ROTHAMSTED RESEARCH

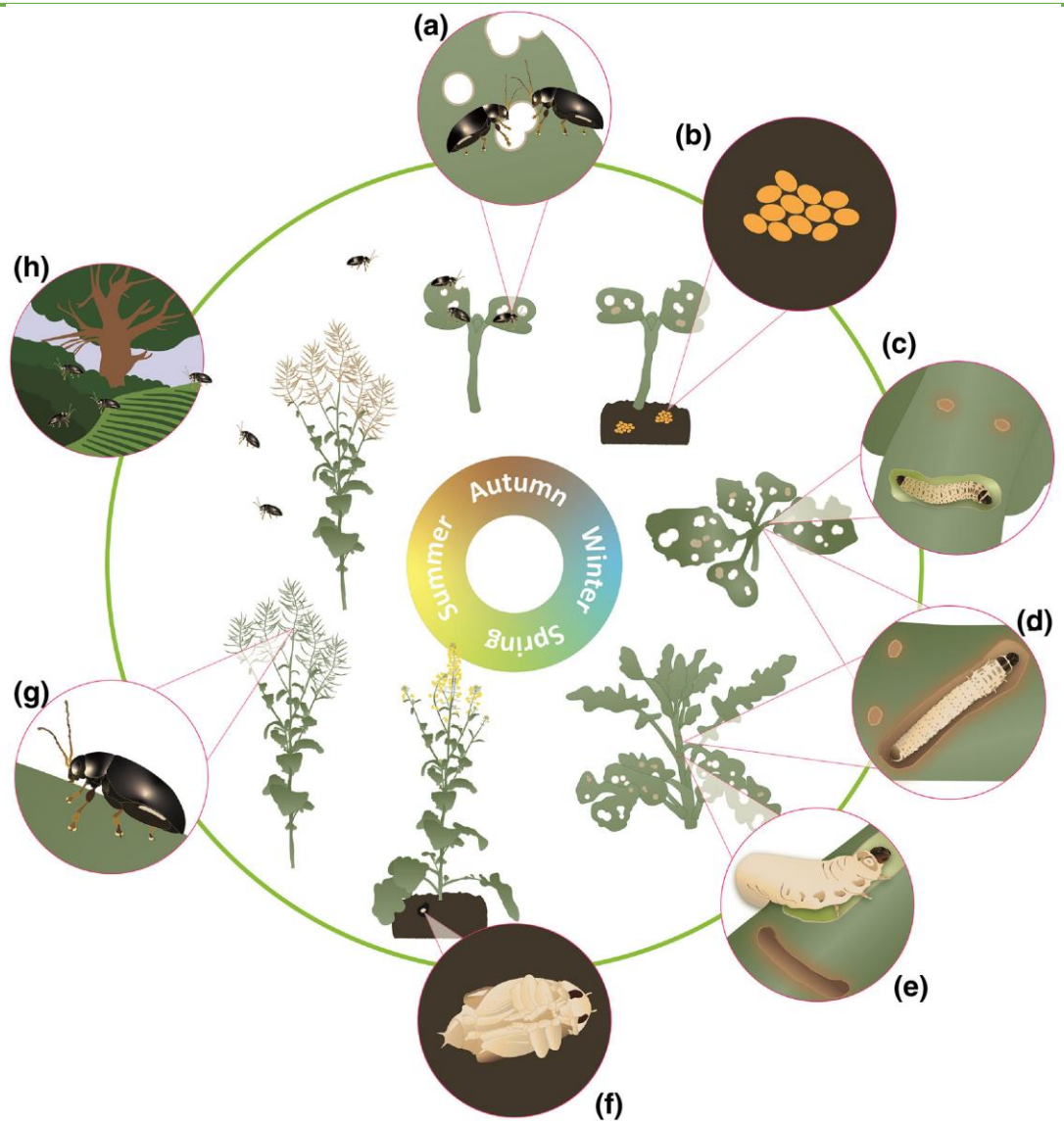
Integrated Pest Management Strategies for cabbage stem flea beetle

Sam Cook &

Patricia Ortega-Ramos

Cabbage Stem Flea Beetle (CSFB) *Psylliodes chrysocephala* Life cycle

ROTHAMSTED RESEARCH



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Ortega-Ramos, P. A., Coston, D. J., Seimandi-Corda, G., Mauchline, A. L., & Cook, S. M. (2021). *Global Change Biology Bioenergy*.

Cabbage Stem Flea Beetle (CSFB) *Psylliodes chrysocephala* "Two pests for the price of one"

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ROTHAMSTED RESEARCH

Adult feeding threatens crop establishment

Larval feeding weakens plant, damages growing point, increases susceptibility to disease

Cabbage Stem Flea Beetle (CSFB) *Psylliodes chrysocephala*
Huge damage potential of adult feeding!

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Seedgrowth.bayer.com

2014 c.5 % crop lost nationally; (70%) in East / South-East

- Pyrethroid resistance confirmed in Germany

  Zimmer et al., 2014 PBP 108:1-7

- Pyrethroid resistance in UK

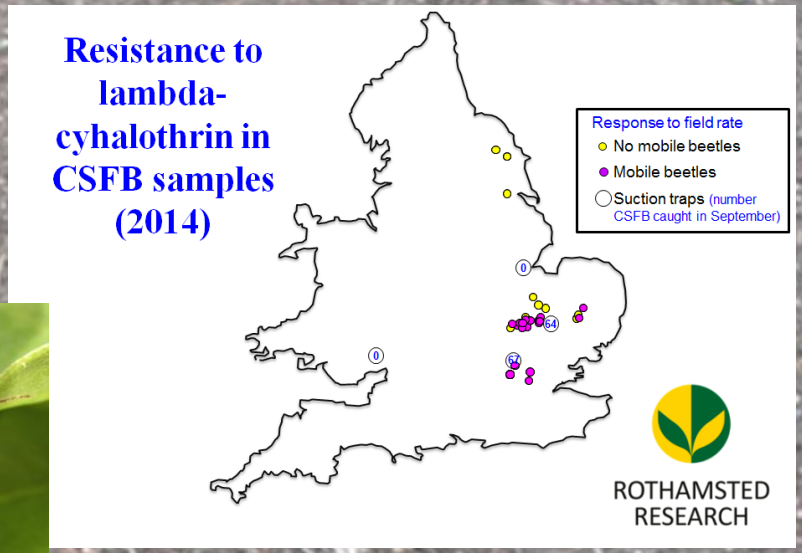
  Steve Foster et al - AHDB Project 214–0019


