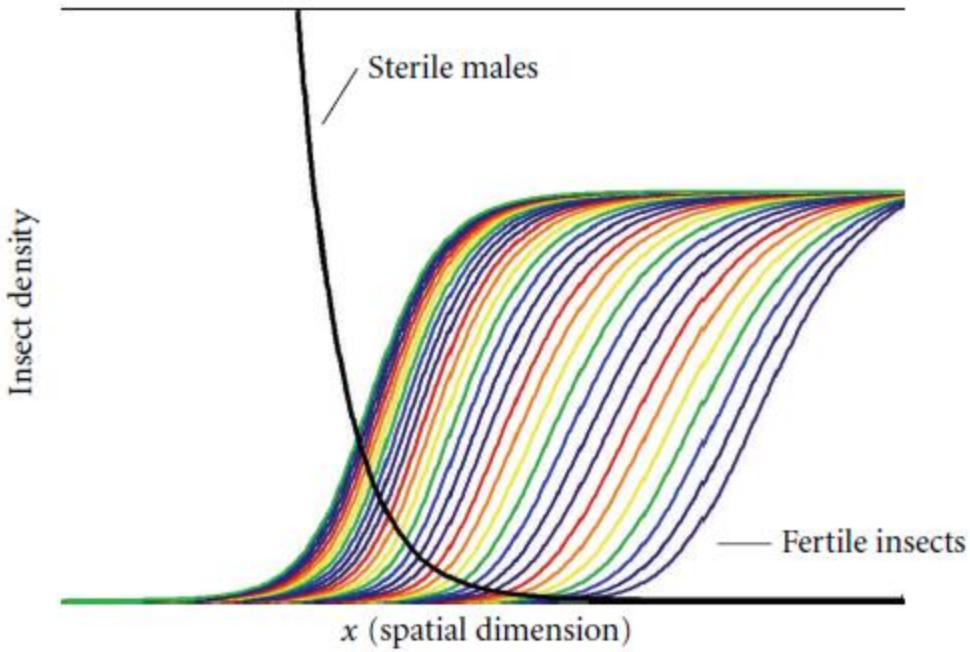


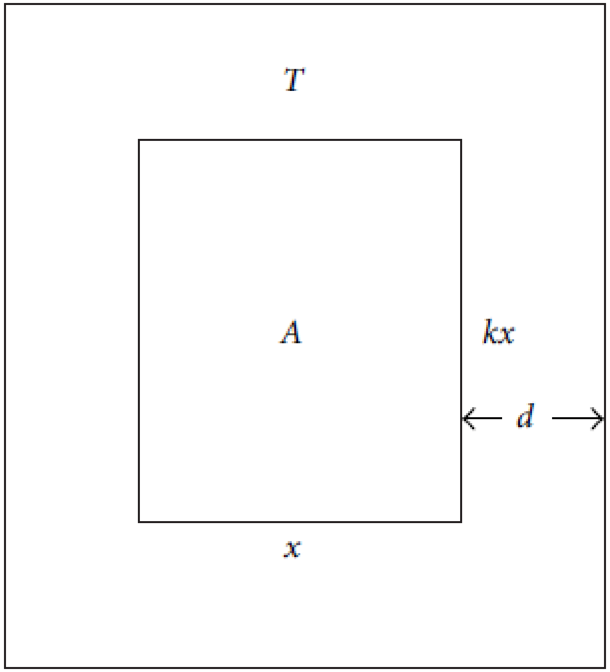
*Research Article*

**A Conceptual Model for Assessing the Minimum Size Area for an Area-Wide Integrated Pest Management Program**

Hugh J. Barclay,[1] Robert Matlock,[2] Stuart Gilchrist,[3,4] David M. Suckling,[5] Jesus Reyes,[6,7] Walther R. Enkerlin,[7,8] and Marc J. B. Vreysen[7,9]

