



Xylella fastidiosa

5th European conference

Bari, Italy | 22-26 June 2026

BEXYL: Illustrating strategic approaches for entomopathogenic fungi-based *Xylella fastidiosa* vector management

Prof. Enrique Quesada-Moraga

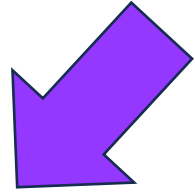
Department of Agronomy, Maria de Maetzu Excellence Unit DAUCO, ETSIAM,
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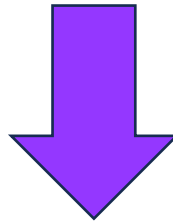
REGIONE PUGLIA



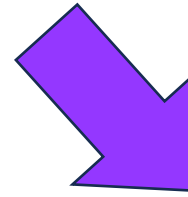
Why entomopathogenic fungi are a strategic biocontrol tool for managing the vector and the infection of *Xylella fastidiosa* on olive trees?



Mode of action of the
entomopathogenic
ascomycetes



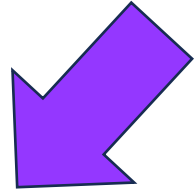
Role of
entomopathogenic
ascomycetes



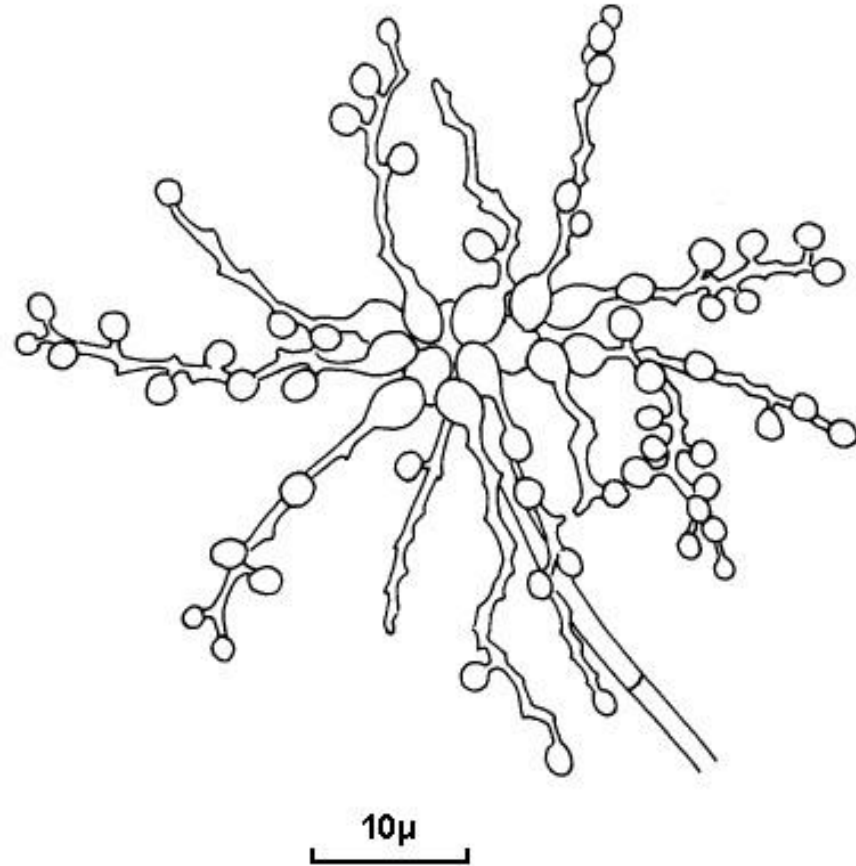
Natural presence and
distribution



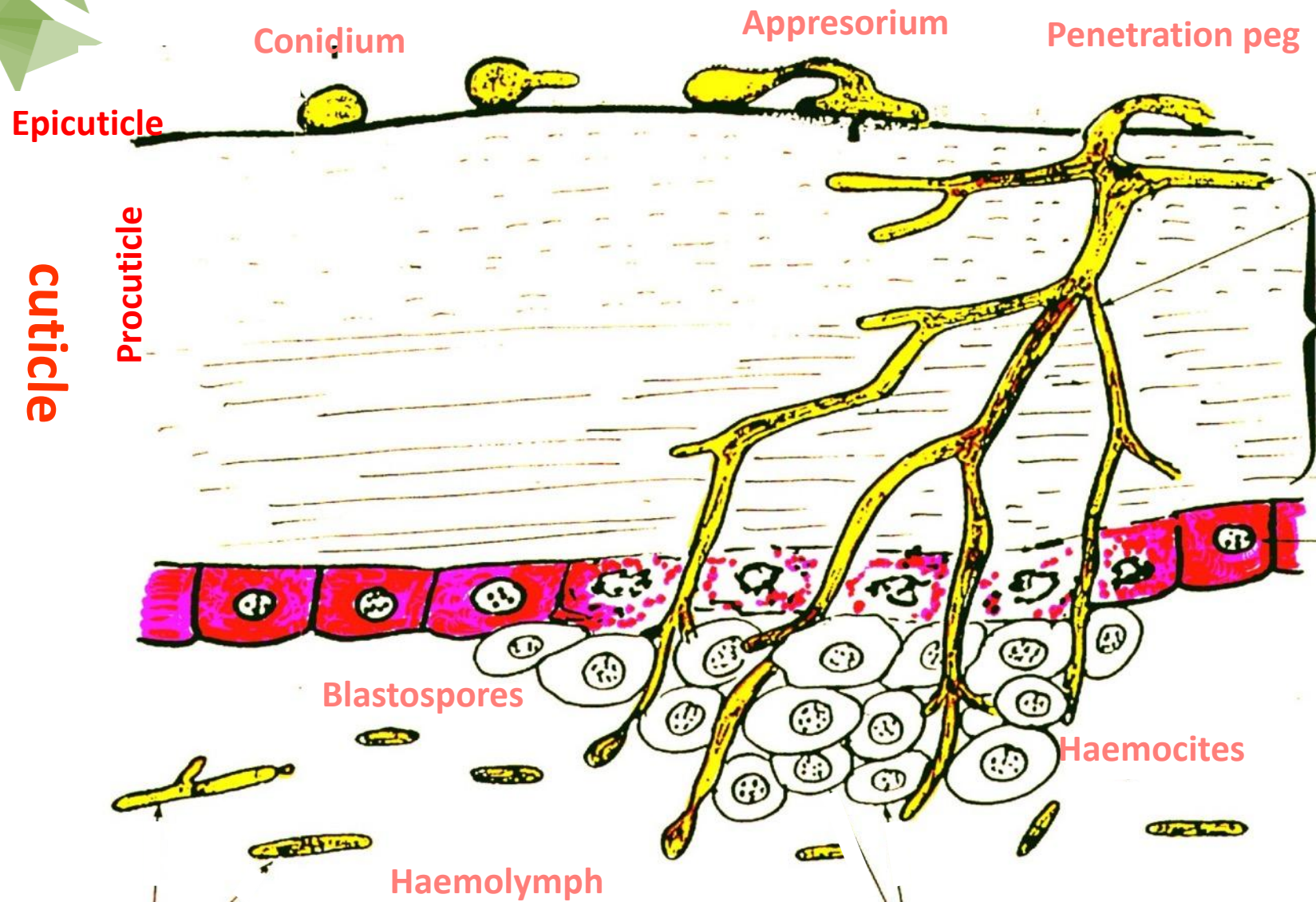
Why entomopathogenic fungi are a strategic biocontrol tool for managing the vector and the infection of *Xylella fastidiosa* on olive trees



Mode of action of the
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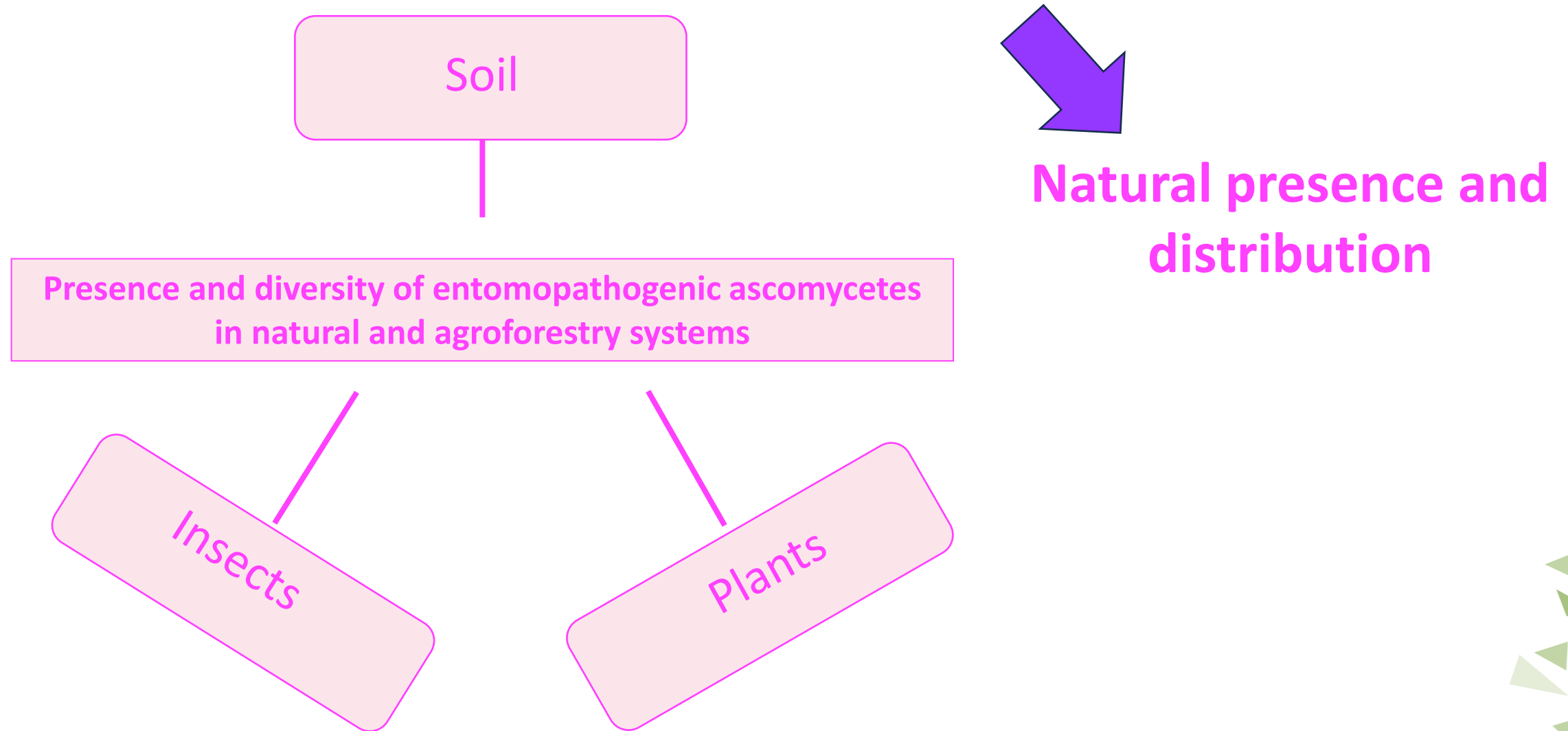
Mode of action of an entomopathogenic ascomycete



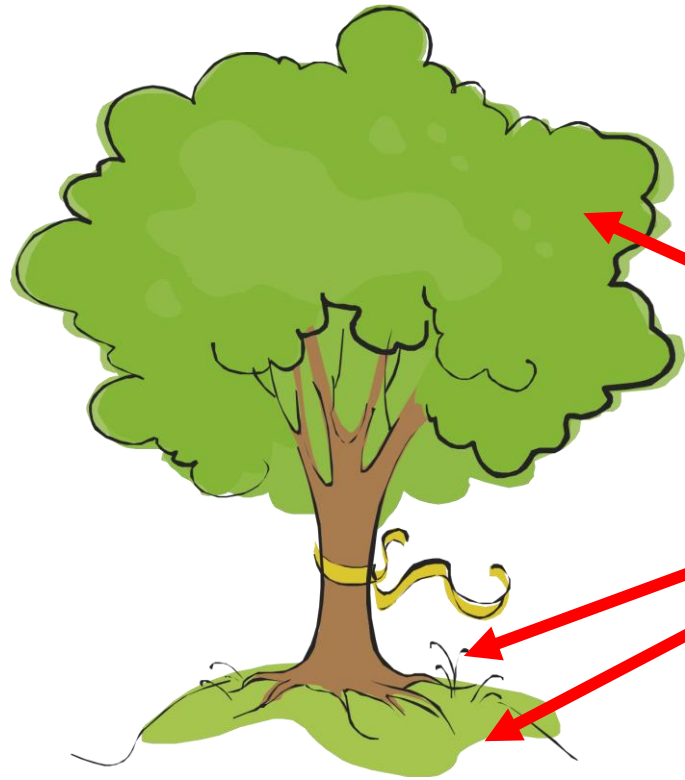
Mode of action by contact unique
among entomopathogenic
microorganisms



Why entomopathogenic fungi are a strategic biocontrol tool for managing the vector and the infection of *Xylella fastidiosa* on olive trees



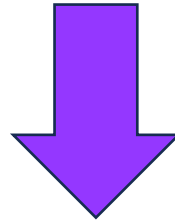
Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees



Selection of fungal strains from olive soils, from olive leaves and from leaves of natural olive covers



Why entomopathogenic fungi are a strategic biocontrol tool for managing the vector and the infection of *Xylella fastidiosa* on olive trees