theguardian
Winner of the Pulitzer prize

Neonicotinoid ban hit UK farmers hard

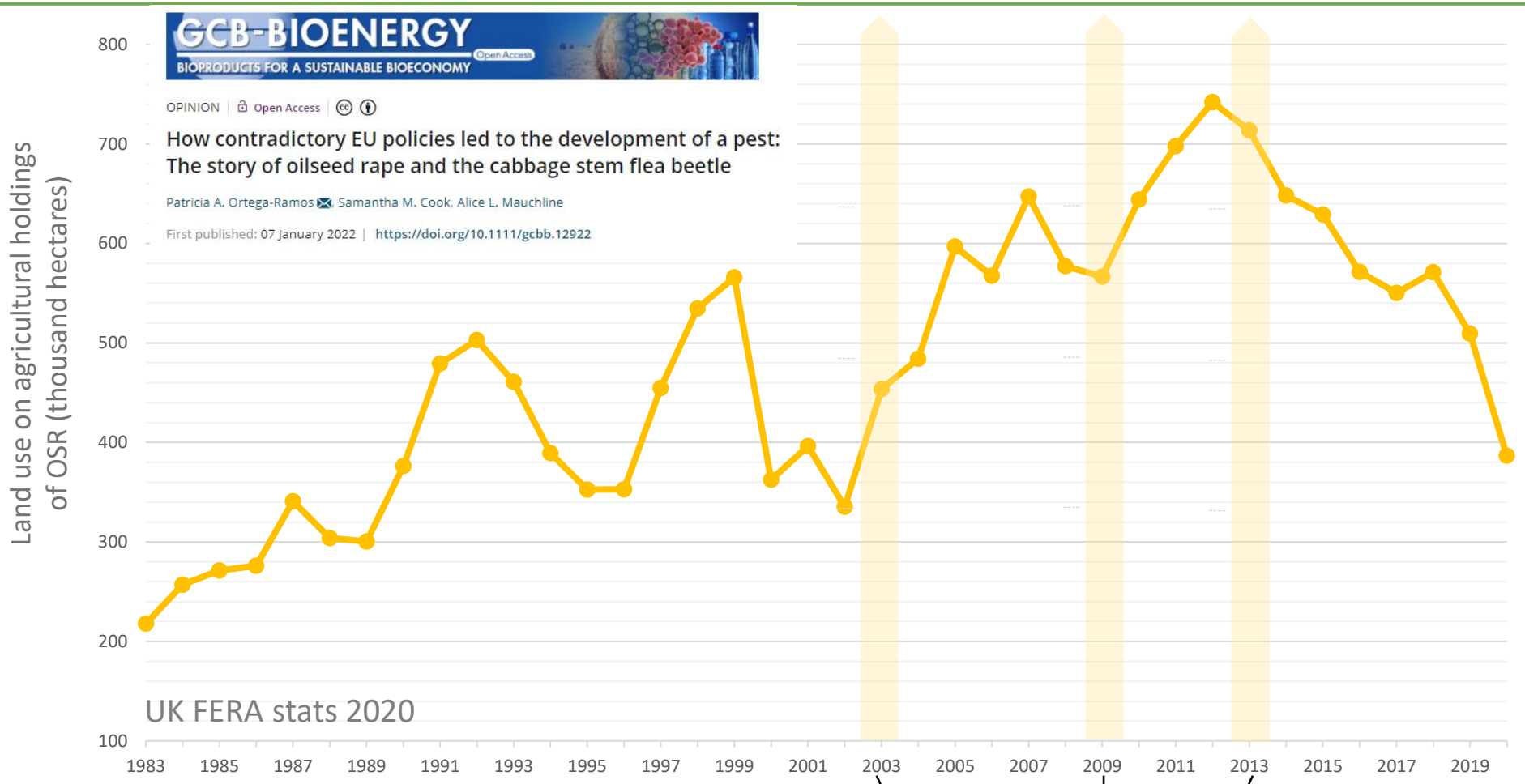
Bugs devour rapeseed crop in Britain as EU ban on pesticide to save bees comes into force

Leaves on a young shoot of rapeseed oil plant eaten by bugs. Photograph: Louise Gray



CSFB (and contradictory EU policies) -responsible for the decline in OSR cropping

ROTHAMSTED RESEARCH



GCB-BIOENERGY
BIOPRODUCTS FOR A SUSTAINABLE BIOECONOMY
Open Access

OPINION | Open Access

How contradictory EU policies led to the development of a pest: The story of oilseed rape and the cabbage stem flea beetle

Patricia A. Ortega-Ramos, Samantha M. Cook, Alice L. Mauchline

First published: 07 January 2022 | https://doi.org/10.1111/gcbb.12922

Directives
Biofuels policy (2003/03/EC)
Energy Taxation(2003/96/EC)

Directives
Renewable Energy (2009/28/EC)
Fuel Quality (2009/30/EC)
Sustainable Use of Pesticides package

Regulation
Neonicotinoid ban (2013/485)

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CSFB (and contradictory EU policies) -responsible for the decline in OSR cropping

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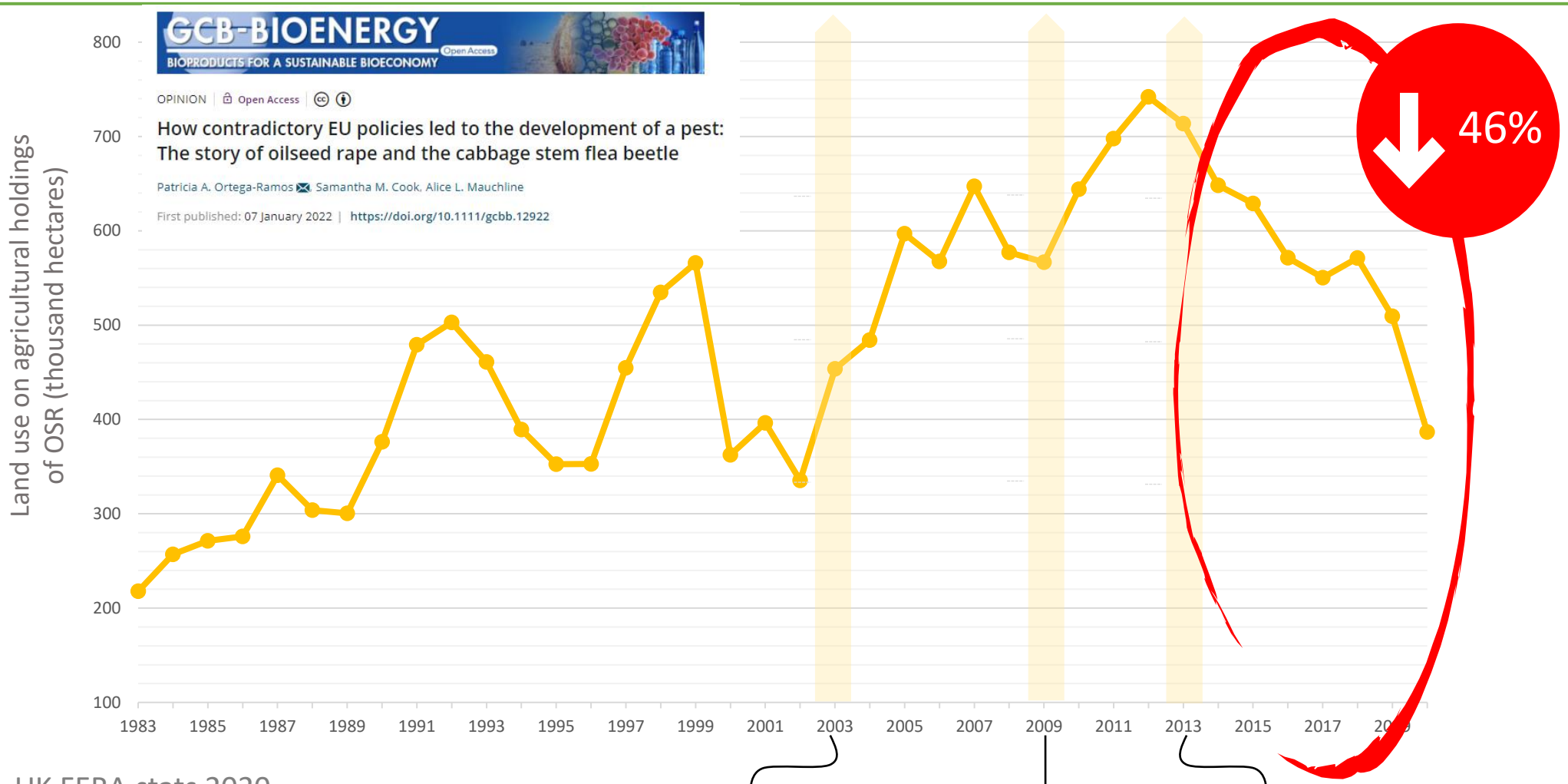

UK FERA stats 2020

Directives
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CSFB (and contradictory EU policies) -responsible for the decline in OSR cropping