**Understanding dispersal is critical**




**"Boutique SIT" ?**

**Painted apple moth in NZ used only ~5000 males per week**

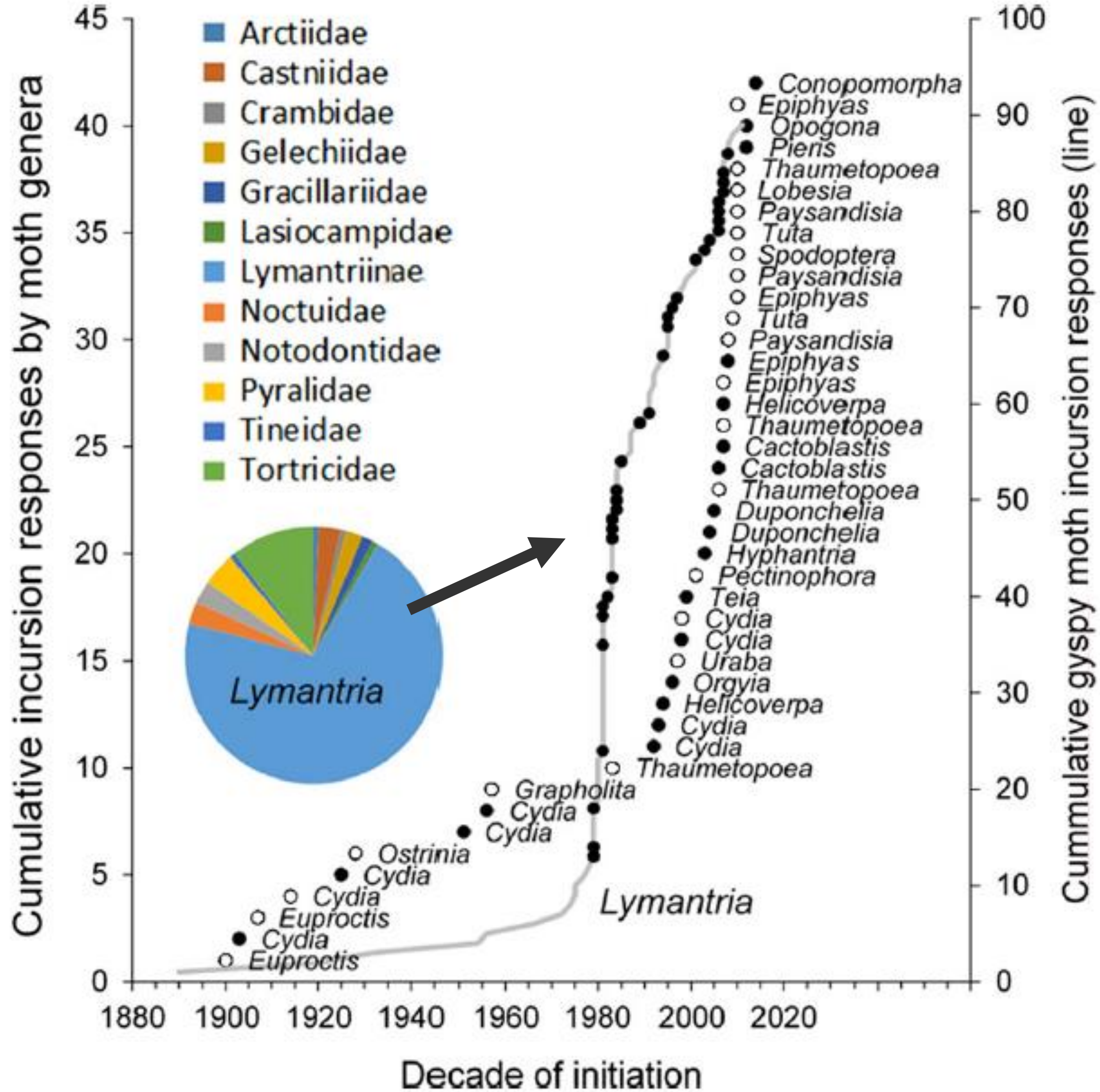
Biol Invasions
DOI 10.1007/s10530-016-1325-9