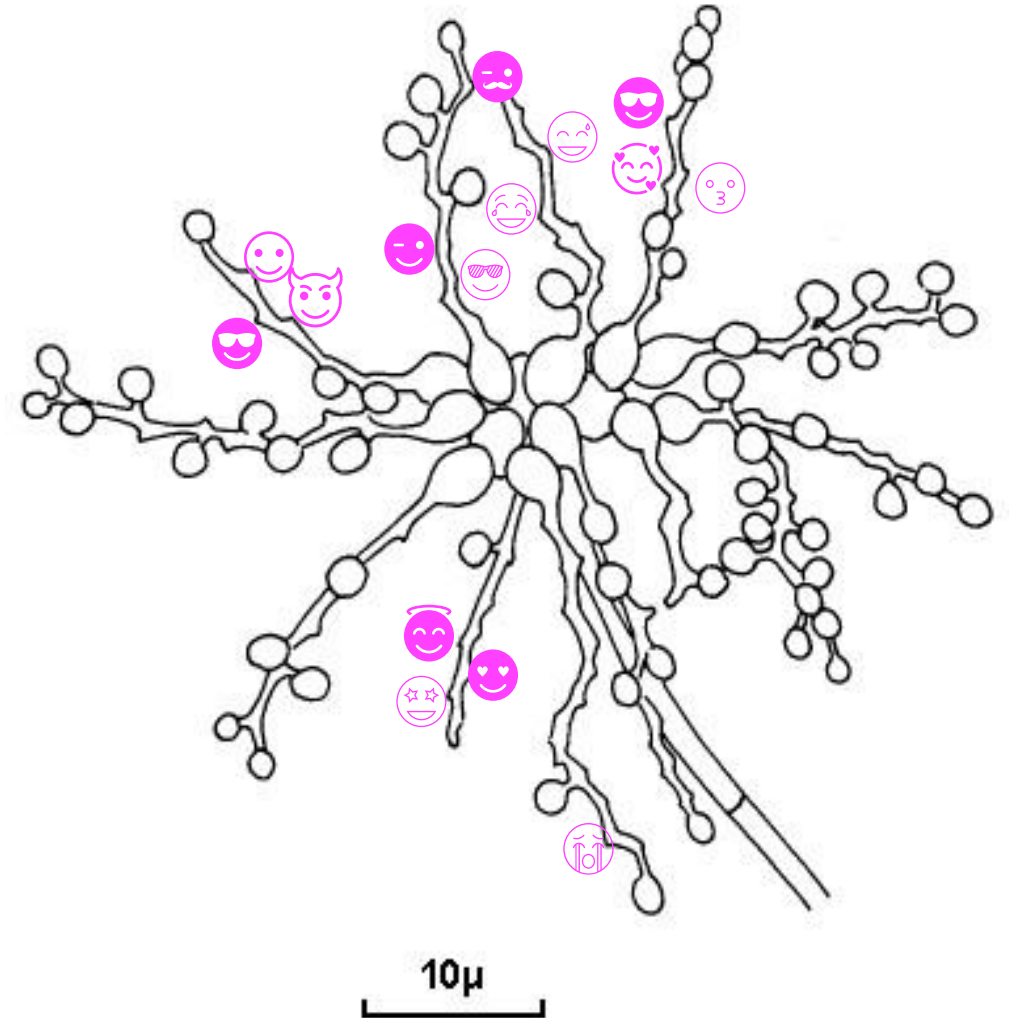
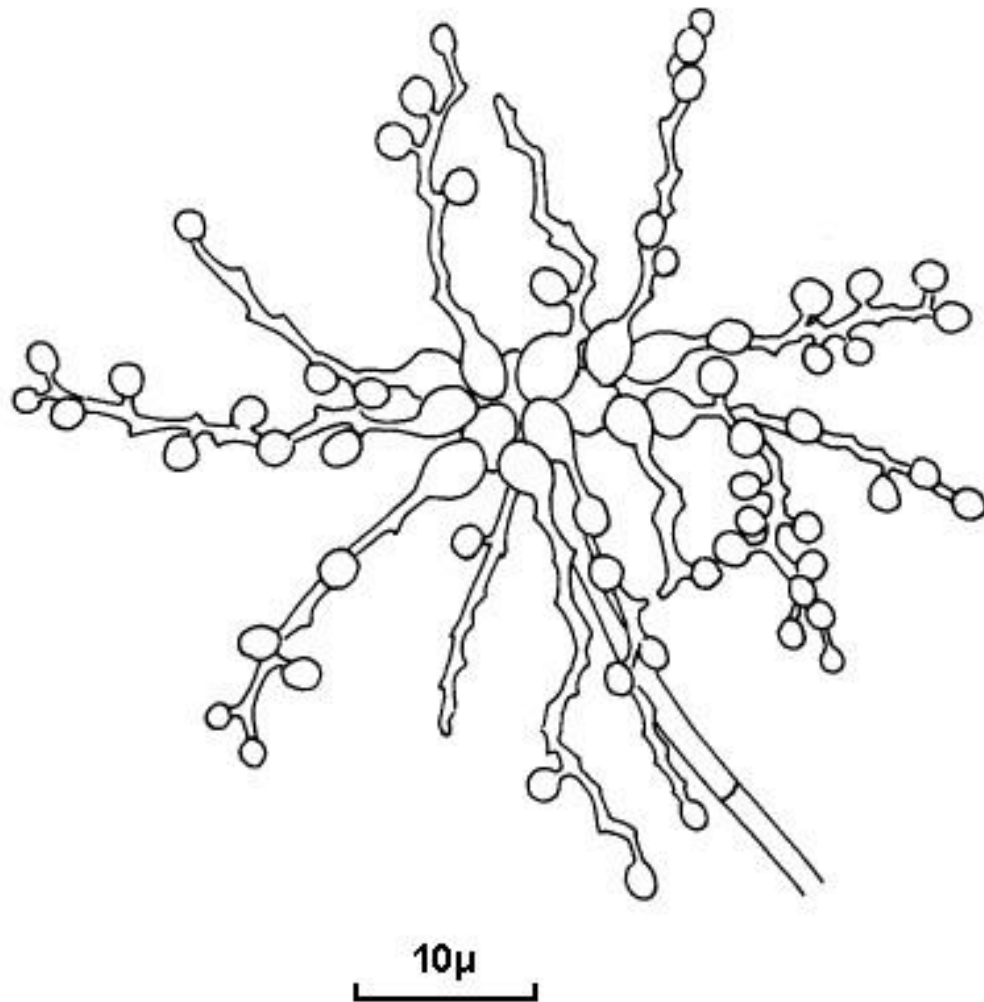
Role of
entomopathogenic
ascomycetes



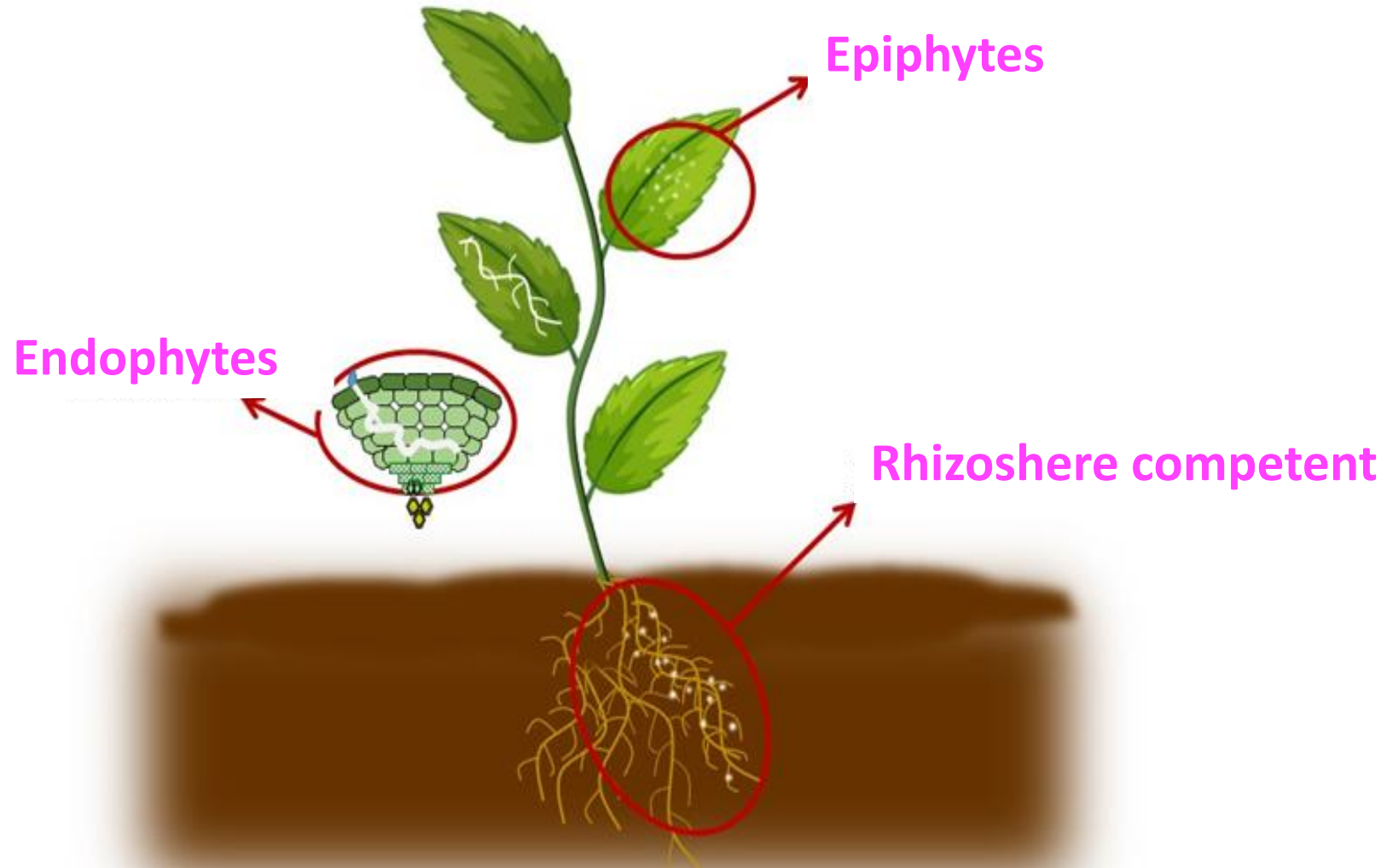
Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

From origin to 2000: entomopathogens

From 2000 to present: multipurpose



Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees



Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

1

Direct spray over the specimens
(nymphs and adults)

Insect vector
☐ Mortality
☐ Feeding behavior

Xylella
transmission



2

Effect of endophytic colonization
(nymphs, adults and *Xylella*)

Insect vector

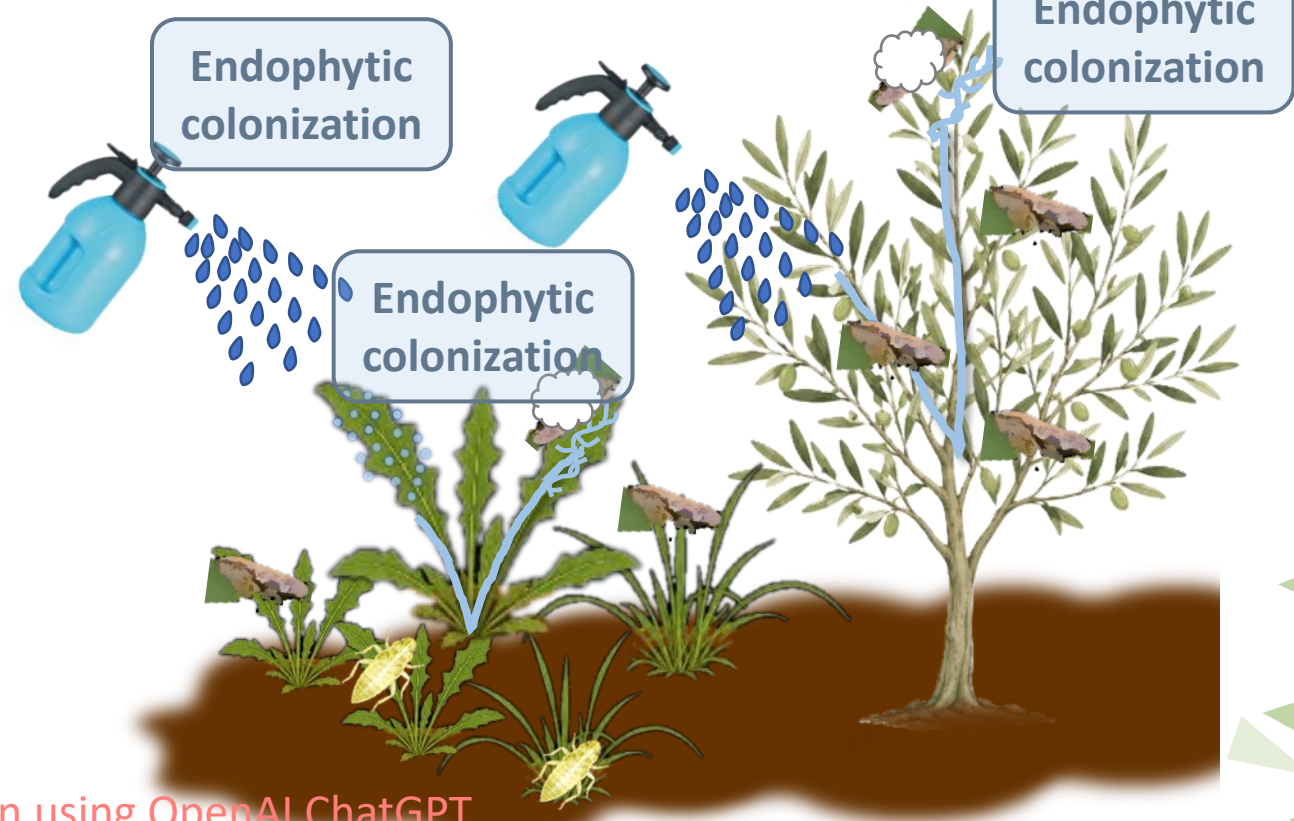
☐ Mortality
☐ Feeding behavior

Xylella
transmission

Endophytic
colonization

Endophytic
colonization

Endophytic
colonization



Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

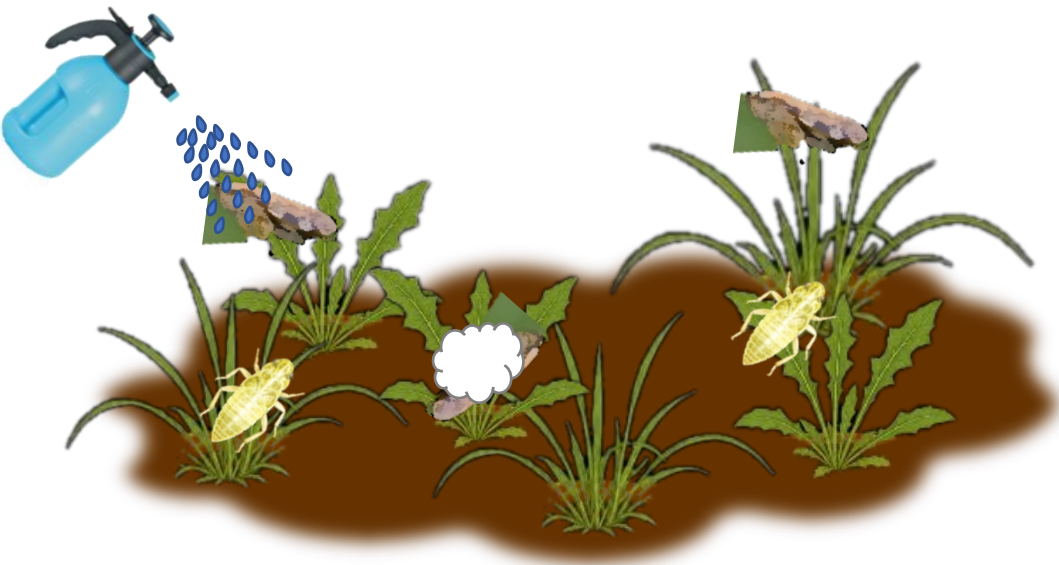
1

Direct spray over the
specimens
(nymphs and adults)

Insect vector

☐ Mortality

Direct adult and nymph control



Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees



EAMa 01/58-Su



EAMb 09/01-Su



EAMa 10/01 - Fil



EAMa 09/01 - Su



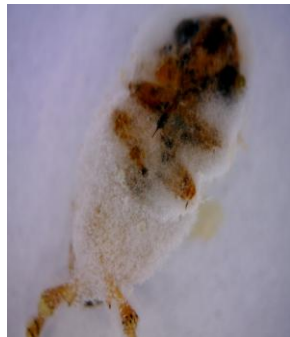
EALx 09/01 - Su



EABb 10/19 - Fil



EABb 10/20 - Fil



EABb 04/01- Tip



EABb 08/04 -Ep

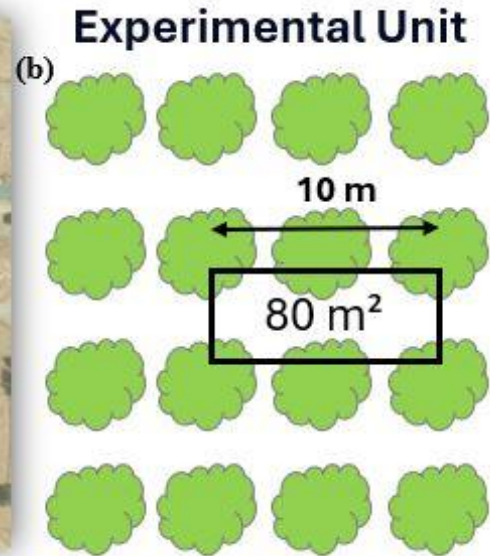
Fungal outgrowth of different EF strains from *P. spumarius* adult cadavers



iii Strain obtained from the phylloplane of an olive cover crop plant iii

Strategic options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes

Effect of cover crop spraying with EAMa 01/58-Su *M. brunneum* strain of *Neophilaenus campestris* nymph and adult survival in an olive crop in Rabanales (Córdoba) in April 2023 and 2024



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Front. Insect Sci. 5:1576244.
doi: 10.3389/finsc.2025.1576244

Targeting the *Xylella fastidiosa* spittlebug vector *Neophilaenus campestris* in the olive cover crops with the entomopathogenic fungus *Metarhizium brunneum*

Juan Carlos Conde-Bravo , María Fernández-Bravo ,
Inmaculada Garrido-Jurado , Meelad Yousef-Yousef ,
and Enrique Quesada-Moraga 