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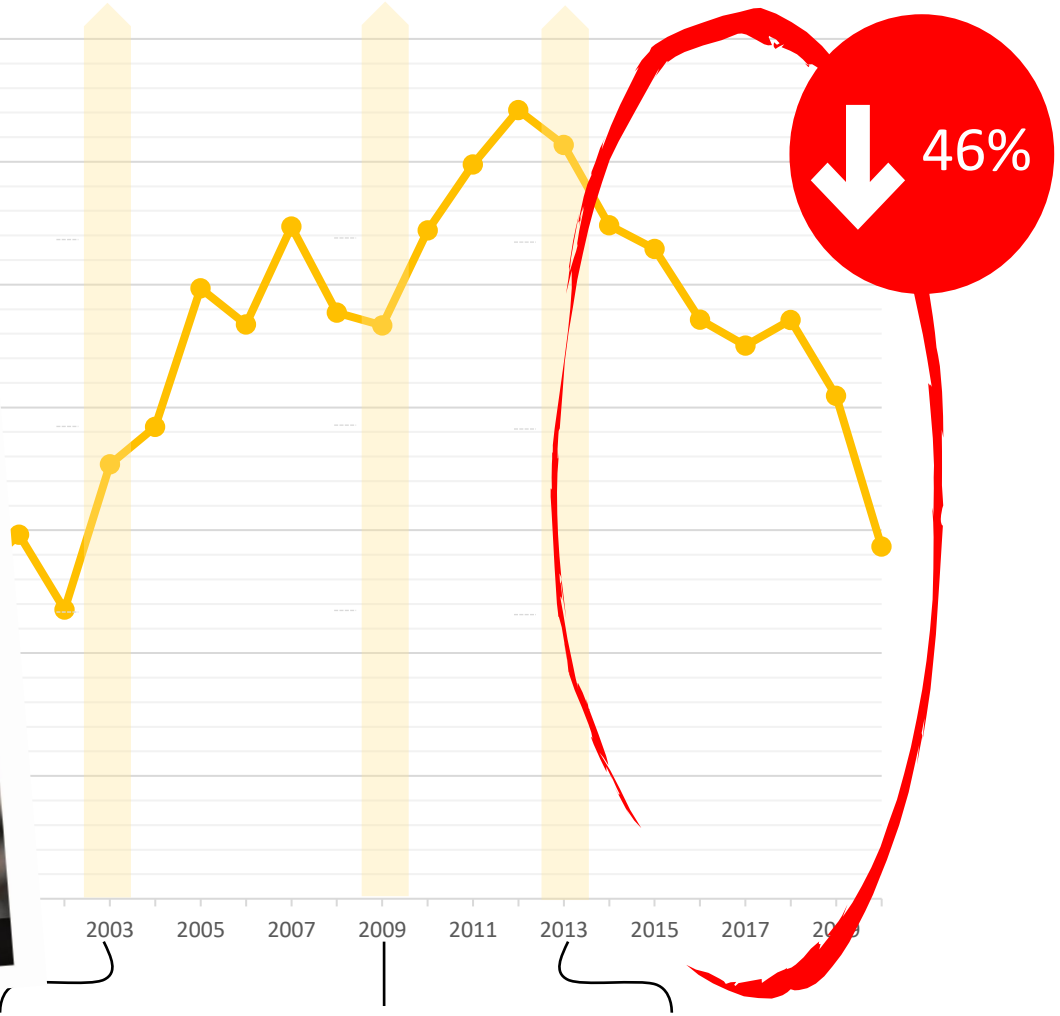
Flea beetle havoc leaves UK needing rapeseed imports



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Integrated Pest Management Strategies for CSFB

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- IPM is an environmentally sensitive approach to pest management that relies on a combination practices (*including the judicious use of pesticides*) using information on the life cycles of pests and their interaction with the environment

- 4 usual steps in IPM programmes:

1. **Set action threshold**
2. **Monitor pest density & Risk assessment**
3. **Prevention** – cultural methods e.g. crop rotation, use of pest-resistant cultivars; semiochemicals (e.g. pheromone repellents); habitat diversification (e.g. companion planting)
4. **Control** – population reduction via: mechanical methods (e.g. mass trapping), inundative biological control, conservation biocontrol & bio/botanical insecticides or synthetic pesticides *as a last resort*

Integrated Pest Management Strategies for CSFB

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ROTHAMSTED RESEARCH

- IPM is an environmentally sensitive approach to pest management that relies on a combination practices (*including the judicious use of pesticides*) using information on the life cycles of pests and their interaction with the environment

EPA United States Environmental Protection Agency

- 4 usual steps in IPM programmes:

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   planting)
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   biological control, conservation
   or synthetic pesticides *as a last*

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DOI: 10.1111/gcbb.12918

REVIEW ARTICLE

GCB-BIOENERGY

WILEY

Integrated pest management strategies for cabbage stem flea beetle (*Psylliodes chrysocephala*) in oilseed rape

Patricia A. Ortega-Ramos[1,2] | Duncan J. Coston[1,2] | Gaëtan Seimandi-Corda[1] | Alice L. Mauchline[2] | Samantha M. Cook[1]

1. Action thresholds

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Pest		UK threshold	
	CSFB	25% leaf area eaten	5 larvae /plant
		AHDB	av. 96 adults/ yellow water trap

Thresholds based on responses to insecticides – not physiological

University of Reading | ROTHAMSTED RESEARCH | Lawes Agricultural Trust

Coston et al (*in prep*)

- Testing OSR response to leaf area injury and infestation with CSFB:
- Year 1 examined simulated leaf area injury at various levels (0, **25%**, 50%, 90%)
- Year 2 combined simulated leaf area injury (0, **25%**, 90%) with controlled larval infection (0, 1, **5** or 25 / plant)

1. Action thresholds

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Coston et al (*in prep*)

- High leaf area injury (90% removal) did *not* impact the productivity of OSR

➡ more research needed to understand crop loss in field

- Responses seen when 25 CSFB larvae (but not <5) were introduced:

  - Plants were shorter, produced less flowers & pods with lower oil content than other treatments

➡ Larval threshold might be too low (?)… but between 5-25 larvae *are* damaging!

❗Use early-sowing strategies to avoid adult damage with caution as these increase time for egg laying and larval development❗

2. Monitoring - adults

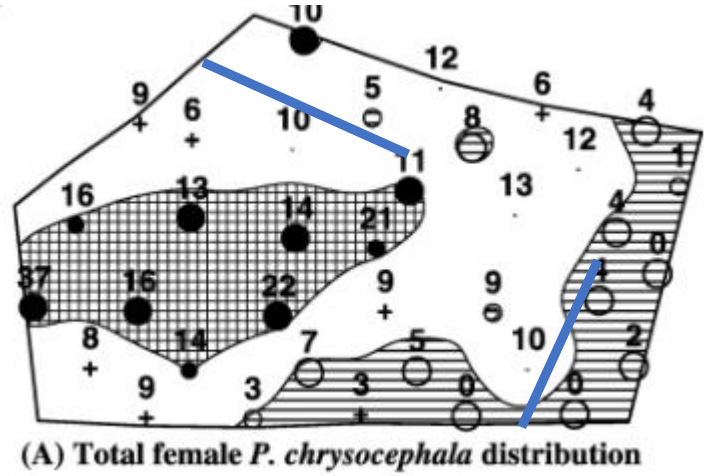
Pest	UK threshold
 CSFB	25% leaf area eaten

Physically demanding, time consuming

25%
Difficult to determine quickly (subjective)

- Assess % feeding damage to leaves from 25 plants in transect into crop

Future-proofing solution?


(A) Total female *P. chrysocephala* distribution

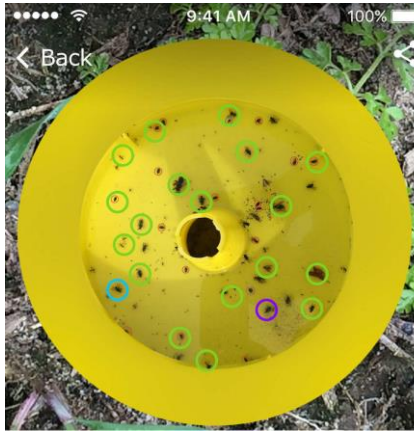
2. Monitoring - larvae

@SamCook_IPM

ROTHAMSTED RESEARCH

Pest		UK threshold	
	CSFB	25% leaf area eaten	5 larvae /plant
			av. 96 adults/ yellow water trap

- Count larvae in plant petioles and stems (from at least 25 plants /field) threshold = average 5/plant
- Run yellow water traps weekly from sowing to end October