PERSPECTIVES AND PARADIGMS

g∅rda
global eradication and response database

# Global range expansion of pest Lepidoptera requires socially acceptable solutions

D. M. Suckling · D. E. Conlong · J. E. Carpenter · K. A. Bloem · P. Rendon · M. J. B. Vreysen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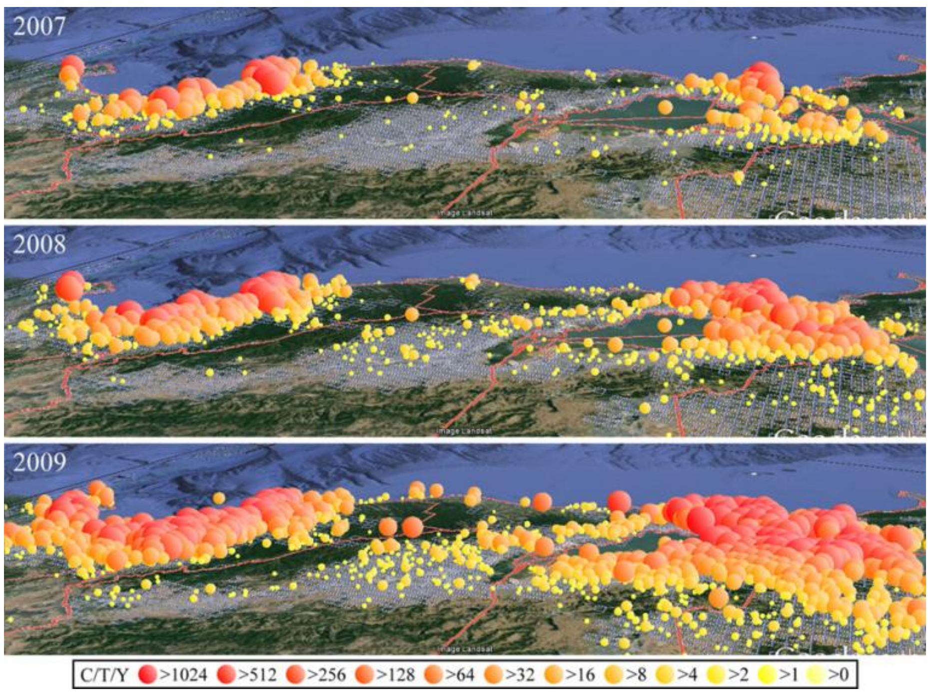
Biol Invasions
DOI 10.1007/s10530-013-0631-8