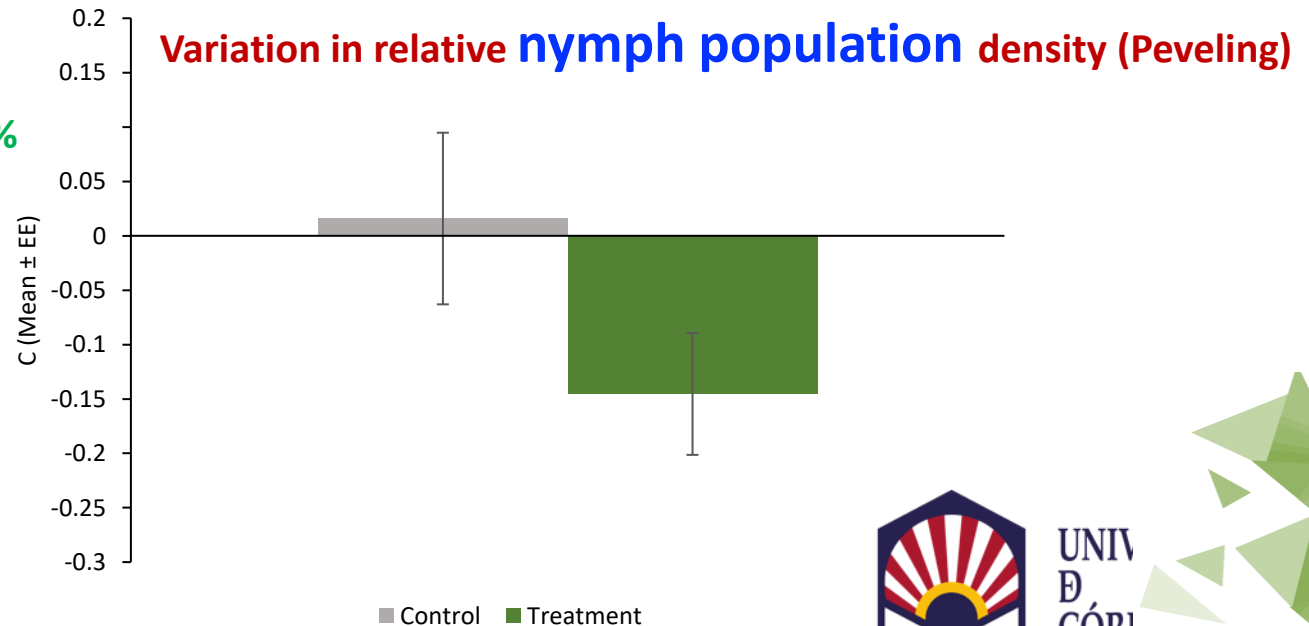
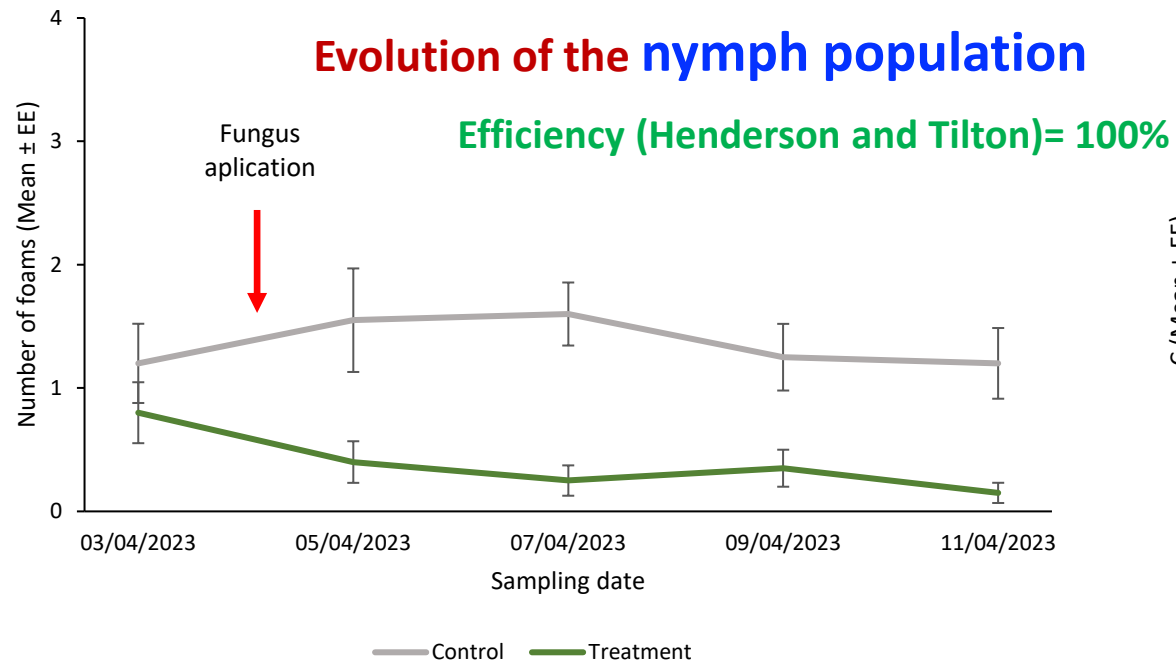
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Introduction: *Neophilaenus campestris* (Fallén) (Hemiptera: Aphrophoridae) is among the most abundant, highly dispersible, and widely distributed *Xylella fastidiosa* Wells (Xanthomonadales: Xanthomonadaceae) vectors to olive tree in Europe with presence in Andalusia. The development of efficient and

Agroecological options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes



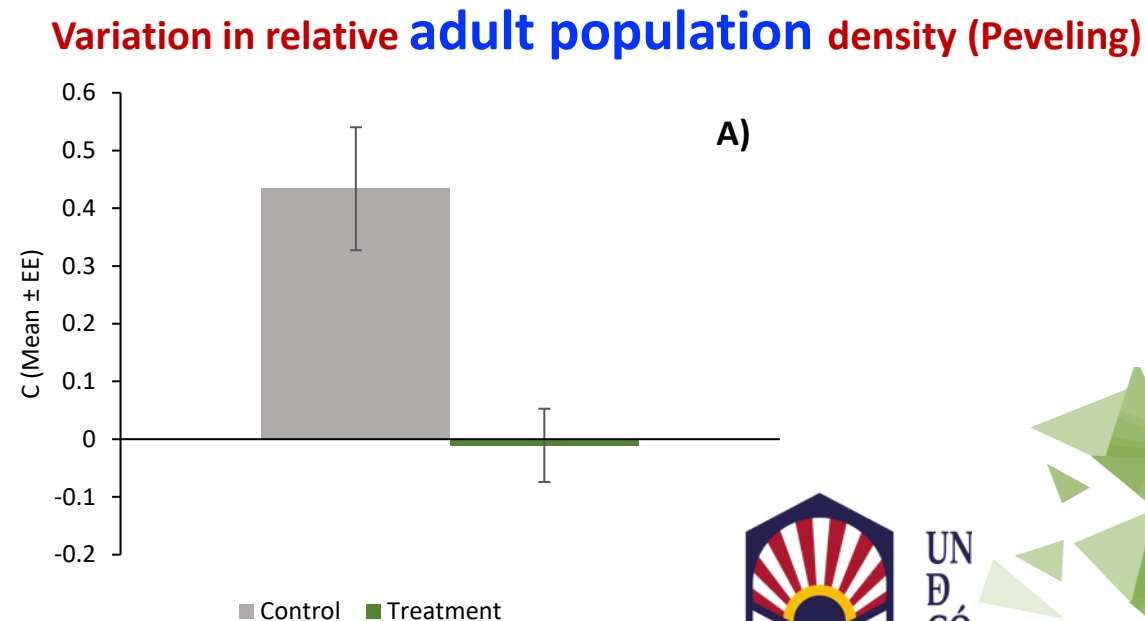
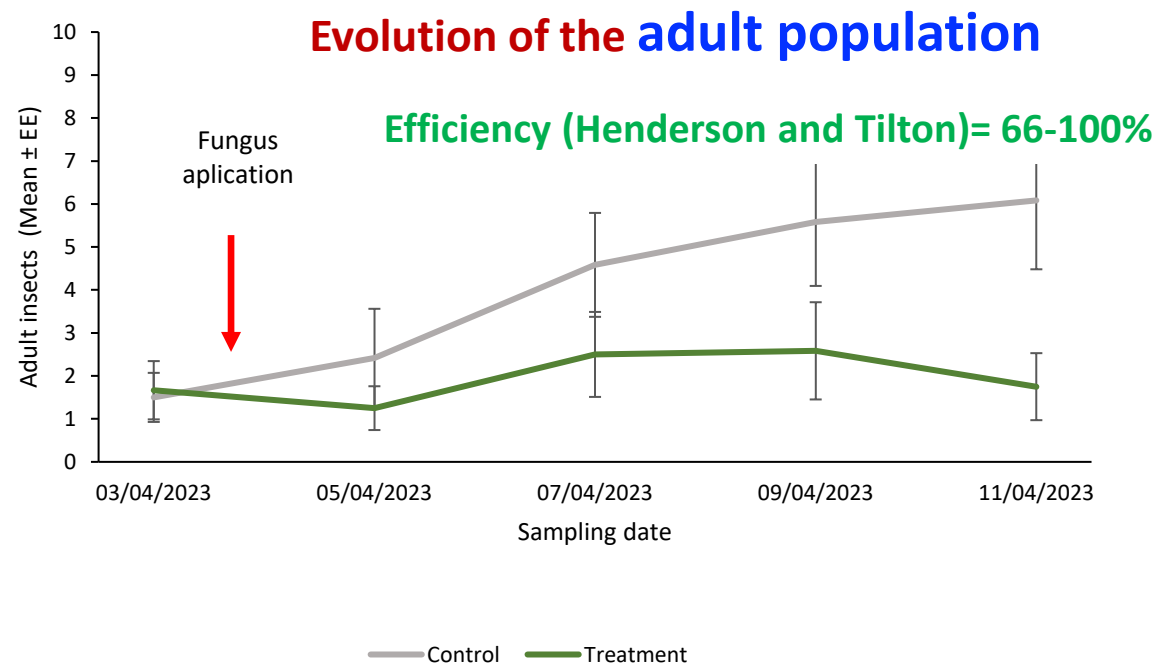
Effect of cover crop spraying with EAMa 01/58-Su M. brunneum strain of *Neophilaenus campestris* nymph and adult survival in an olive crop in Rabanales (Córdoba) in April 2023 and 2024



Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees



Effect of cover crop spraying with EAMa 01/58-Su M. brunneum strain of *Neophilaenus campestris* nymph and adult survival in an olive crop in Rabanales (Córdoba) in April 2023 and 2024



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Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

1

Direct spray over the
specimens
(nymphs and adults)

Insect vector

☐ Feeding behavior



Xylella
transmission



Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

Metarhizium brunneum direct exposure reduces survival and disrupts feeding behaviour in *Philaenus spumarius*

Tamara Hernández-Lao, ICA CSIC (ES)

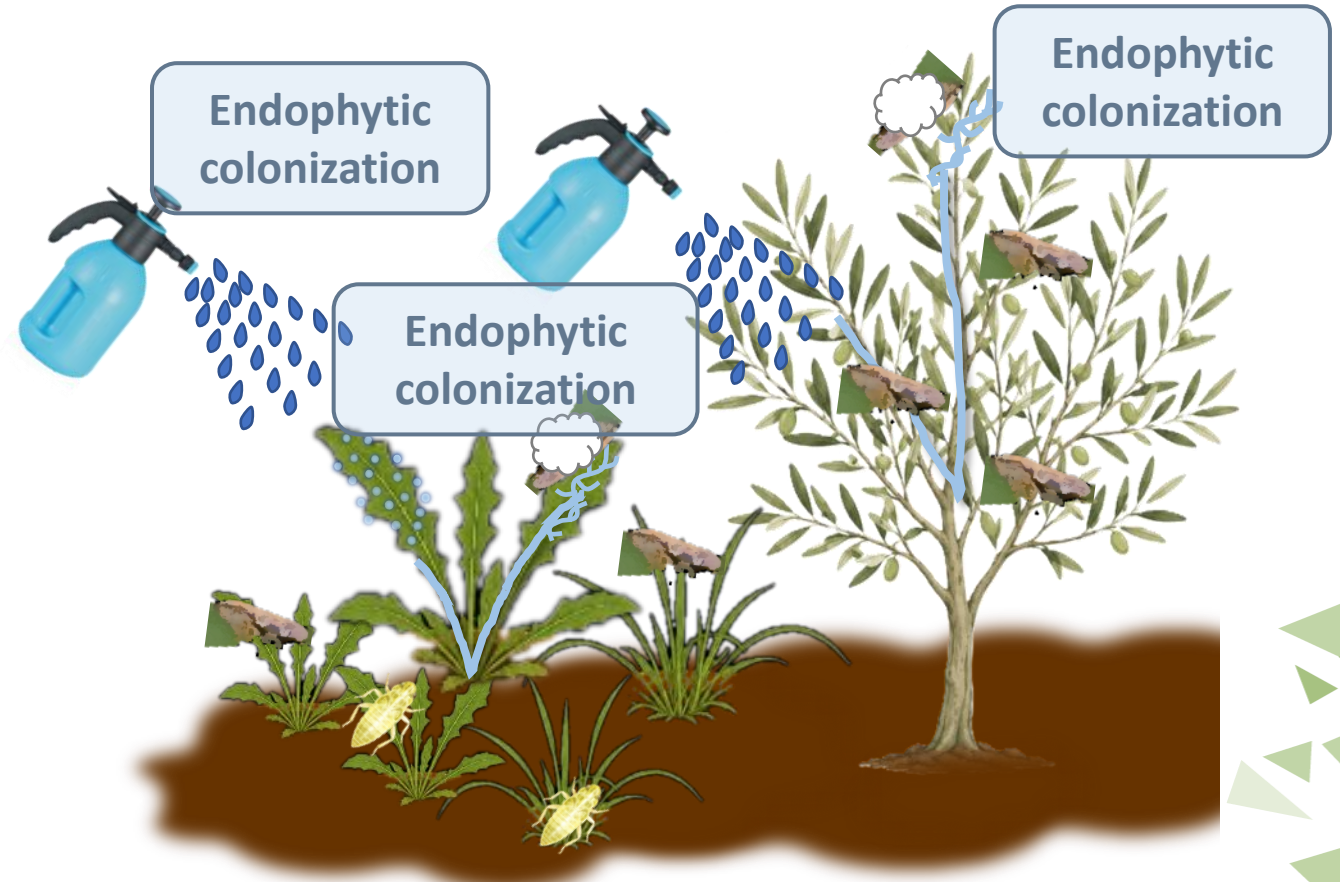
10:00-10:30 “Pitch talks” today. Nº 81

Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

2

Effect of endophytic colonization
(nymphs, adults and *Xylella*)

Insect vector
☐ Mortality



Strategic options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes

Mortality of *P. spumarius* adults feeding on *M. brunneum* EAMa 01/58-Su colonised Sowthistle (*Sonchus oleraceus* L.) plants for 4 hours



Treatment	% Mortality	
	Unsprayed leaves (apical)	Sprayed leaves (basal)
Control	18.8	13.6
EAMa 01/58-Su	48.2	53.8

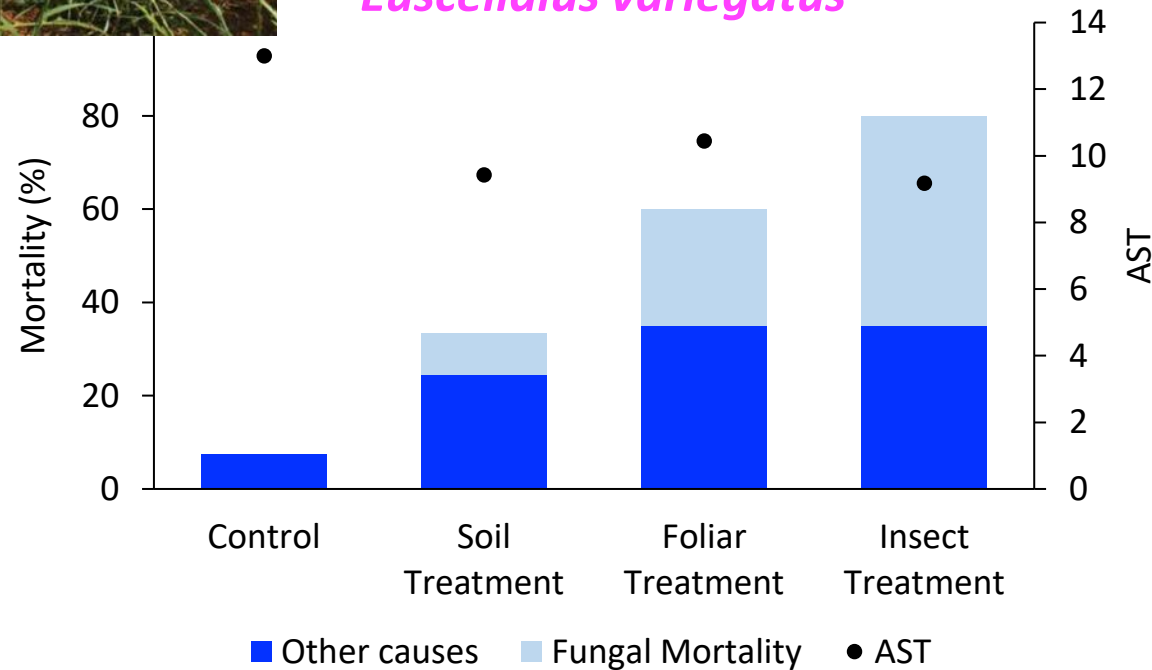


Strategic options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes

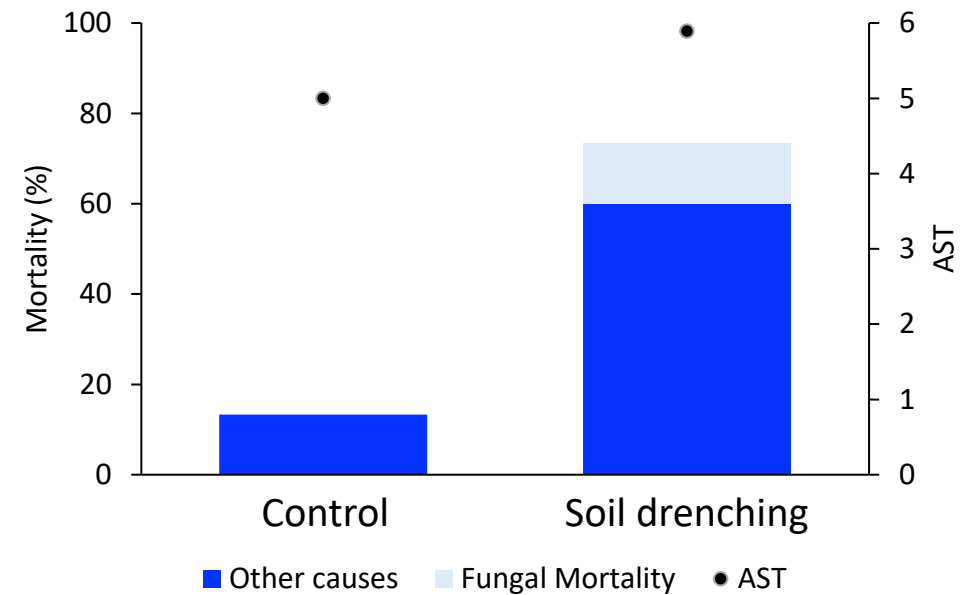


Survival of *Neophilenus campestris* and *Euscelidius variegatus* feeding on *Lolium rigidum* plants colonised by *M. brunneum* EAMa 01/58-Su strain