Requires identification skills

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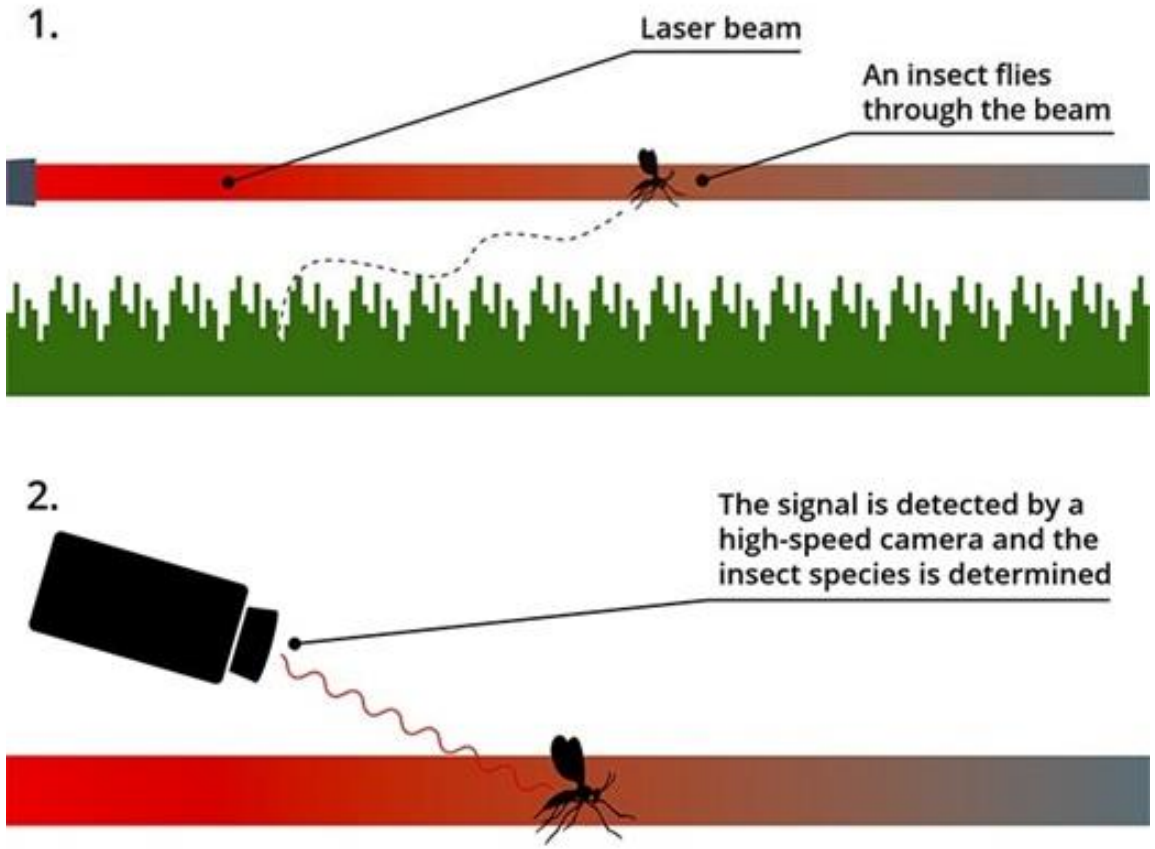
2. Monitoring

Potential of optical sensors for real-time monitoring of pest *and beneficial insects*



2. Monitoring

Potential of optical sensors for real-time monitoring of pest and beneficial insects

Create database library of traces for known species & machine learning for identification algorithms

Kirkeby, Rhydmer, Cook et al., (2021) Scientific Reports 11(1): 1555

CSFB main target; distinguish from *Phyllotreta*

80-95% accuracy

2. Monitoring

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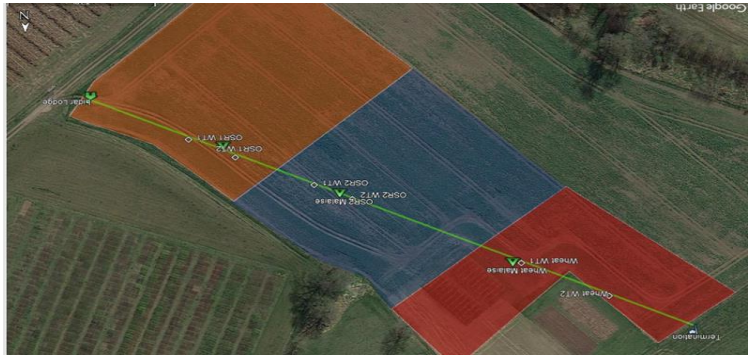
ROTHAMSTED RESEARCH

Potential of optical sensors for real-time monitoring of pest and beneficial insects

- Activity and abundance of insects detected by sensor and assigned to CSFB correlates with trap catches in the field



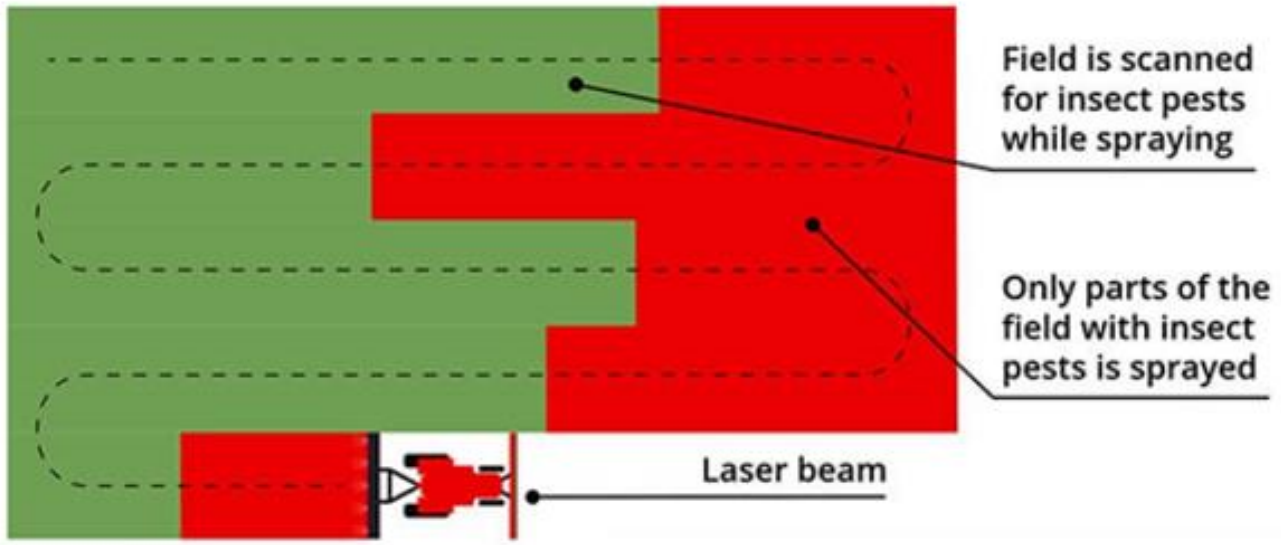
Cook *et al* in prep

ROTHAMSTED RESEARCH

2. Monitoring

Potential of optical sensors for real-time monitoring of pest and beneficial insects

Vision of the future: tractor mounted apparatus that sprays only areas where pests density exceeds threshold (& beneficial density is low)



Cook *et al* in prep

3. Prevention

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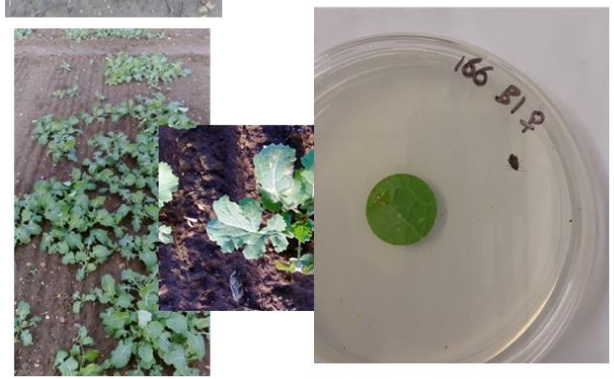
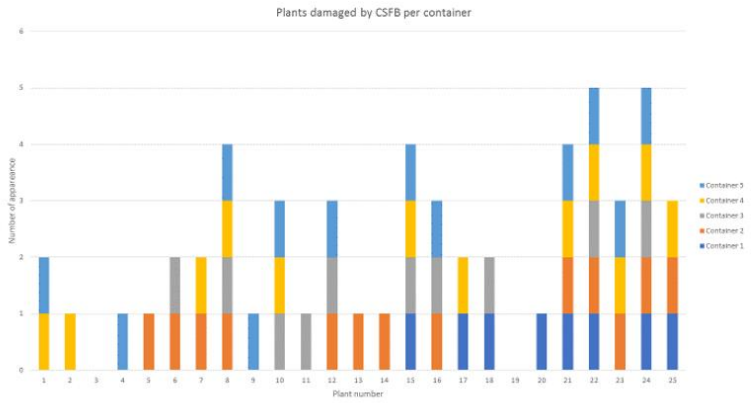
CSFB resistant cultivars