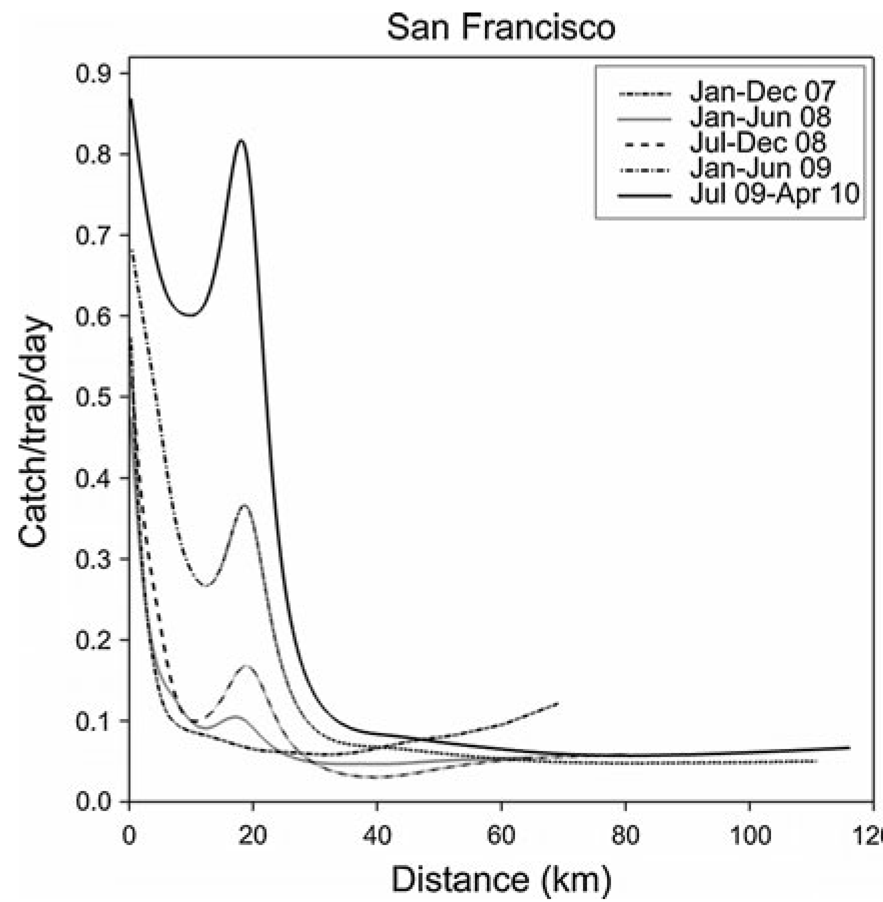
ORIGINAL PAPER

# Light brown apple moth (*Epiphyas postvittana*) (Lepidoptera: Tortricidae) colonization of California

D. M. Suckling · L. D. Stringer · D. B. Baird ·
R. C. Butler · T. E. S. Sullivan · D. R. Lance ·
G. S. Simmons

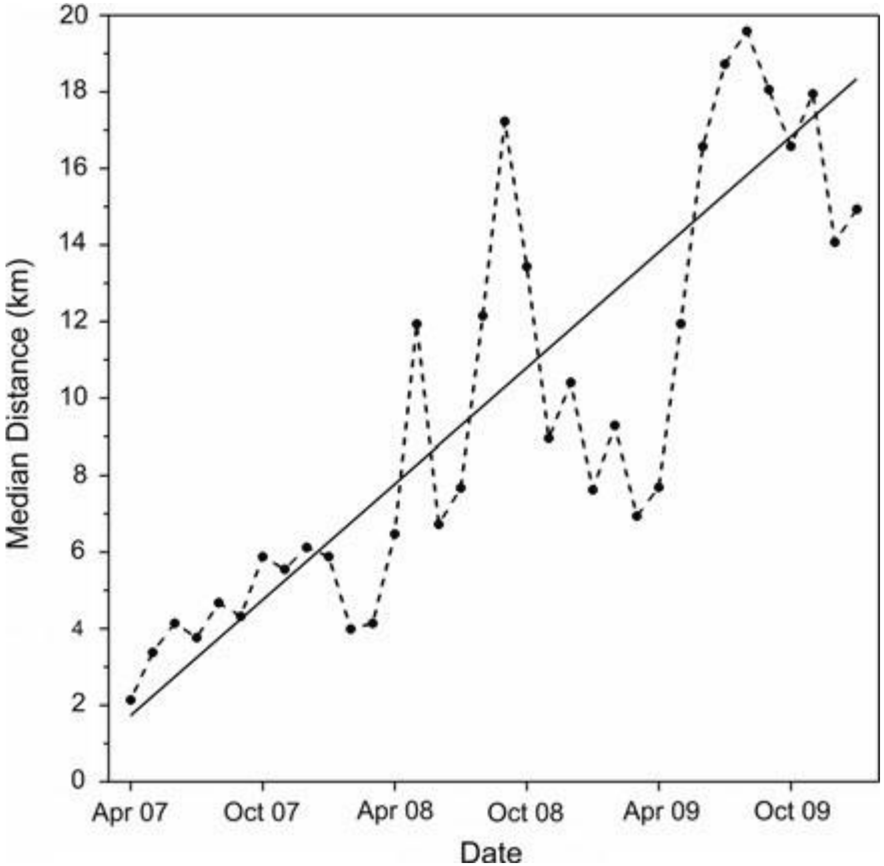
Received: 29 March 2012 / Accepted: 21 December 2013