Euscelidius variegatus

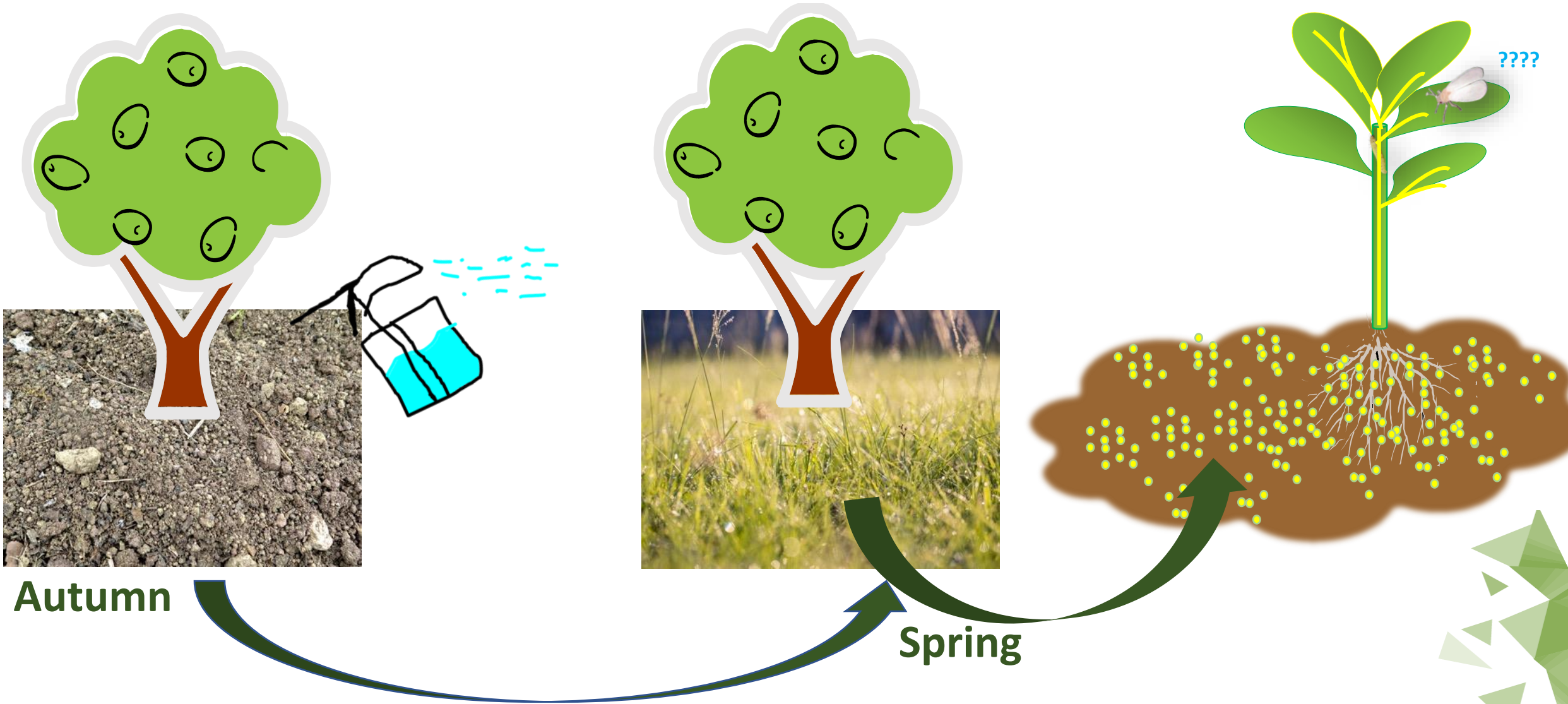


Neophilenus campestris



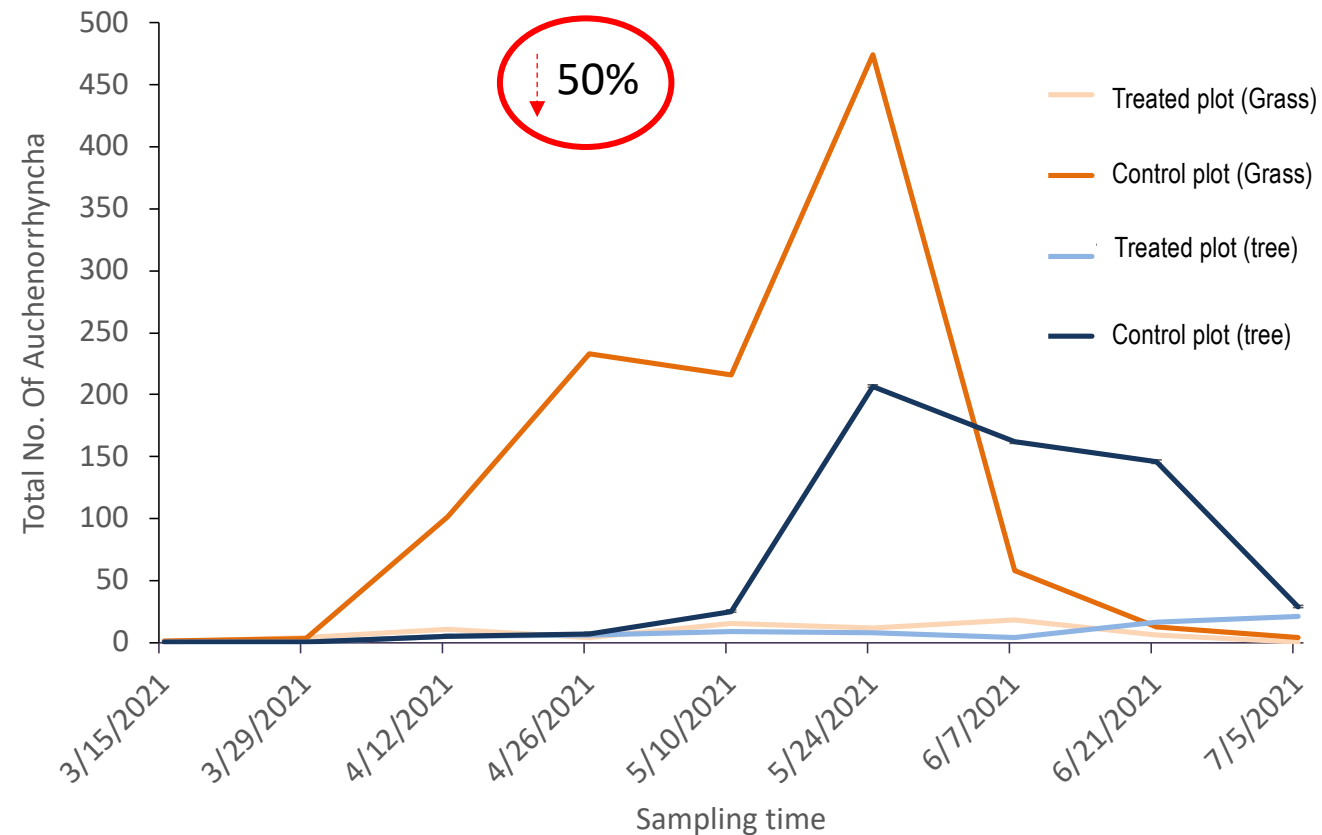
Strategic options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes

Does wide area soil application of EAMa 01/58-Su *M. brunneum* strain targeting olive fly preimaginals during Autumn or Spring influence presence and abundance of Auchenorrhyncha (Hemiptera) populations?



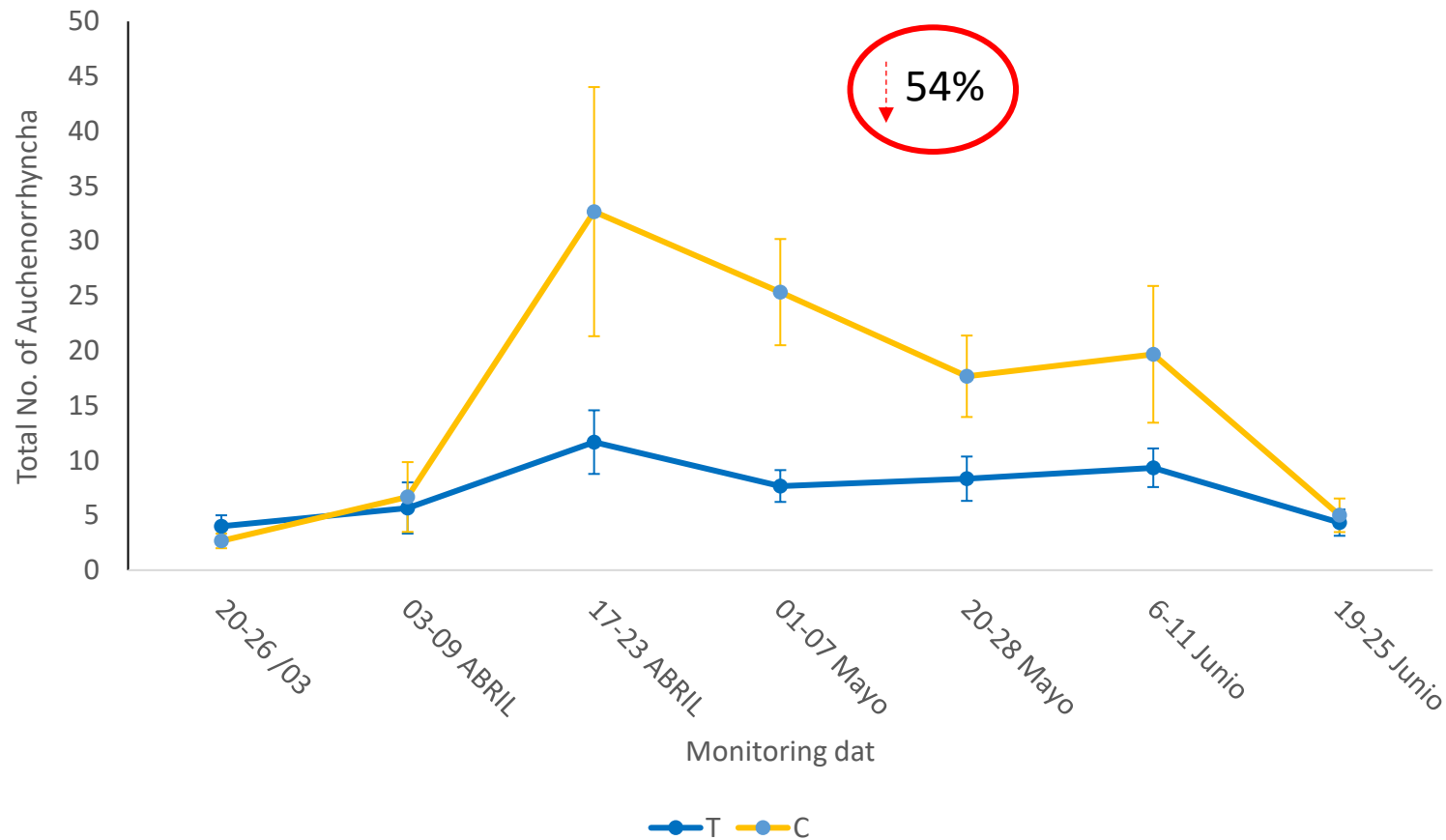
Strategic options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes

Effects of wide area soil application of EAMa 01/58-Su *M. brunneum* strain during **AUTUMN** on the presence and abundance of Auchenorrhyncha (Hemiptera) population



Strategic options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes

Effects of wide area soil application of EAMa 01/58-Su *M. brunneum* strain during **SPRING** on the presence and abundance of Auchenorrhyncha (Hemiptera) population



Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

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Effect of endophytic colonization
(nymphs, adults and *Xylella*)

Insect vector
☐ Feeding behavior

Xylella
transmission

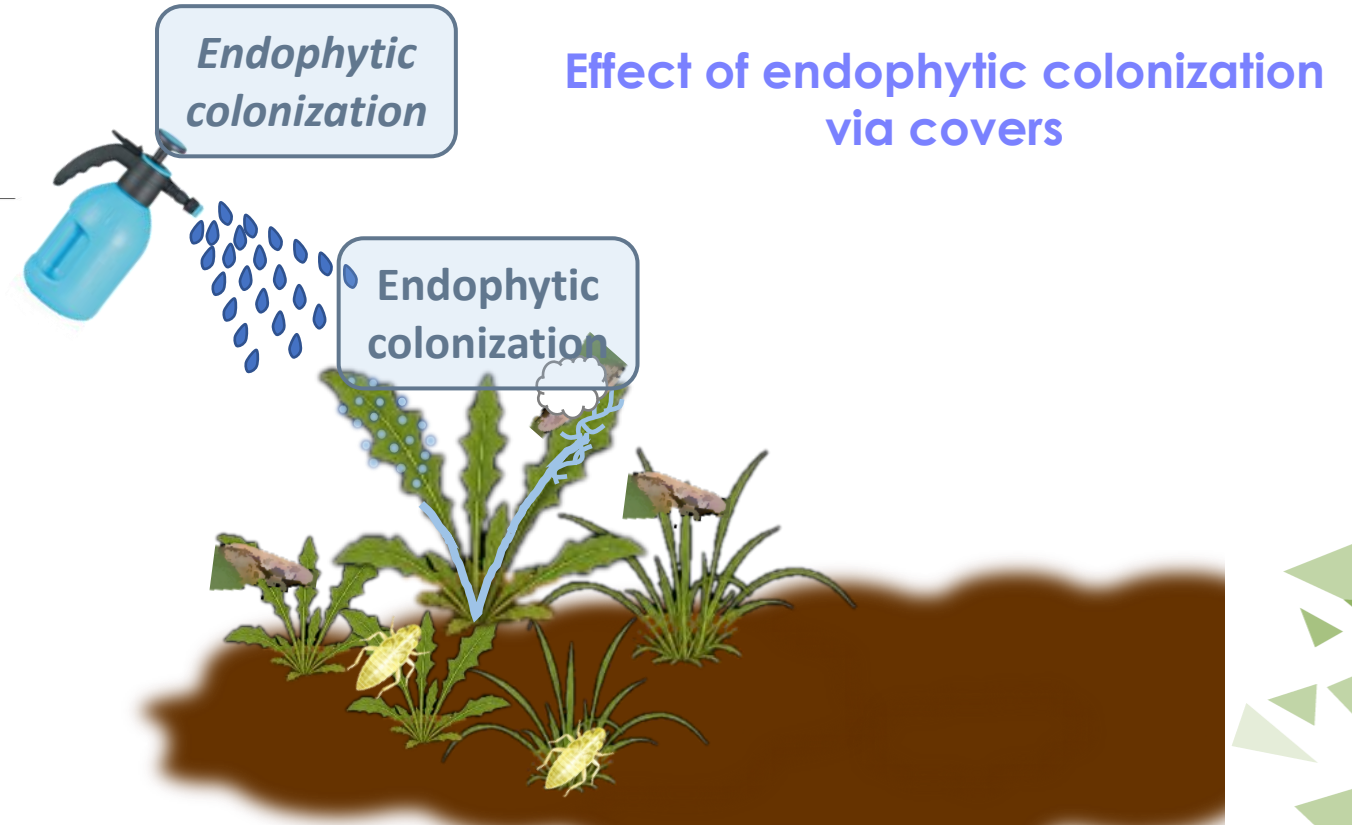


Direct and indirect effects of two endophytic entomopathogenic fungi on survival and feeding behaviour of meadow spittlebug *Philaeus spumarius*