Variation in feeding responses observed in studies at RRes

OREGIN (Oilseed Rape Genetic Improvement Network)

- Field assessments of diversity sets
- Assessing effects of sucrose and metabolites on feeding





Breeding for Resistance to cabbage stem flea beetle BR2CSFB

UKRI Biotechnology and Biological Sciences Research Council

John Innes Centre

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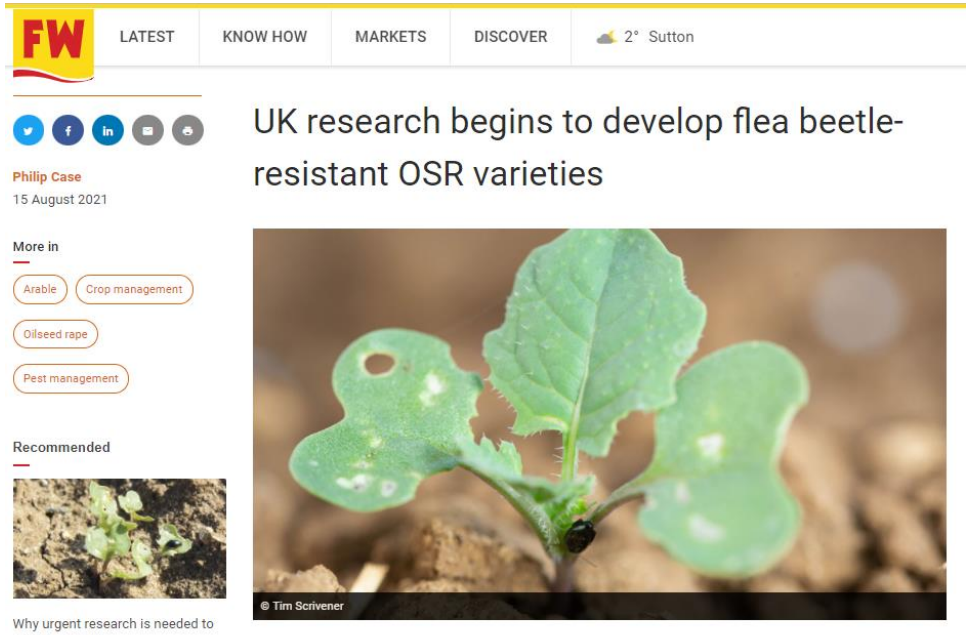

FW LATEST KNOW HOW MARKETS DISCOVER 2° Sutton

Philip Case
15 August 2021

More in

Arable | Crop management | Oilseed rape | Pest management

Recommended

Why urgent research is needed to fight flea beetles

UK research begins to develop flea beetle-resistant OSR varieties

© Tim Scrivener

Research teams in the UK have received significant funding to develop new varieties of oilseed rape which are resistant to cabbage stem flea beetle (CSFB).

Scientists from the John Innes Centre (JIC) and Rothamsted Research will work together with seven crop breeding companies as part of the project which aims to find solutions to one of the most significant crop pests, which can devastate OSR crops.

It is thanks to a £1.8m cash injection from a Biotechnology and Biological Sciences Research Council (BBSRC) partnership award.

3. Prevention

Companion planting **= the cultivation of different types of plants in close proximity so as to benefit each other**

- Companion planting methods include e.g. intercropping, trap cropping, undersowing etc.

3. Prevention

Companion planting: Trap cropping

Trap crops = plants more attractive than the main crop used to divert pest pressure away from the crop

2005: Turnip rape trap crop borders significantly reduced no. CSFB larvae in OSR vs controls

Barari, Cook, Clark & Williams (2005) BioConrol 50: 69-86

2015-16: Turnip rape trap borders borders significantly reduced CSFB feeding in OSR vs controls

Coston (2020) PhD ; Coston et al., *in prep*

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3. Prevention

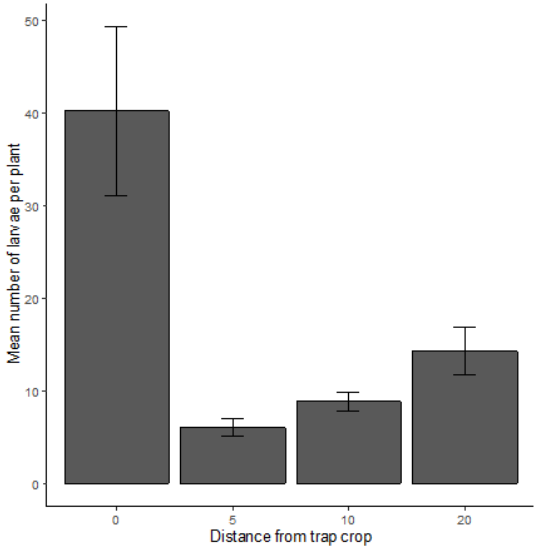
Companion planting: Trap cropping

2005: Turnip rape trap crop borders significantly reduced no. CSFB larvae in OSR vs controls

Barari, Cook, Clark & Williams (2005) BioConrol 50: 69-86

2015-16: Turnip rape trap borders borders significantly reduced CSFB feeding in OSR vs controls

2021-22 Turnip rape trap crop in-field strips significantly reduced CSFB larvae



Grant Agreement no. 773554

3. Prevention

Companion planting: undersown ‘nurse’ plants

nurse crop: a crop planted with another to shelter it from competition with weeds *(&/or pests*)

- Undersowing with mixed brassicas/white mustard in Clearfield OSR strategy reduces feeding and larval infestation BUT timing of companion removal difficult