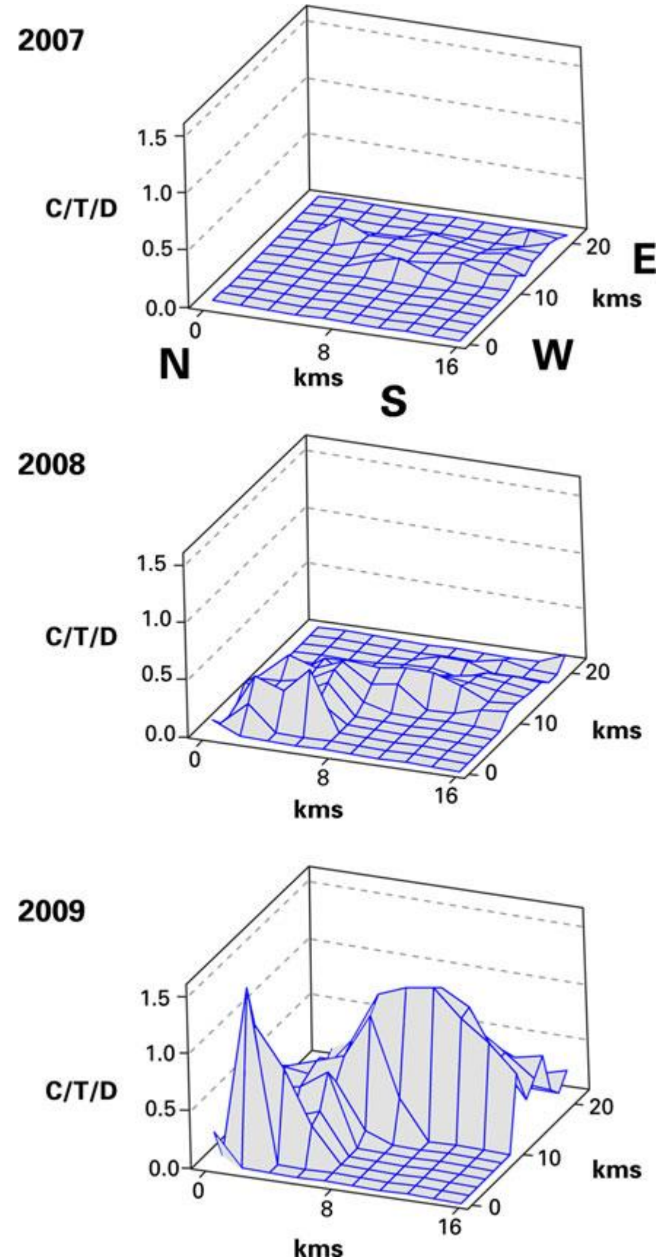



# LBAM spread was seasonal

# Berkeley



PLOS ONE

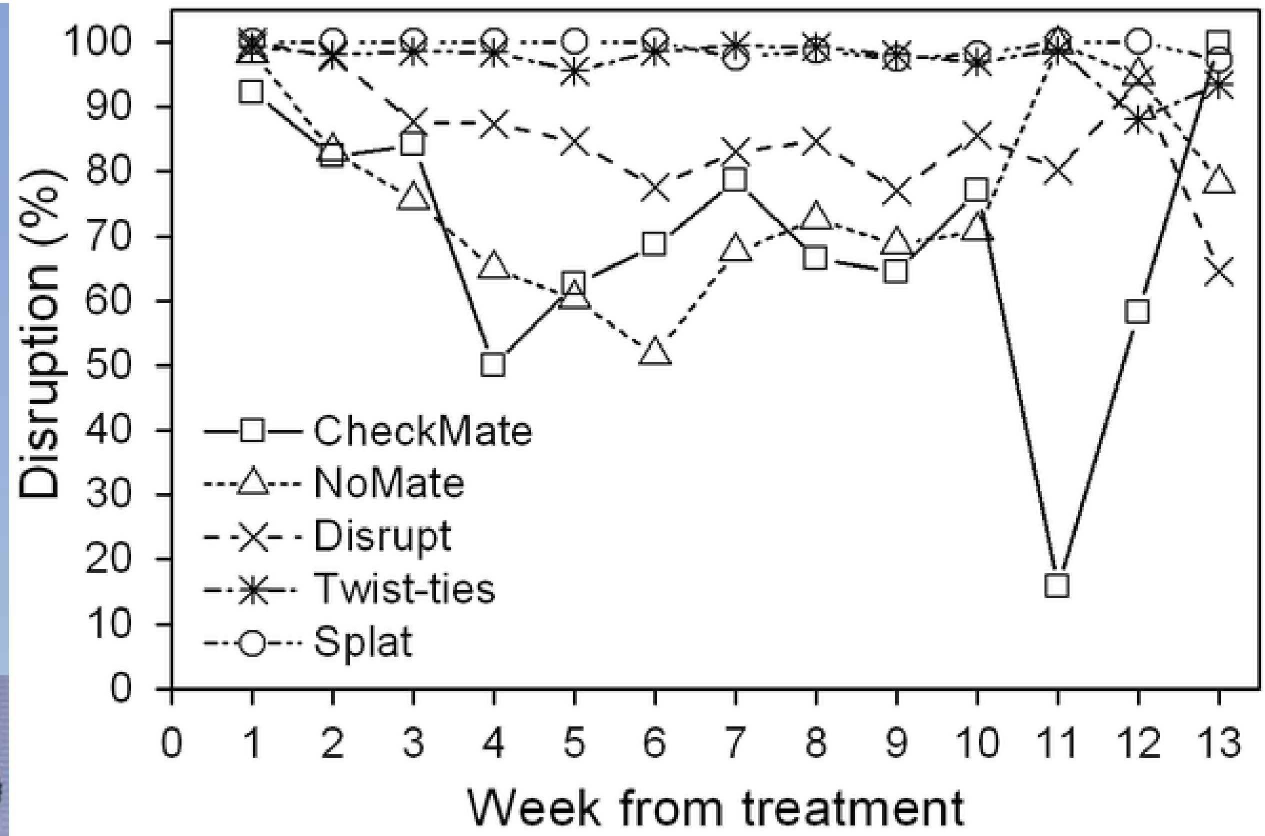
OPEN ACCESS PEER-REVIEWED

RESEARCH ARTICLE

# Aerial Application of Pheromones for Mating Disruption of an Invasive Moth as a Potential Eradication Tool

Eckehard G. Brockerhoff, David M. Suckling, Mark Kimberley, Brian Richardson, Graham Coker, Stefan Gous, Jessica L. Kerr, David M. Cowan, David R. Lance, Tara Strand, Aijun Zhang

Published: August 24, 2012 • DOI: 10.1371/journal.pone.0043767

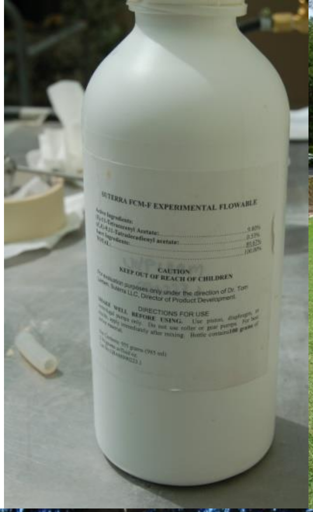
Research Article

Received: 10 October 2010 Revised: 29 November 2010 Accepted: 7 December 2010 Published online in Wiley Online Library: 7 April 2011

(wileyonlinelibrary.com) DOI 10.1002/ps.2150

# Mobile mating disruption of light-brown apple moths using pheromone-treated sterile Mediterranean fruit flies

David M Suckling,[a]* Bill Woods,[b] Vanessa J Mitchell,[a] Andrew Twidle,[a] Ian Lacey,[b] Eric B Jang[c] and Andrew R Wallace[a]



# New Zealand – unmanned aerial vehicle for release of Sterile Insects imported from Canada

**<u>100 ha orchard at 1 flight</u>**

- **Efficient high quality delivery**
- **Controlled release**
- **20,000 moths**
- **10 minute flight**