Meelad Yousef-Yousef^{a,1}, Marina Morente^{b,1}, Natalia González-Mas^a, Alberto Ferreres^b, Enrique Quesada-Moraga^{a,*}, Aranzazu Moreno^{b,*}

^a Departamento de Agronomía (DAU/CO) María de Maeztu Unit of Excellence 2021–2023), Campus de Rabanales, Universidad de Córdoba, Edif. C4, 14071 Córdoba, Spain

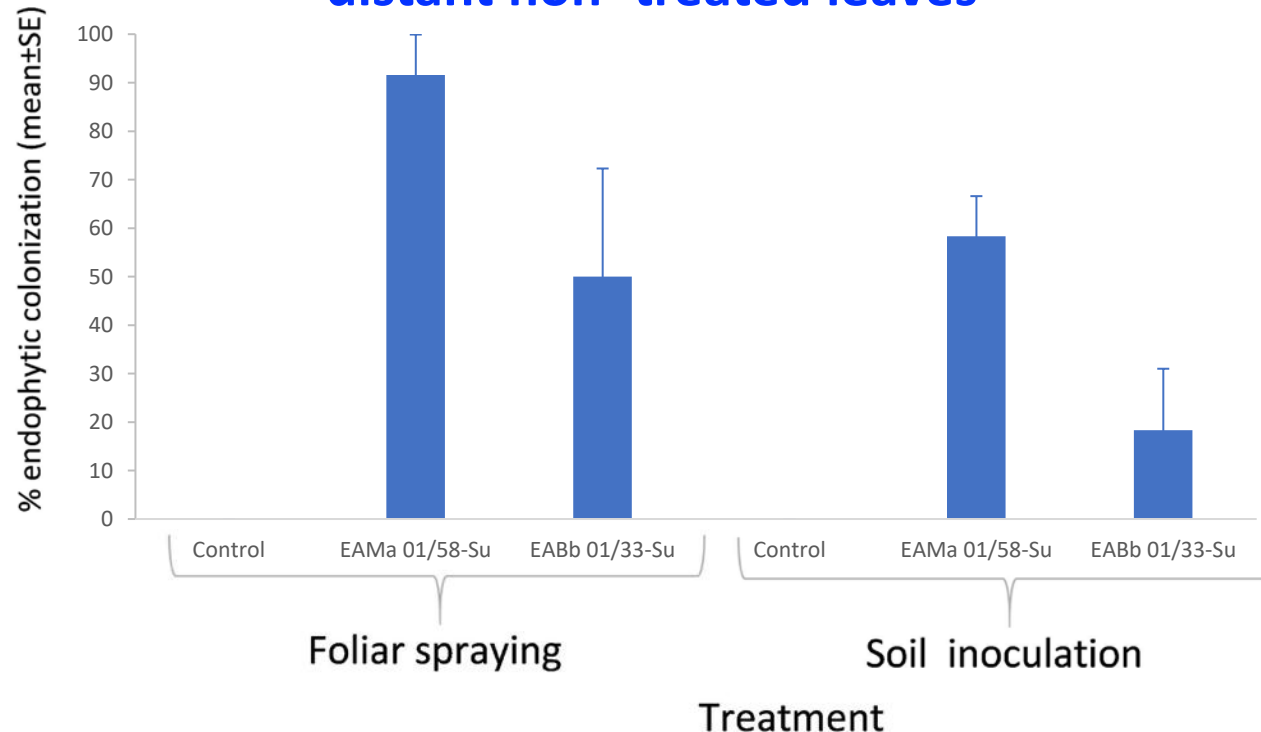
^b Instituto de Ciencias Agrarias, Consejo Superior de Investigaciones Científicas (ICA-CSIC), C/ Serrano, 115 dpdo., 28006, Madrid, Spain



Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

The feeding behaviour of *P. spumarius* on *S. oleraceus* plants previously colonized by *M. brunneum* using the 'Electrical Penetration Graph' technique was evaluated

45-55% mortality of adults feeding on distant non- treated leaves

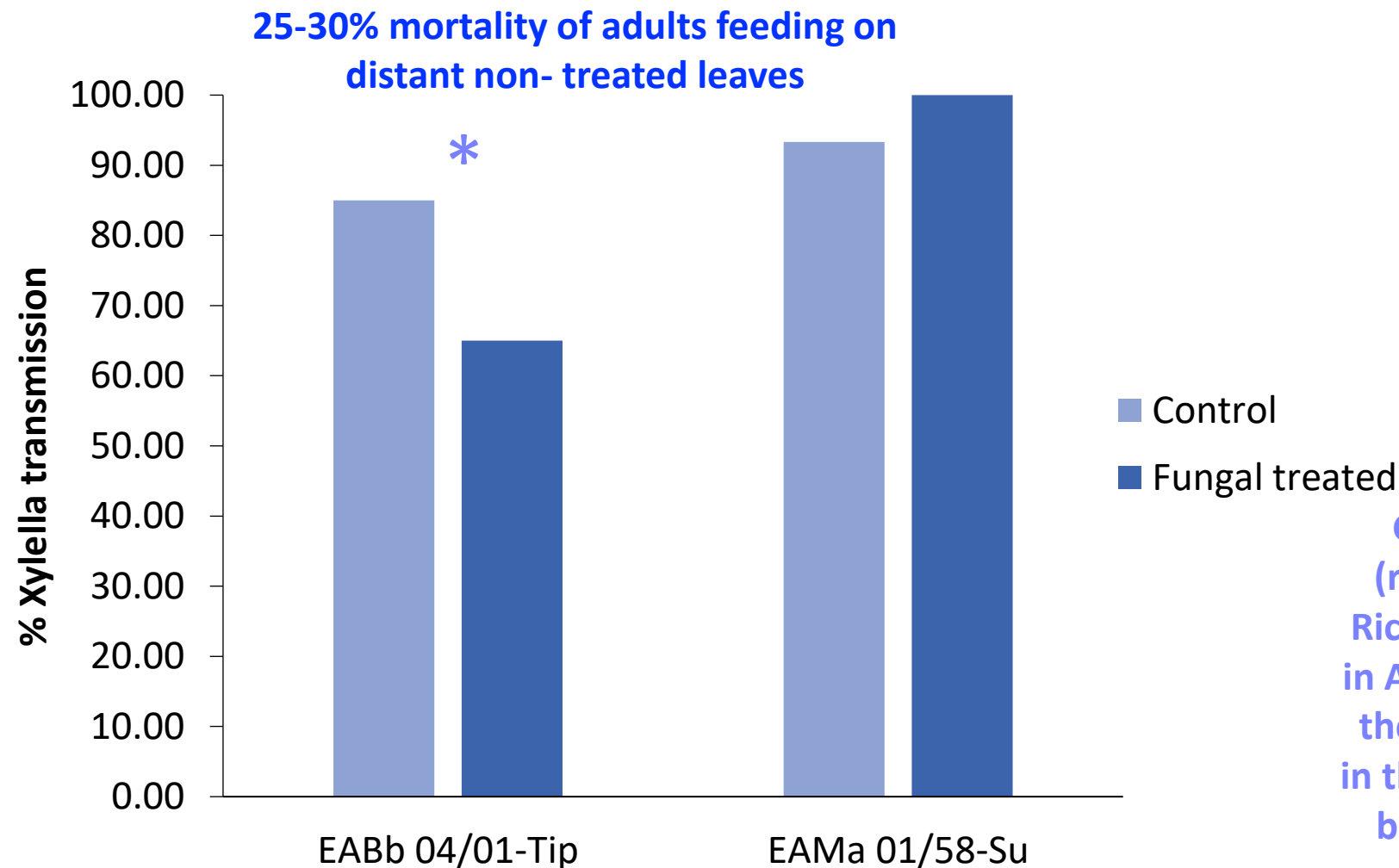


P. spumarius feeding on colonized plants reached xylem vessels faster than insects feeding on non-colonized plants

Impact on *X. fastidiosa* transmission?

Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

X. fastidiosa transmission in periwinkle plants endophytically colonized by entomopathogenic fungi (EF)



González-Mas et al. In preparation
(research performed in the Centro di
Ricerca, Sperimentazione e Formazione
in Agricoltura Locorotondo (Italy) during
the fellow of Dr. Natalia González-Mas
in the laboratory of Dr. Dongiovanni also
belonging to the BEXYL consorptium
WP5)

Entomopathogenic fungi-related strategies for managing the vector and the infection of *Xylella fastidiosa* on olive trees

2

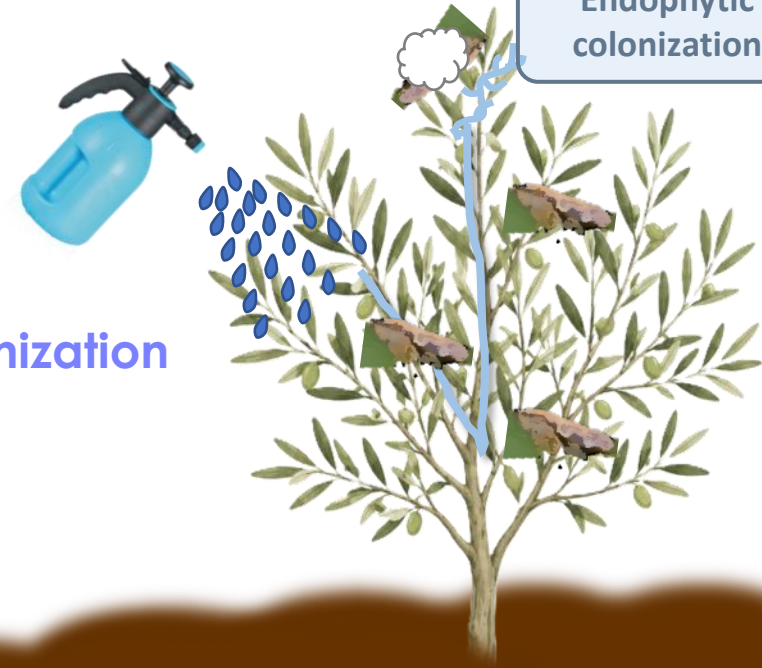
Effect of endophytic colonization
(nymphs, adults and *Xylella*)

Insect vector
☐ Feeding behavior

Xylella
transmission

Endophytic
colonization

Endophytic
colonization



Effect of endophytic colonization
via the olive crop

Journal of Pest Science (2026) 99:54
<https://doi.org/10.1007/s10340-026-02015-3>

RESEARCH



Endophytic colonization and epiphytic presence of *Metarhizium brunneum* alter the feeding behavior of the *Xylella fastidiosa* vector *Philaenus spumarius*

Clara Lago^{1,2} · Meelad Yousef Yousef³ · Alberto Fereres¹ · Enrique Quesada-Moraga³ · Aranzazu Moreno¹ · Natalia González-Mas³

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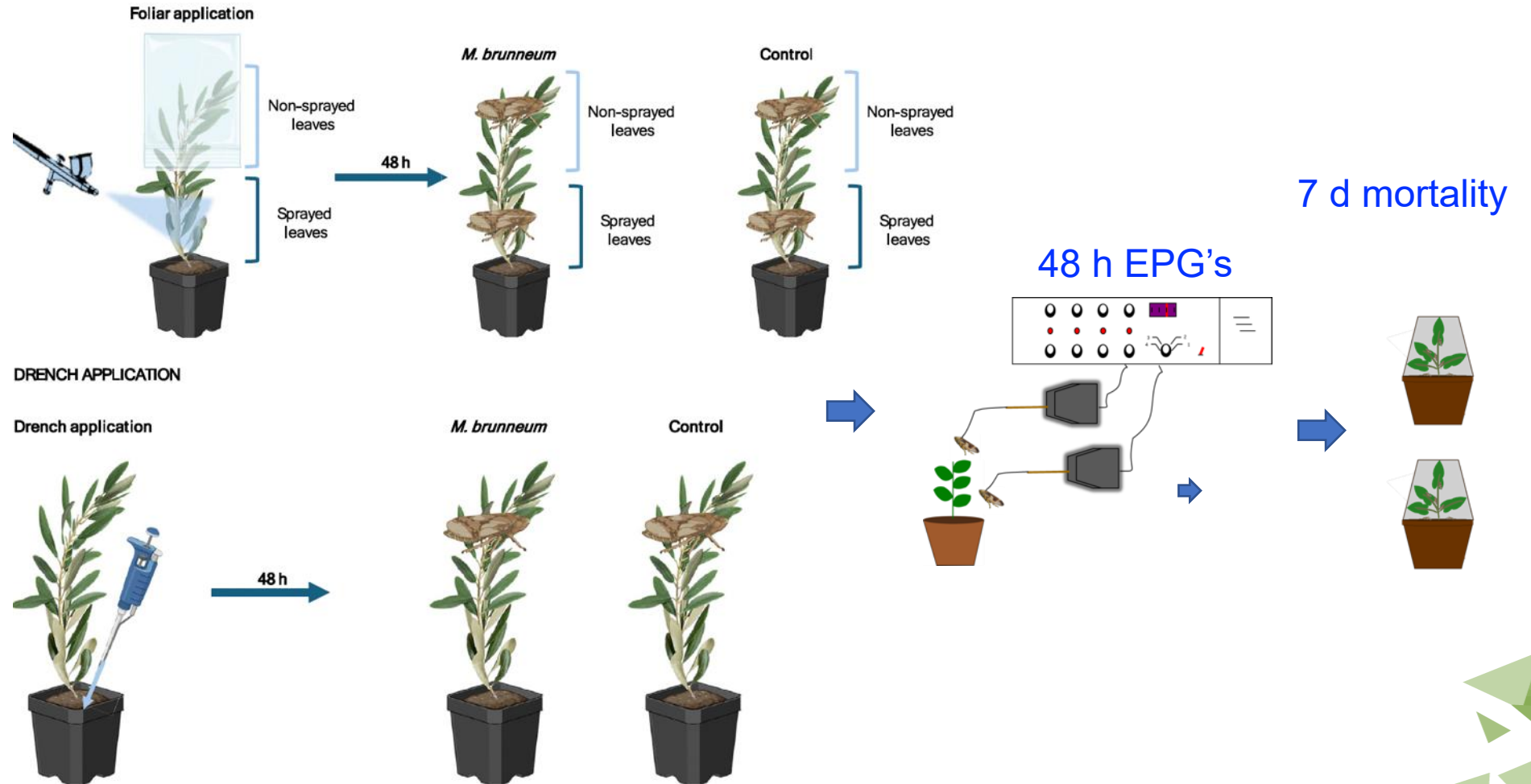
Strategic options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes

Olive tree colonization by entomopathogenic fungi and impact on *P. spumarius* feeding behavior

Foliar Treatment
(2 mL:1 × 10⁸ conidia mL⁻¹)



Soil treatment
(5 mL:1 × 10⁸ conidia mL⁻¹)