Coston (2020) PhD ; Coston et al., *in prep*

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Duncan Coston

3. Prevention

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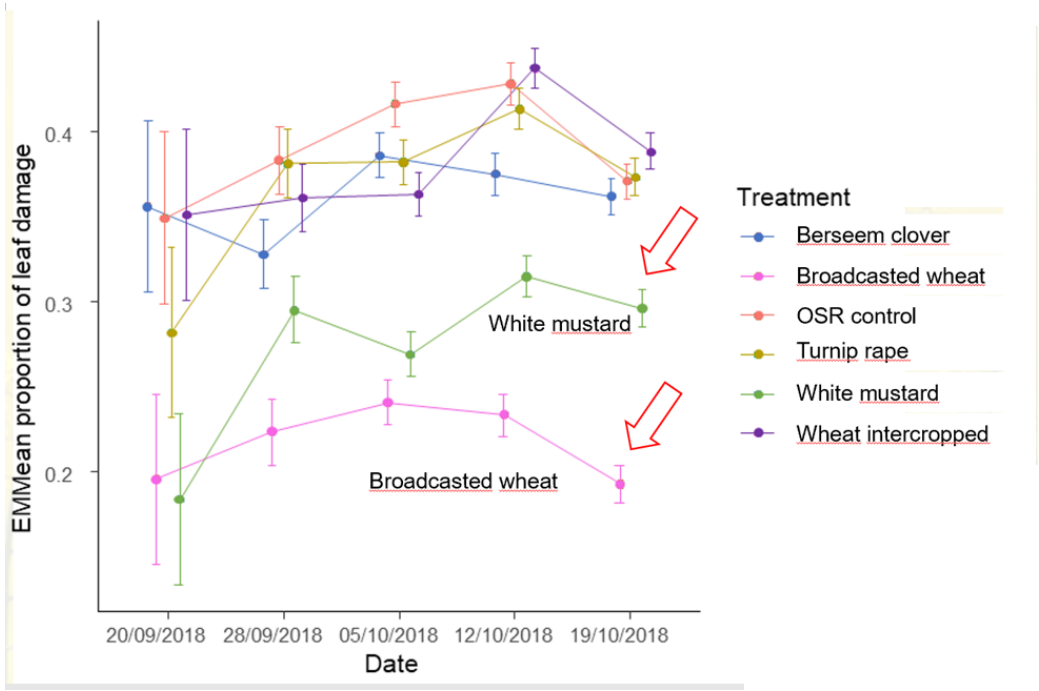
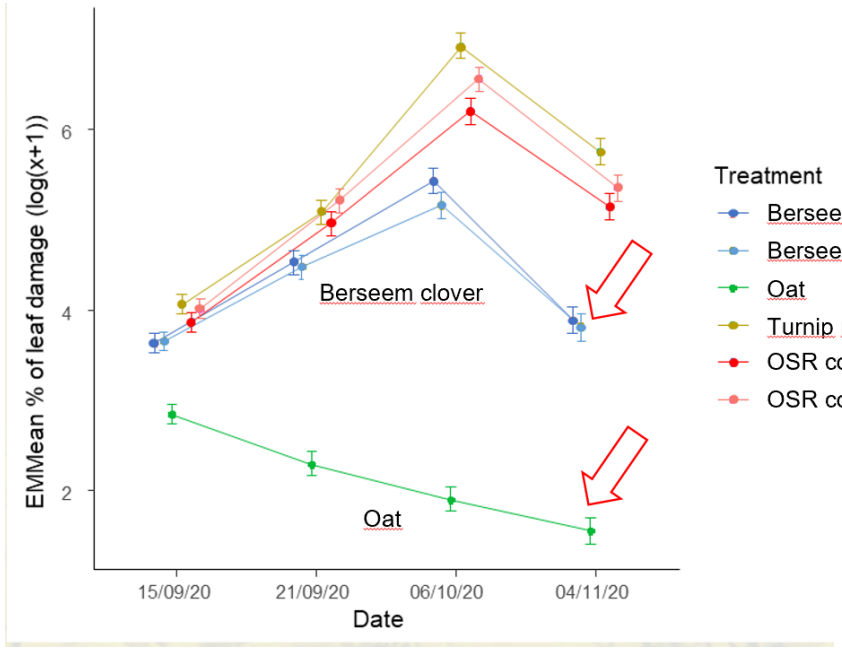
Companion planting: undersown ‘nurse’ plants

- Undersowing with mixed brassicas/white mustard in Clearfield OSR strategy reduces feeding and larval infestation BUT timing of companion removal difficult

- Undersowing with berseem clover, wheat/oats reduces adult damage and larval infestation (inconsistent – WHY?)





Gaëtan Seimandi-Corda

EcoStock

3. Prevention

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- **Longer rotations**
- **Minimum tillage**
- **Long stubble**
- **Organic matter / fertilizer**

- Plants with more biomass (larger more leaves) more able to cope with larval infestation

Addition of organic matter / biodigestate (Cross Farm, Harpenden 2020)

EcoStack
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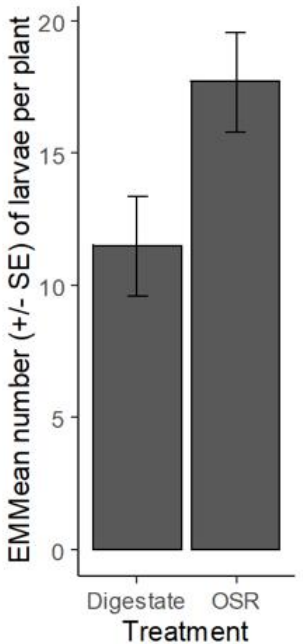

4. Control

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New insecticides

Promising new approaches e.g. post-transcriptional gene silencing via RNA interference (RNAi), which prevents the manufacture of key proteins in insects, leading to death when ingested


MINI REVIEW article
Front. Agron., 10 December 2021 | https://doi.org/10.3389/fagro.2021.794312

RNAi Targets in Agricultural Pest Insects: Advancements, Knowledge Gaps, and IPM

Jonathan Willow[1,2*], Clauvis Nji Tizi Taning[2], Samantha M. Cook[3], Silva Sulg[1], Ana I. Silva[4], Guy Smagghe[2] and Eve Veromann[1]

https://www.frontiersin.org/articles/10.3389/fagro.2021.794312/full

Biopesticides

entomopathogenic fungi → *Metarhizium anisopliae* and *Beauveria bassiana*

entomopathogenic nematodes → *Steinernema feltiae* tested along with *Heterorhabditis bacteriophora*

4. Control

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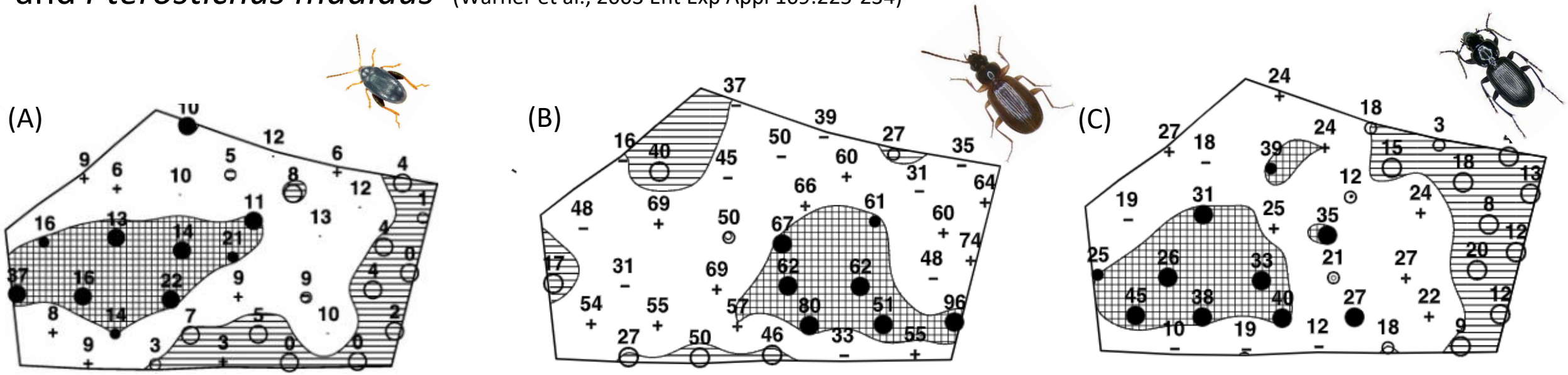
ROTHAMSTED RESEARCH

Conservation Biological Control = Use of **agronomy** & **habitat management** methods to conserve the natural enemies of crop pests in the agri-environment to provide pest regulation

Predators

Carabid (ground) beetles: Spatial association & biocontrol potential of *Trechus quadristriatus* and *Pterostichus madidus* (Warner et al., 2003 Ent Exp Appl 109:225-234)



(A) Total female *P. chrysocephala* (B) *T. quadristriatus*, and (A) *P. madidus* distributions. Posted symbols and number indicate sampling position and the number of beetles trapped in the pitfall trap at each sample location, respectively.

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ROTHAMSTED RESEARCH

Conservation Biological Control = Use of **agronomy** & **habitat management** methods to conserve the natural enemies of crop pests in the agri-environment to provide pest regulation

Predators

EcoStack project (2020 – 2023)

- Role of predators in pest regulation
- Effect of companion crops
- Comparison of pitfall and camera trapping in the UK and Denmark

AARHUS UNIVERSITY
EcoStack
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Grant Agreement no. 773554

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Parasitoids

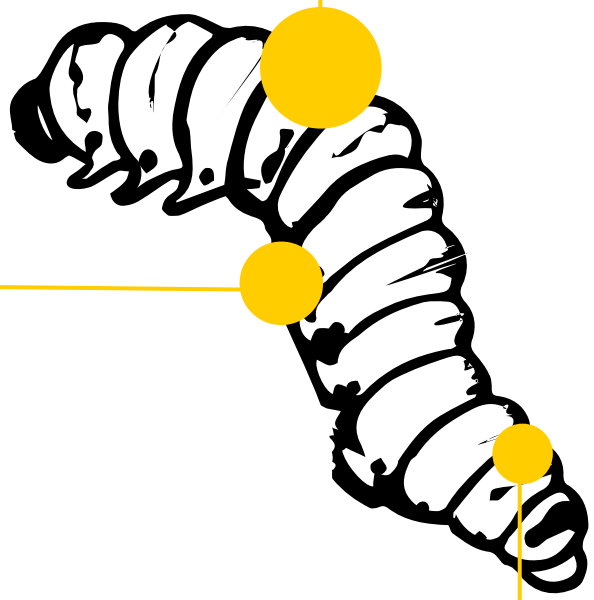
Misidentification!