## Can we get local eradication of Codling Moth with mating disruption plus sterile insects ?

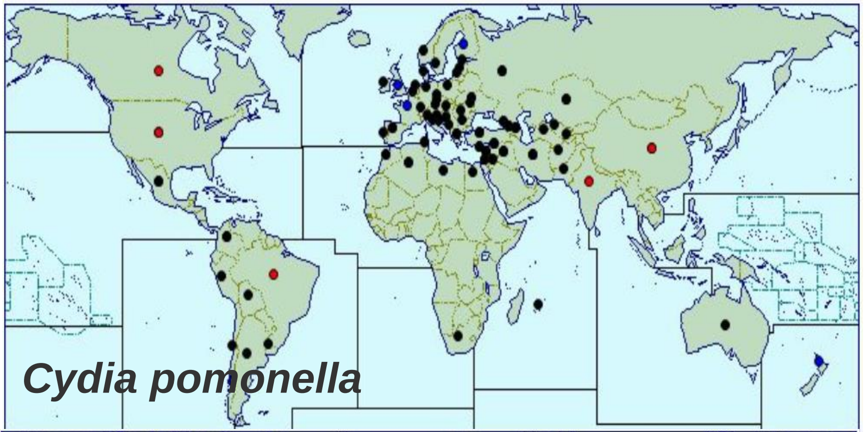
2015-16 vs 2013-14

- 87% lower with SIT, so far
- Area now doubled to >400 ha

**Data: Jim Walker**

Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

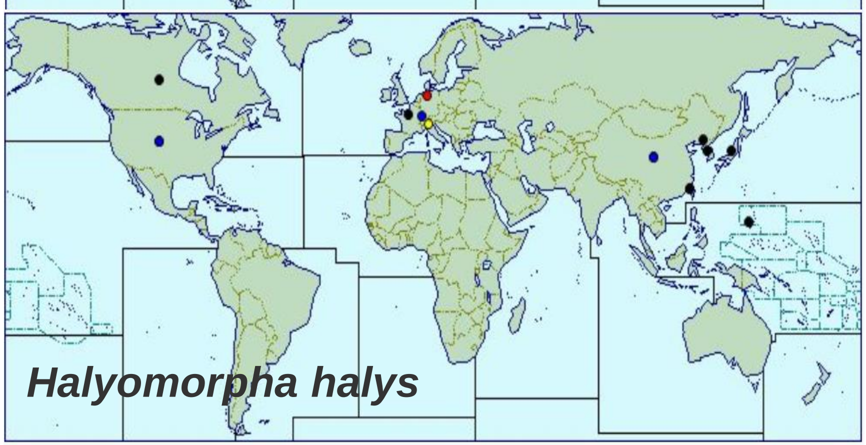
OKANAGAN-KOOTENAY STERILE INSECT RELEASE PROGRAM




**Codling moth**

**Almost everywhere**


**Apple leafcurling midge**
**Patchy**




**Brown marmorated stink bug**
**Limited, spreading fast**

- ● = Present, no further details
- ● = Widespread
- ● = Localised
- ● = Confined and subject to quarantine
- ● = Occasional or few reports
- ● = Evidence of pathogen
- ● = Last reported
- ● = Presence unconfirmed
- ● = See regional map for distribution within the country

# Does Globalisation mean less Integrated Pest Management ?

**Data: CABI**

# Some trends

More programs all the time, “J” shaped but where is the tipping point ??

Usual suspects like FF showing range expansion, pest accumulation

New organisms emerging as invasive, adding complexity to systems

Options for future organic production lessening, more pesticides used

More incursions, raising awareness (SWD, BMSB in EU), too late ?

More controversy and desire for public transparency (“Nosebo Effect”)

Less Classical Biological Control ? Fear of non-target effects has risen

More theory (models) underpinning field attempts

# Future outlook – very challenging !

Globalisation  - Biogeography at Warp Speed

More invasive species incursions and **haywire** impacts with globalisation

New taxa but few good surveillance and eradication tools for most

Need for socially acceptable tools and optimal use patterns

More desperation - “hope” technologies

(MMD, Bug SIT, RNAi, Gene drive ?)

We’ve done it to ourselves, can we fix it in time?

The

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