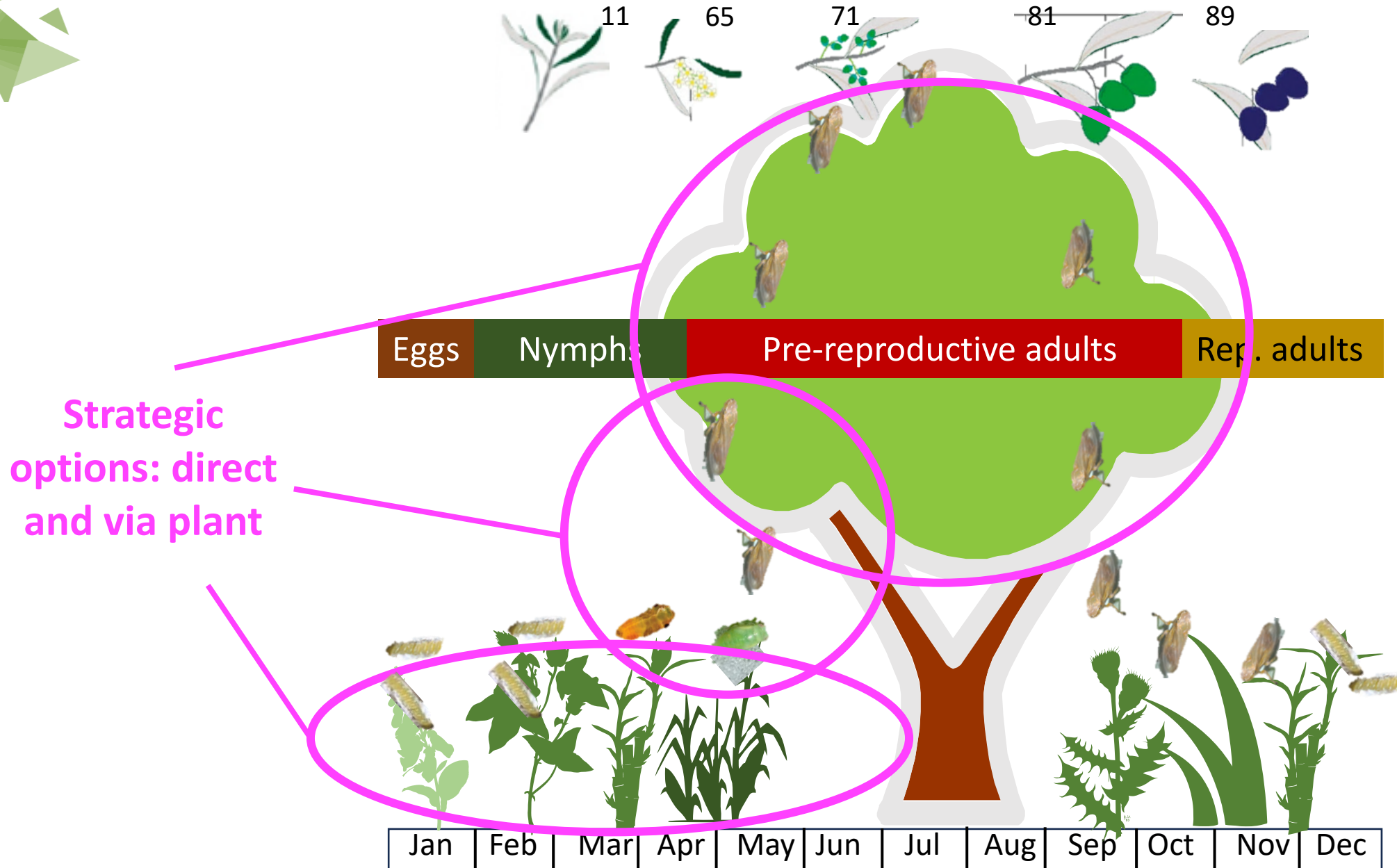
Strategic options for managing *Xylella fastidiosa* vectors with entomopathogenic ascomycetes

X. fastidiosa mortality in olive plants endophytically colonized by entomopathogenic fungi (EF)

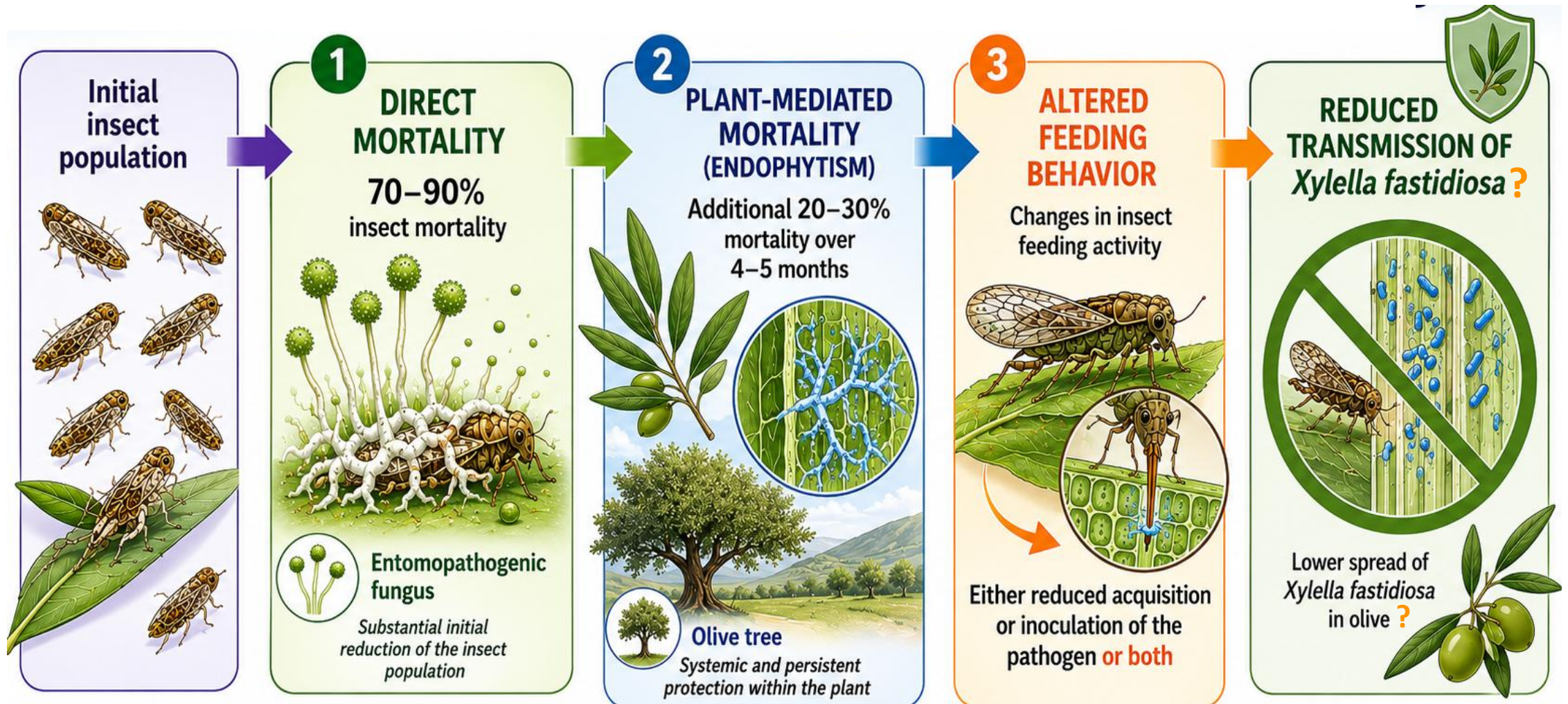
To now, it has been demonstrated that EAMa 01/58-Su strain colonises 65.3% of the fungally challenged targeted olive leaves while the fungus is detected in 8.3% of the distant non-targeted leaves

- *Metarhizium brunneum* (Mb) foliar application disrupts *P. spumarius* feeding behaviour
- Feeding disruption intensified with dual epiphytic and endophytic Mb presence
- Mb increased probing, reduced xylem contacts and interruptions, and delayed xylem ingestion
- Mb application to olive plants shows potential for mitigating Xf spread.

Philaenus spumarius life cycle in southern Spain related to covers and olive trees phenology (modified from Liccardo et al. 2020)



Cumulative effect of entomopathogenic-fungi based *Xylella fastidiosa* vector management strategies

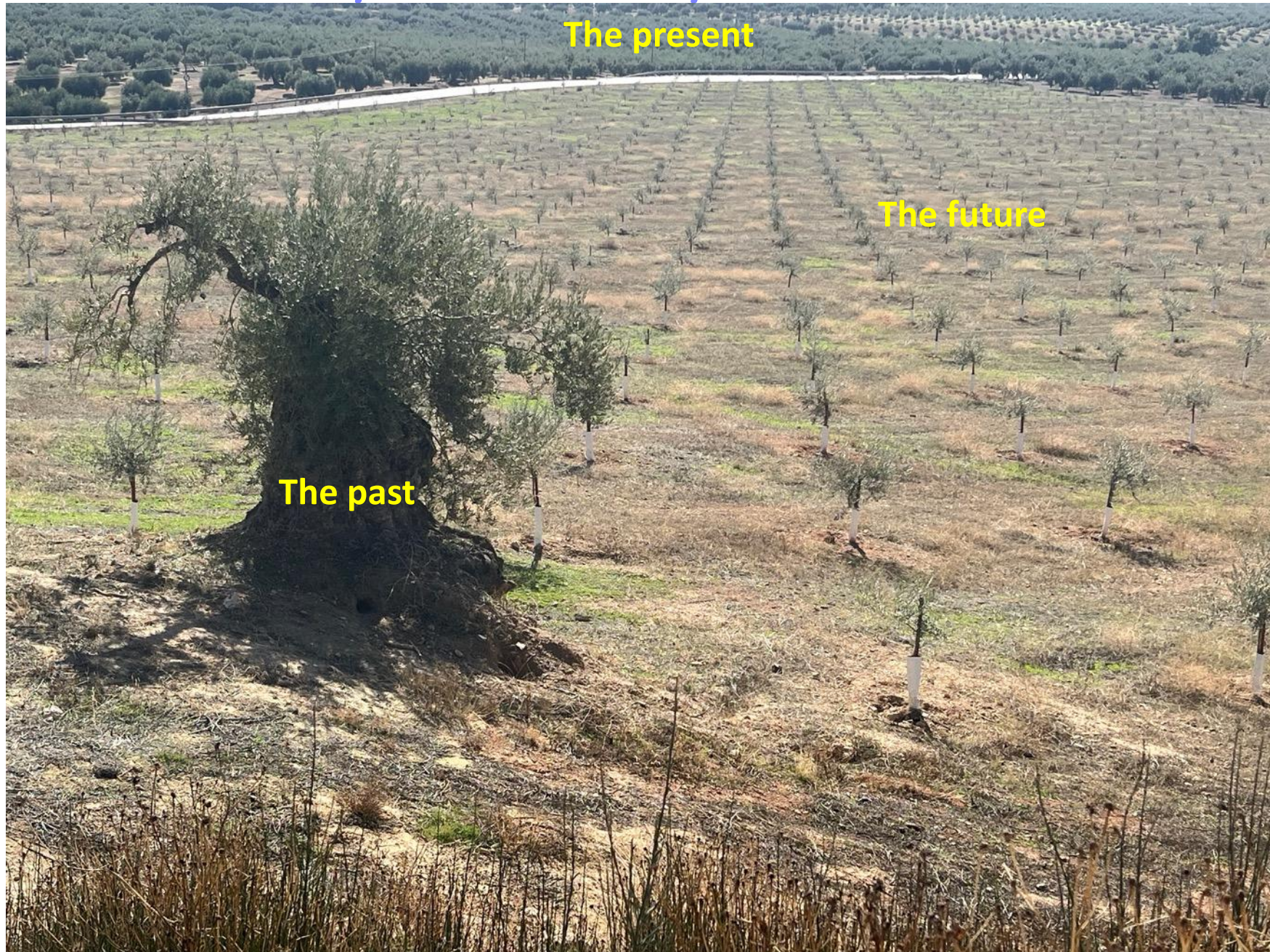




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iii Many thanks for your attention iii



UNRAVELING THE INTERACTION BETWEEN *XYLELLA FASTIDIOSA* AND ITS INSECT VECTORS

Daniele Cornara, Monica Marra, Nadia Serale, Oumayma Jemei, Cristina Marzachì, Andre Szejner-Sigal, Dylan Beal, Lisa Treidel, Alberto Fereres, Michela Chiumenti, Rodrigo P.P. Almeida



*Xylella
fastidiosa*

5th European conference

Bari, Italy | 22-26 June 2026



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ALDO MORO

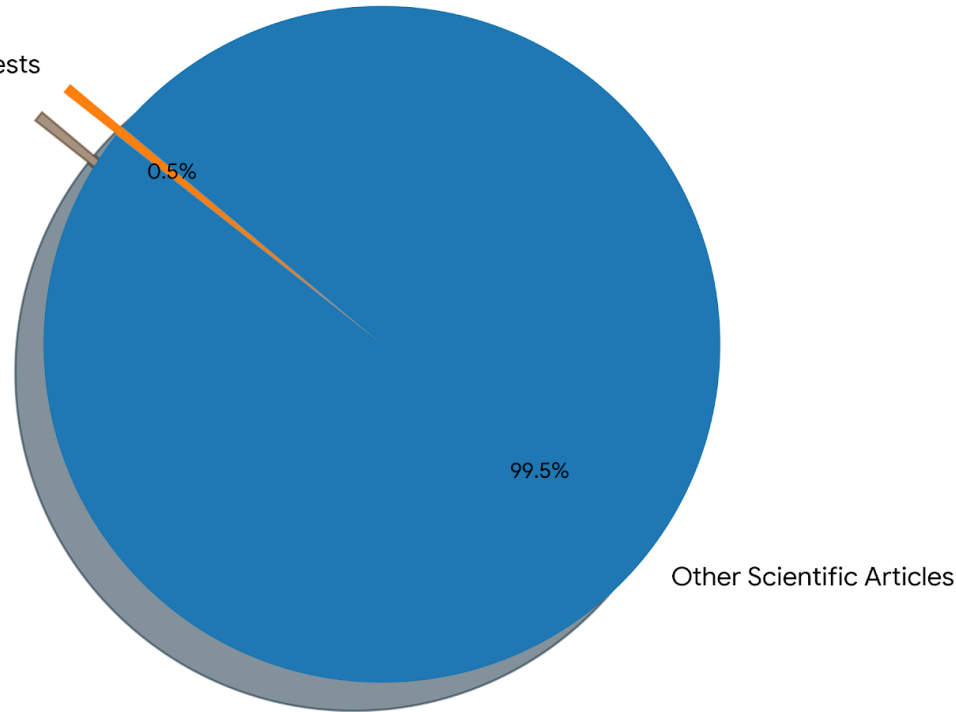
D.I.S.S.P.A. – DEPARTMENT OF
SOIL, PLANT AND FOOD SCIENCES

daniele.cornara@uniba.it



Annual Worldwide Scientific Articles:
Agricultural Pests vs. All Other Disciplines
(Total: ~5,000,000/year, ~13,700/day)

Articles on Agricultural Pests



Paradigms: Examples from the Bacterium *Xylella fastidiosa*

Alexander Purcell

Department of Environmental Science, Policy and Management, University of California,
Berkeley, California 94720-3114; email: ahpurcell@berkeley.edu

Living in two Worlds: The Plant and Insect Lifestyles of *Xylella Fastidiosa*

Subhadeep Chatterjee,¹ Rodrigo P. P. Almeida,²
and Steven Lindow¹

¹Department of Plant and Microbial Biology, ²Department of Environmental Science,
Policy and Management, University of California, Berkeley, California 94720;
email: schatt@nature.berkeley.edu, rodrigo@nature.berkeley.edu, icelab@berkeley.edu