Tersilochus tripartitus

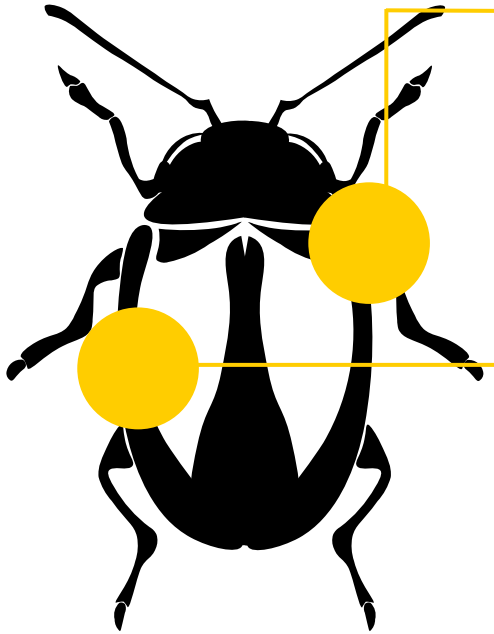
60% parasitization rate
(Aubert et al., 1958)

Tersilochus microgaster

7.7% parasitization (Barari et al., 2005)



Others



Microctonus melanopus

Low incidence
(Jourdheuil, 1960)

Microctonus brassicae

First reared from CSFB in Rothamsted 1996
(Ferguson)

fera The Food and Environment Research Agency

University of Reading

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Parasitoids (attacking CSFB larvae)

Determining **parasitism rates** and **distribution** using nested tagging DNA metabarcoding

Up to **33% parasitisation rate** detected

Tersilochus microgaster sequence detected

Newcastle University

fera The Food and Environment Research Agency

University of Reading

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Parasitoids (attacking adult CSFB)

Microctonus brassicae

first reared from CSFB adults in 1996
by A.W. Ferguson at RRes

First described in: Jordan et al (2020) Ent. Exp Appl 168:360-370

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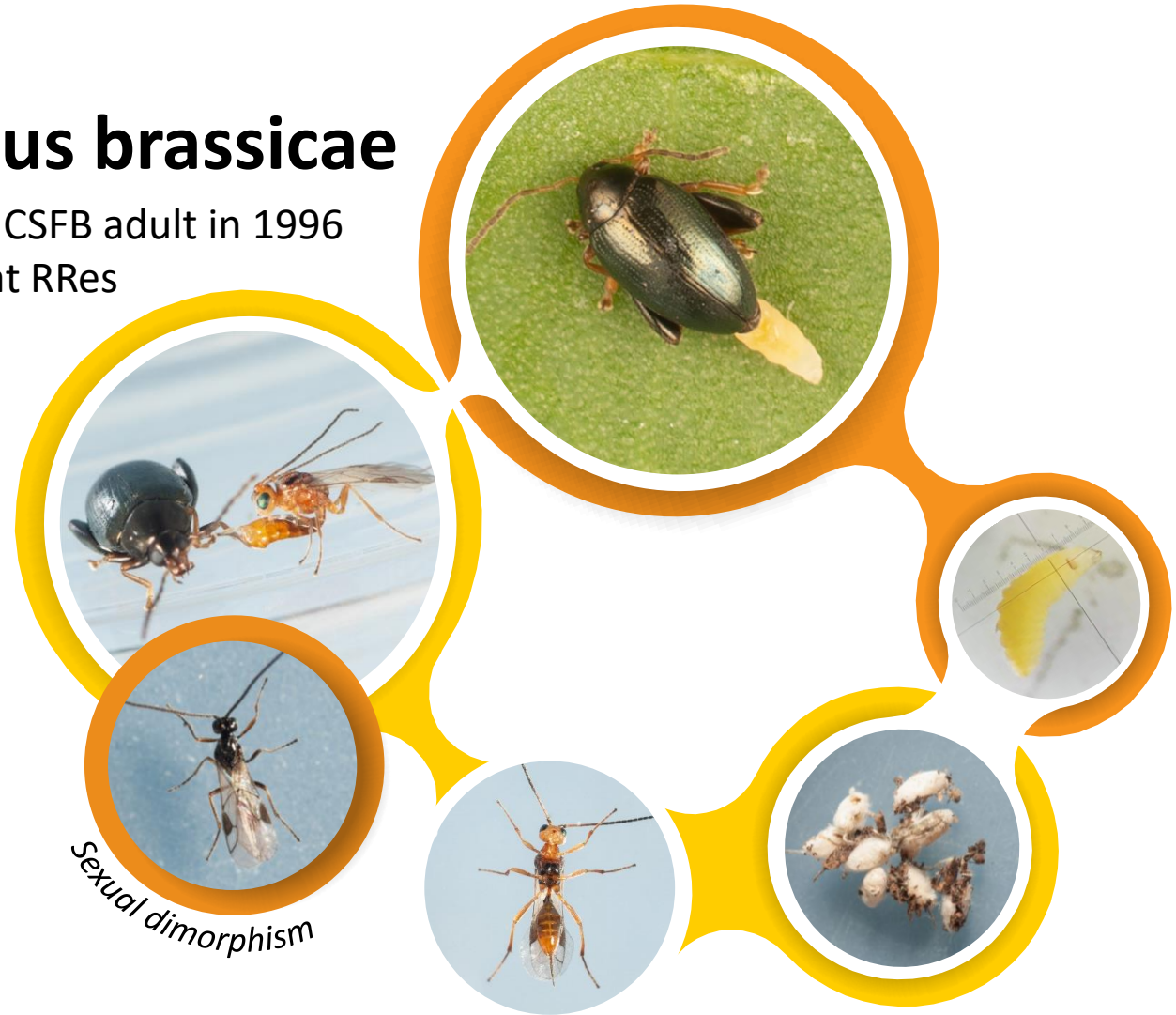

First described in: Jordan et al (2020) Ent. Exp Appl 168:360-370

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ROTHAMSTED RESEARCH

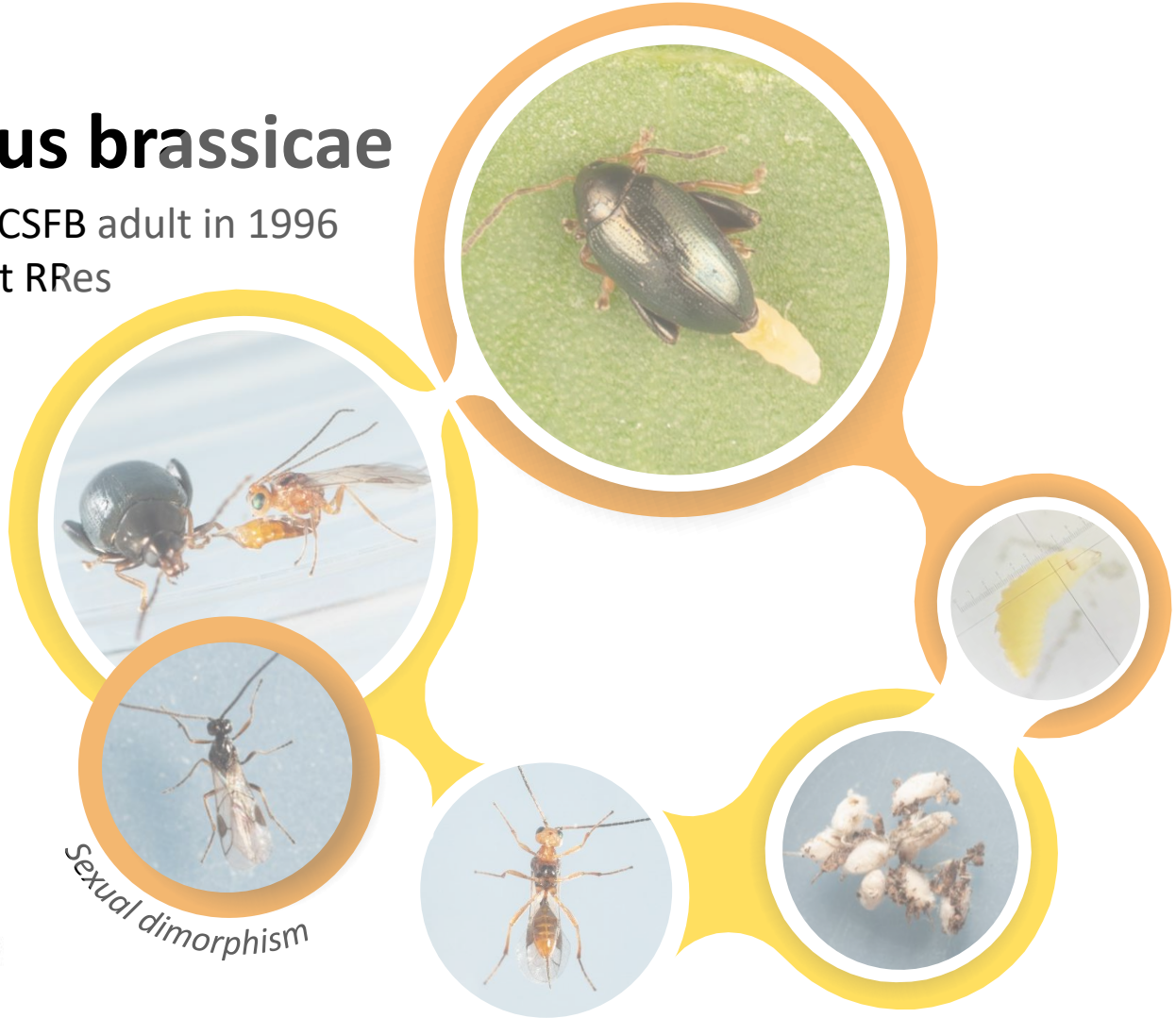
Parasitoids (attacking adult CSFB)

Microctonus brassicae

first reared from a CSFB adult in 1996 by A.W. Ferguson at RRes

Present in **96% of the fields studied**

Maximun parasitization rate 36%



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4. Control

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ROTHAMSTED RESEARCH

How can we support CSFB natural enemy populations?

Soil management

Both adult and larval parasitoids pupate in the soil; minimum tillage can improve survival

Field margins

Provision of uncultivated habitat & pollen/nectar resources?

Pesticide use

Susceptible to pyrethroids – spray only when necessary!

assist
EcoStack
Grant Agreement no. 773554

4. Control

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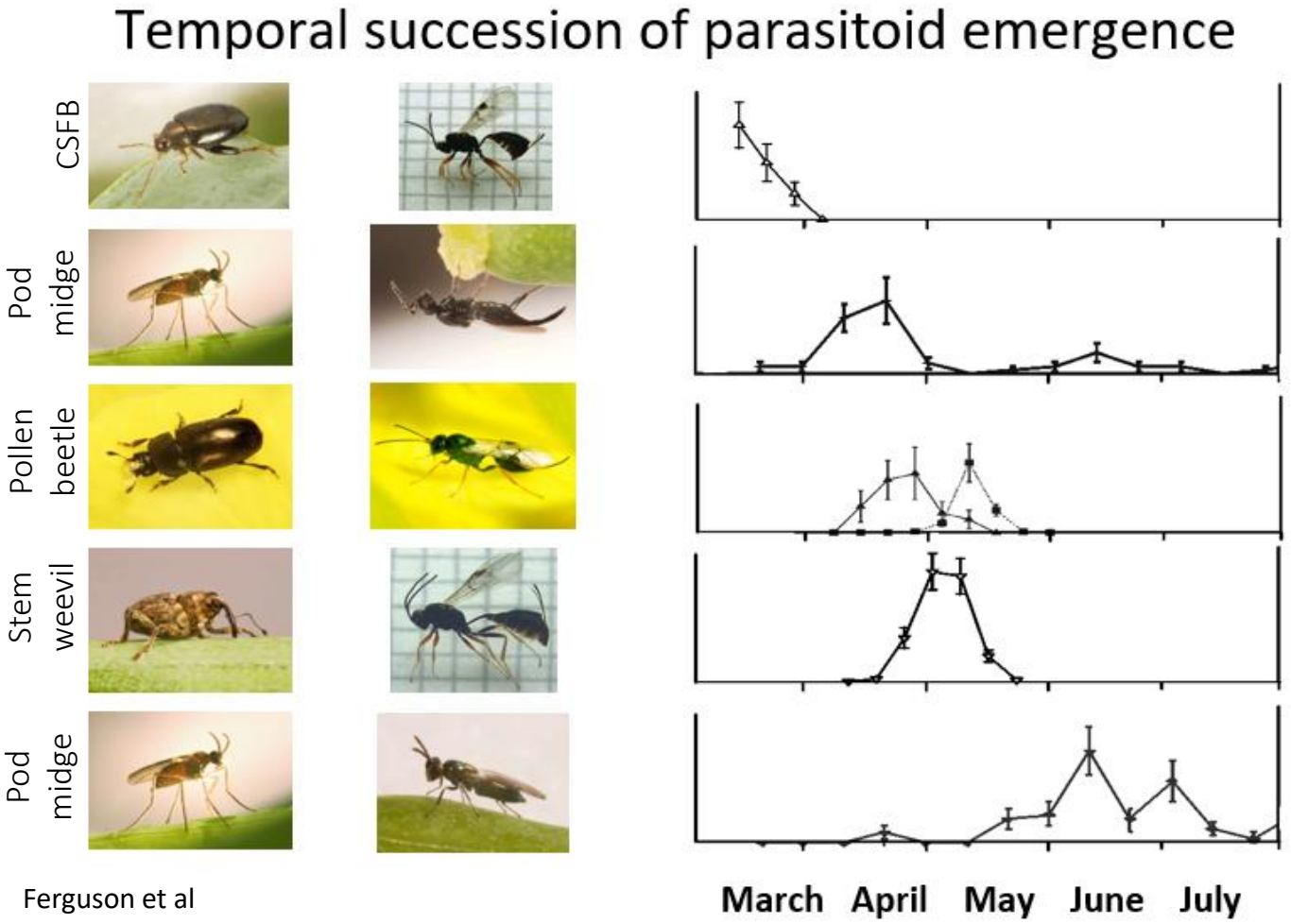
ROTHAMSTED RESEARCH

How can we support CSFB natural enemy populations?



Ferguson et al

Pesticide use

Susceptible to pyrethroids – spray only when necessary!

assist
EcoStack
Grant Agreement no. 773554

Summary of IPM strategies for CSFB

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@SamCook_IPM

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1. Set action threshold

Action thresholds must be **based on scientific studies**, consider the variation in **crop tolerance**, control efficacy, **insecticide cost, crop value** and presence and abundance of **natural enemies**.

3. Prevention – cultural methods

Further work is required to understand the trade-offs between **crop establishment** and larval damage and adult migration; effect of **stubble length**; the efficacy of **nurse and trap crop species**.

Sensor-based **automatic identification** of adults **in real time** Identification, synthesis of **attractant semiochemicals** could improve monitoring efficacy.

2. Monitor pest density & risk assessment

No information on the natural enemies' **distribution, control potential and impacts** of landscape and management factors. Few or **no effective synthetic insecticides available**.

4. Control methods

Moving forward into IPM

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@SamCook_IPM

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In a future where fewer synthetic insecticides will be available and their use less profitable…

IPM strategies will be vital to providing a framework for sustainable pest management

There is a need for further research to produce the scientific advances necessary for the development and commercialization of tools and techniques needed to make IPM a reality.

Also, to facilitate the successful adoption of IPM techniques, farmers need to be incentivized to adopt IPM - farmers' needs should be better considered.

Thank you for listening!

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