Received: 21 March 2025 | Accepted: 13 September 2025

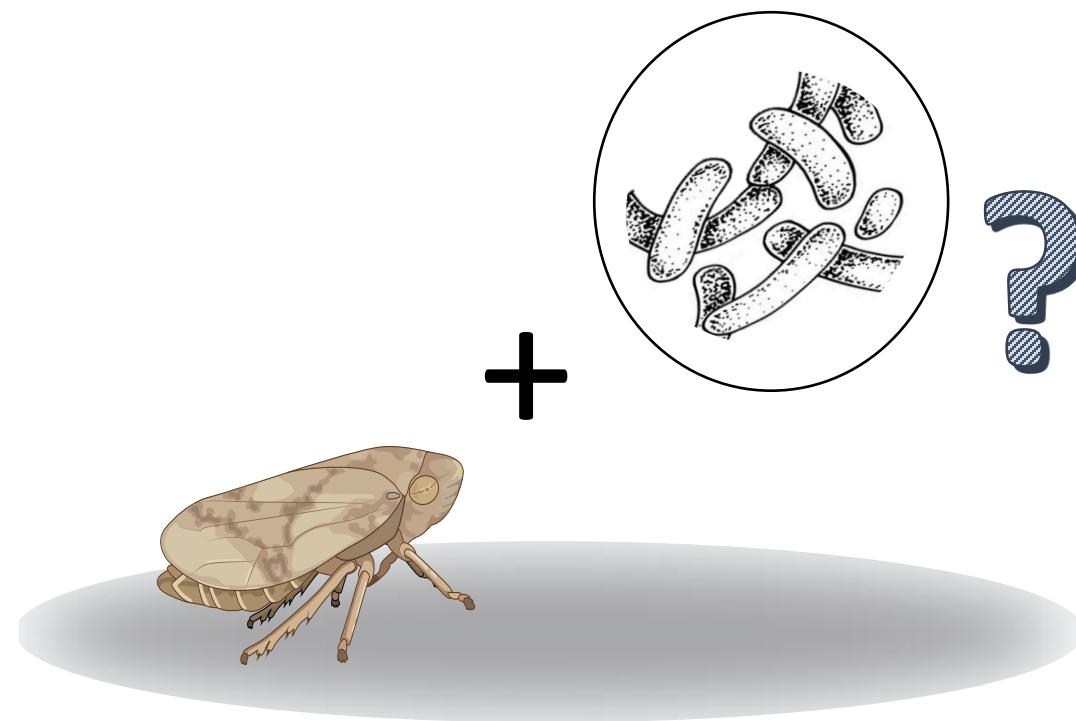
DOI: 10.1111/1365-2435.70180

RESEARCH ARTICLE

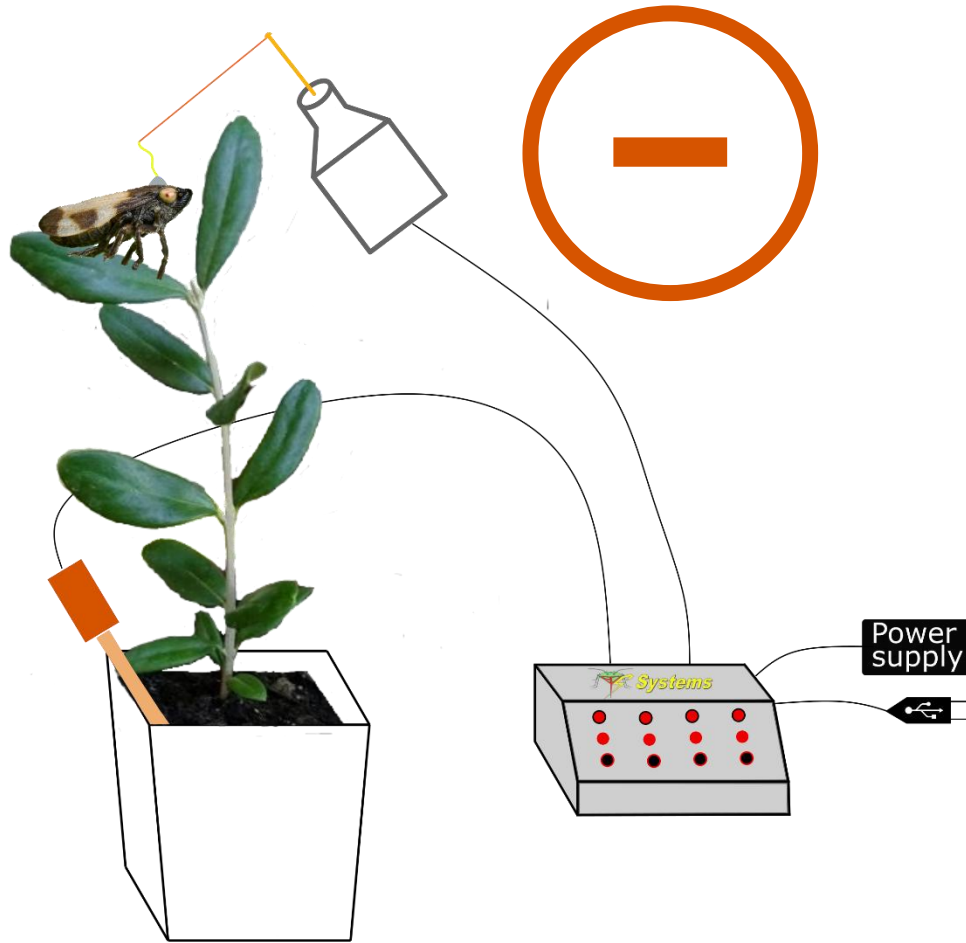
**BRITISH
ECOLOGICAL
SOCIETY** Functional Ecology

Meta-analysis reveals strong evidence for adaptive host and vector manipulation by plant viruses

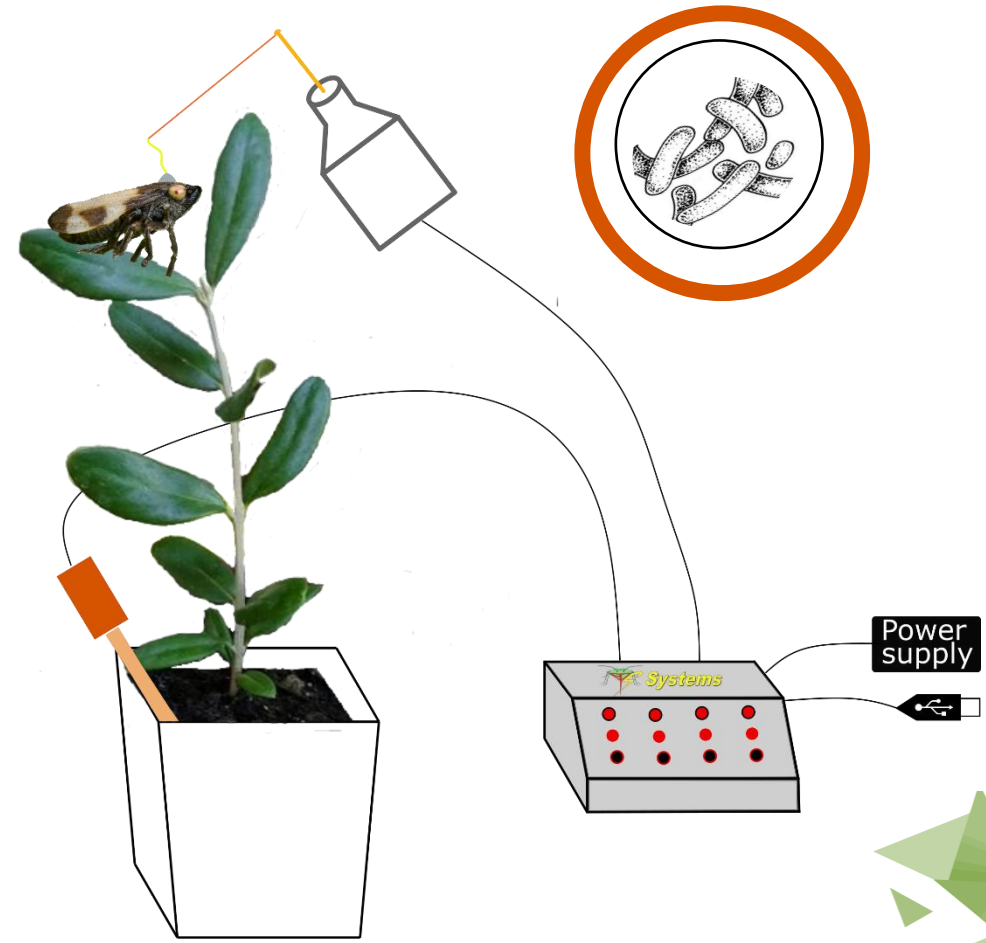
Quentin Chesnais^{1,2} | Christie A. Bahlai³  | Angela Peace⁴ | David W. Crowder⁵  |
Nilsa A. Bosque-Pérez⁶ | Kerry E. Mauck¹ 



Xf «affect» its vectors? → Probing behavior

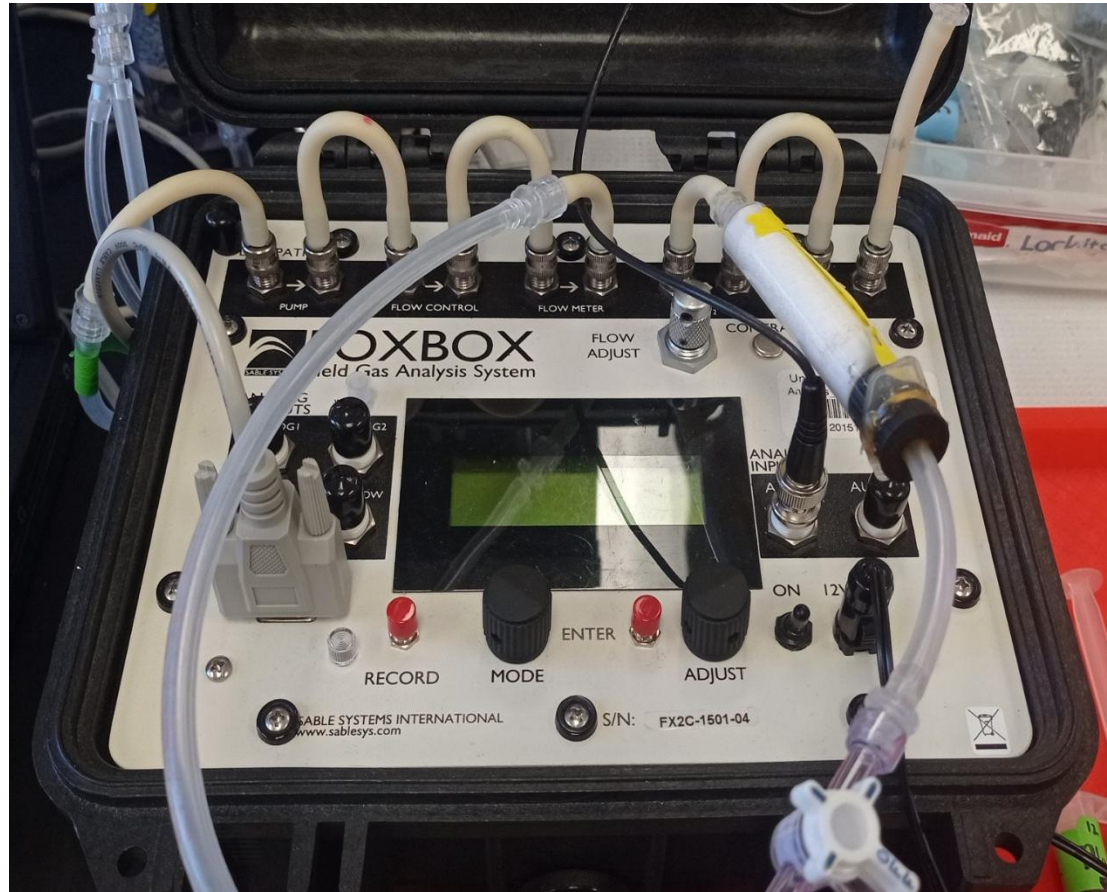


VS

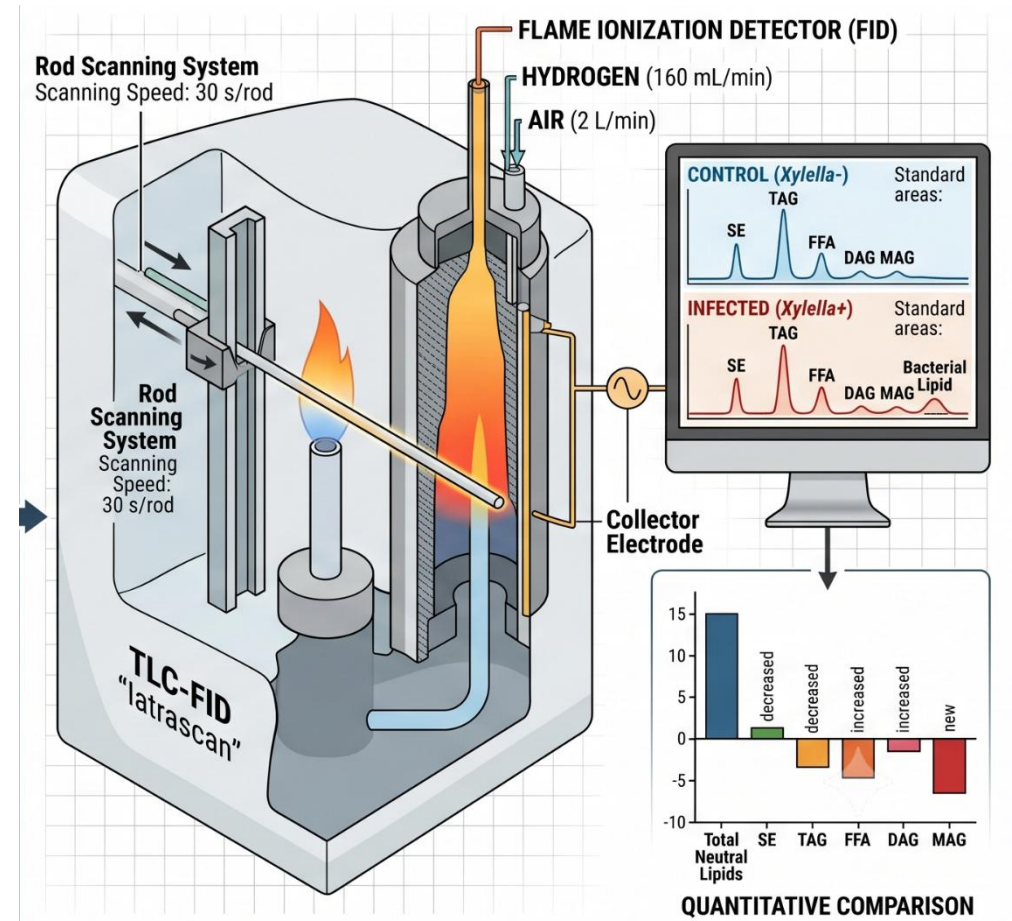


Xf «affect» its vectors? → Probing behavior

Metabolic rate

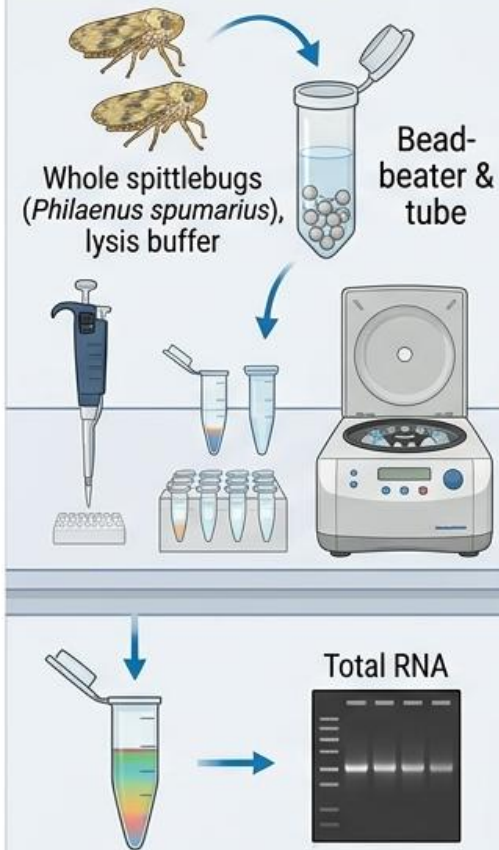


Neutral lipid levels → «energy storage»

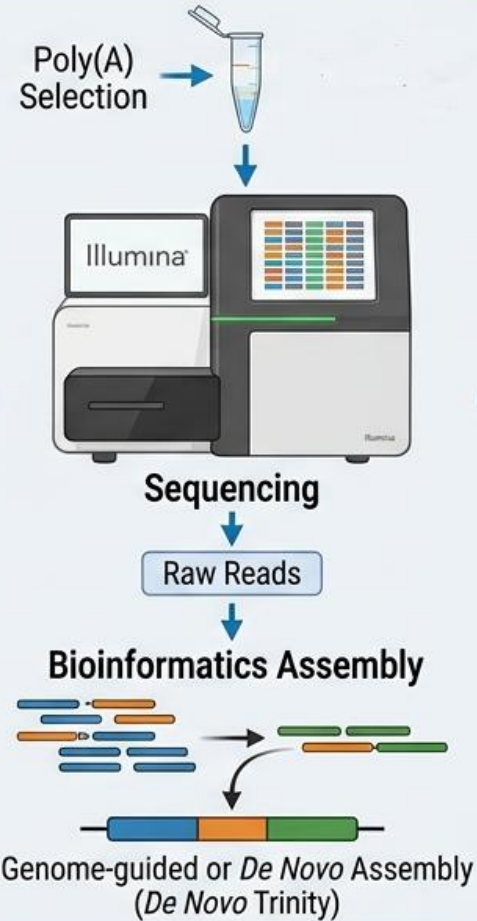


Xf «affect» its vectors? → Gene expression

1. RNA EXTRACTION

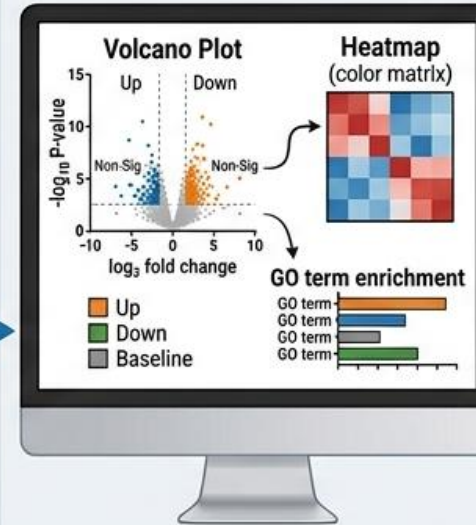


2. RNAseq & ASSEMBLY



3. DGE ANALYSIS

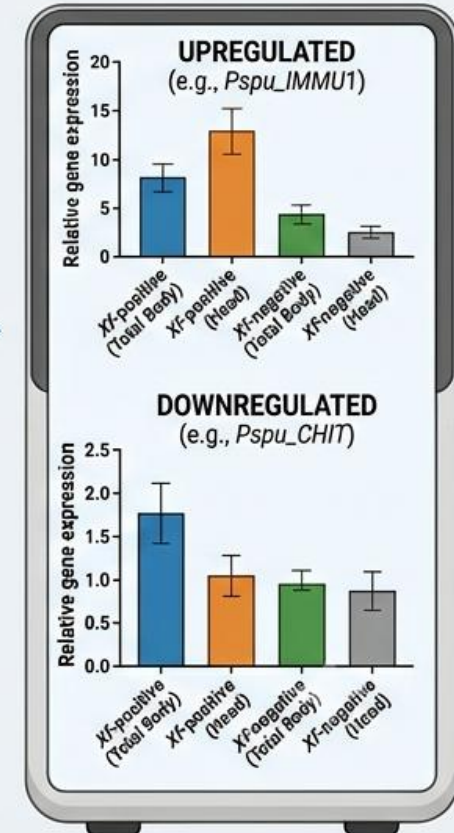
Transcriptomic Analysis



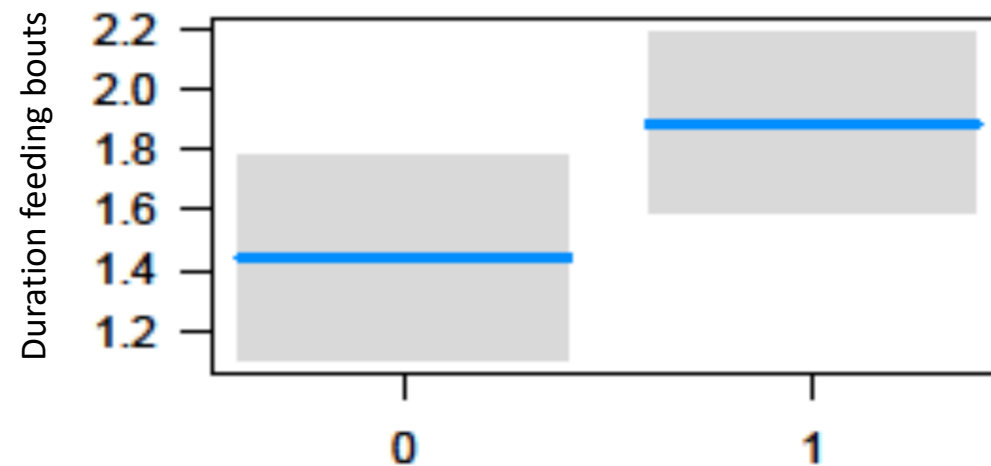
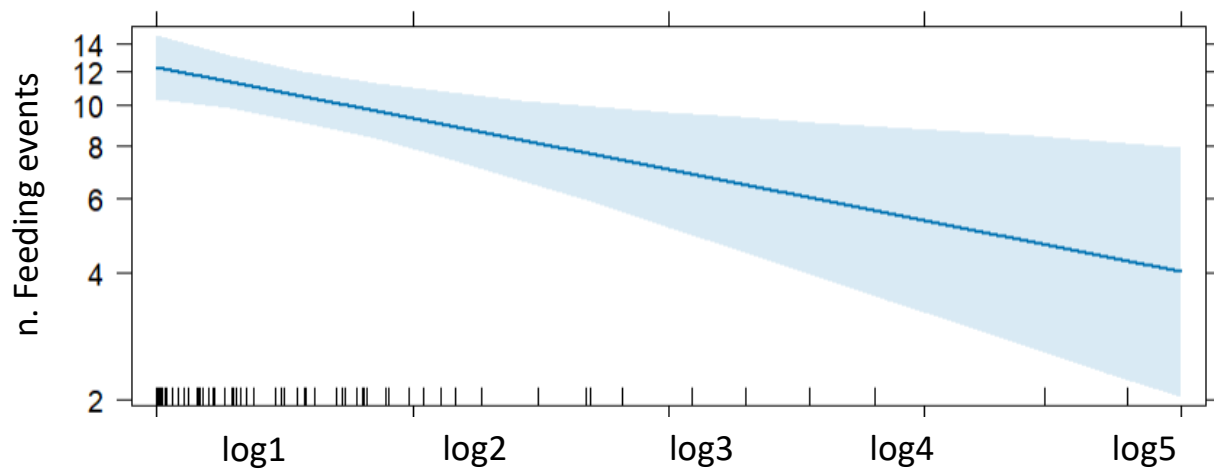
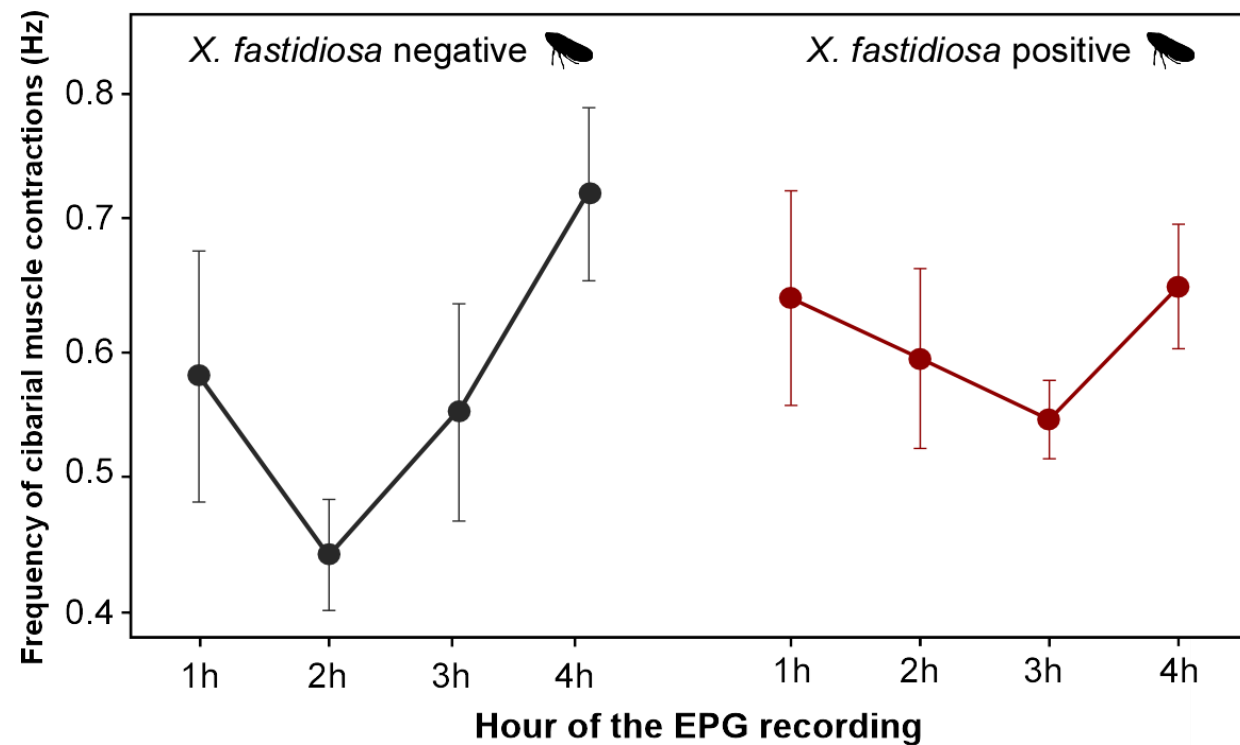
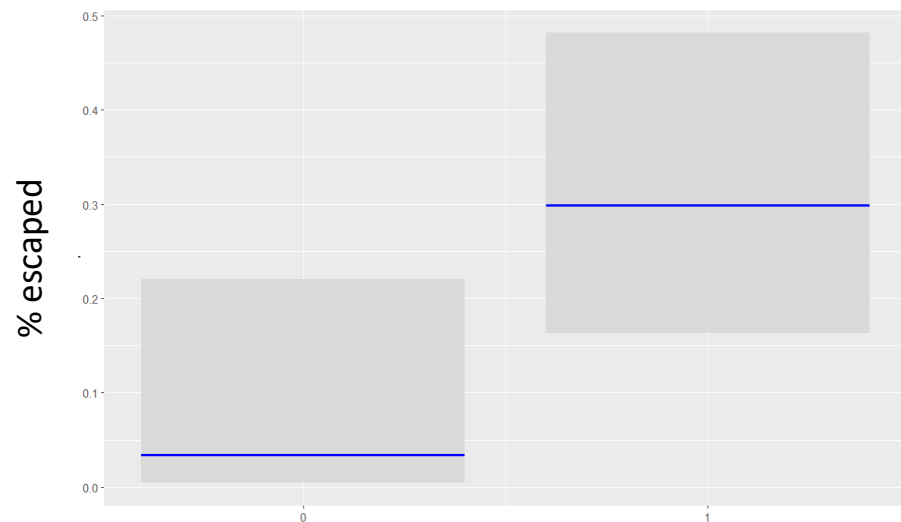
- Systemic DGE observed in head and total body

4. qRT-PCR CONFIRMATION

qRT-PCR Confirmation of DGE

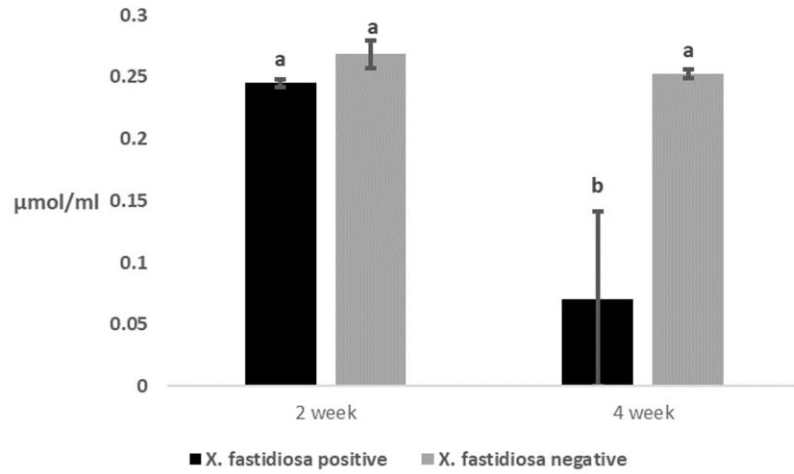


Xf «affect» probing behavior

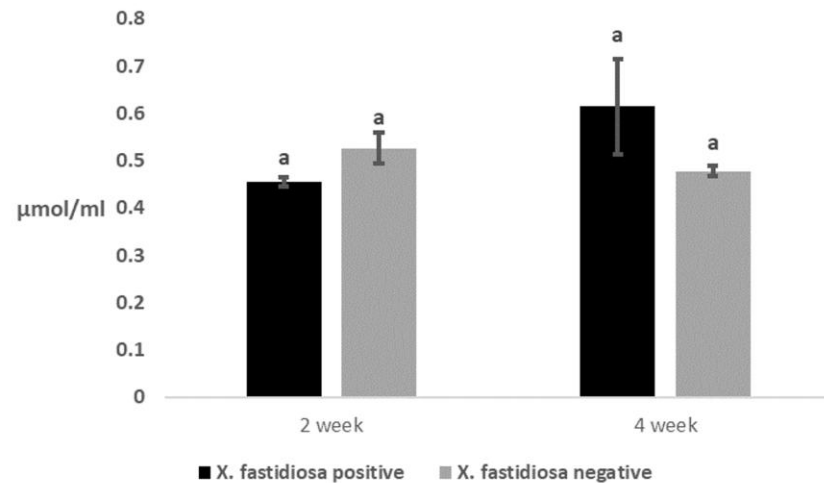


Xf «affect» energy storage

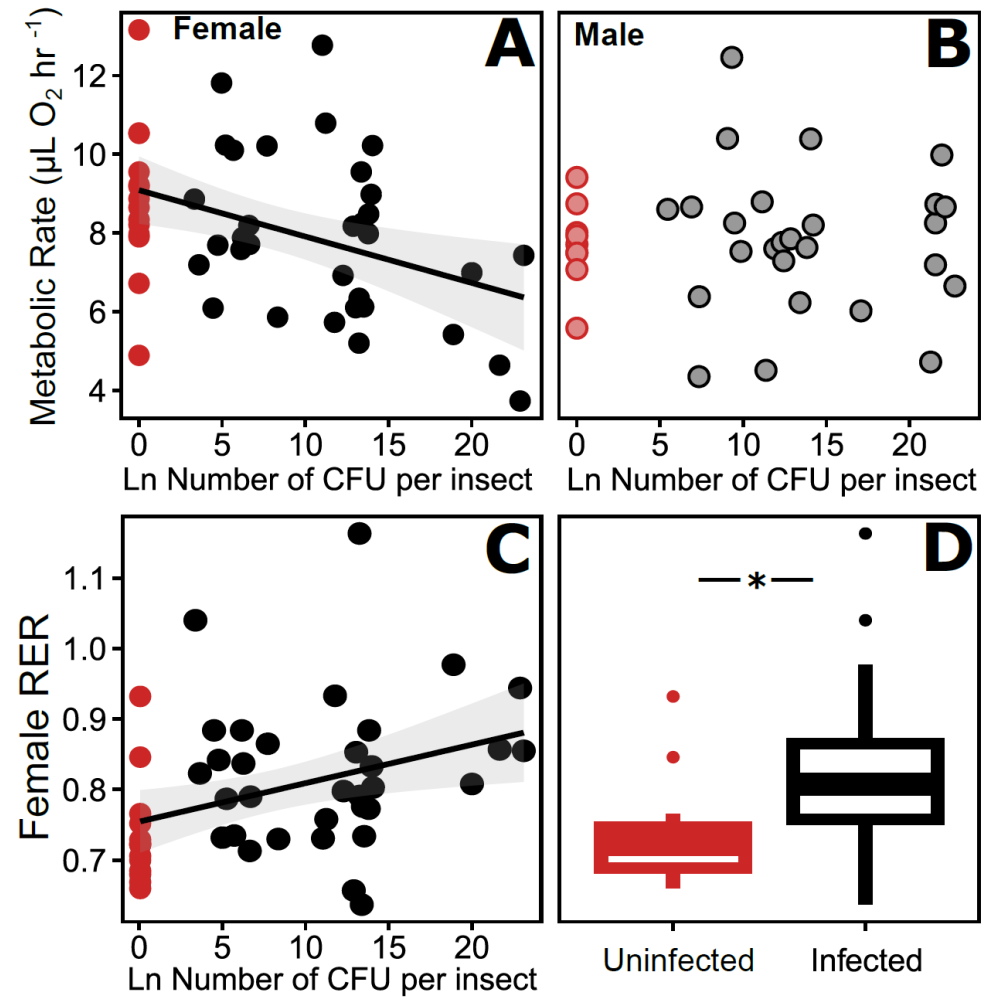
TAG



CE



RER: 0.7 → 0.82



*Metabolically more
demanding state Xf+*

Xf impact on insect vectors (76 DET)

Muscle & contractile apparatus

Myosin light chain 1-like → UP

Troponin T → UP (head)

Titin-like → DOWN

Cytoskeleton & structural proteins

Chitin deacetylase 1 → UP



Lipid & isoprenoid metabolism

Acetyl-CoA acetyltransferase, cytosolic → UP

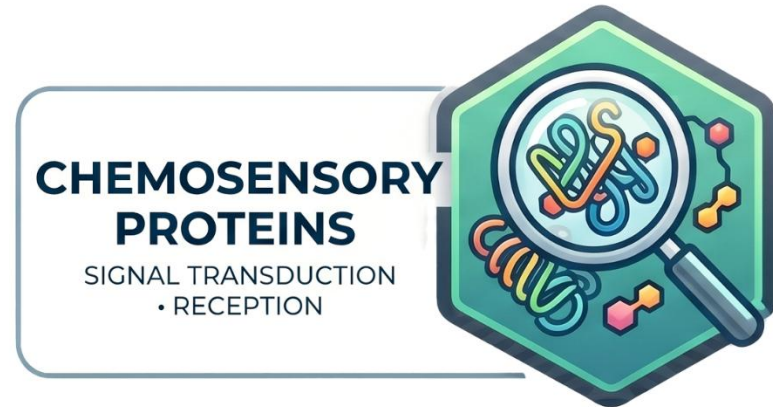
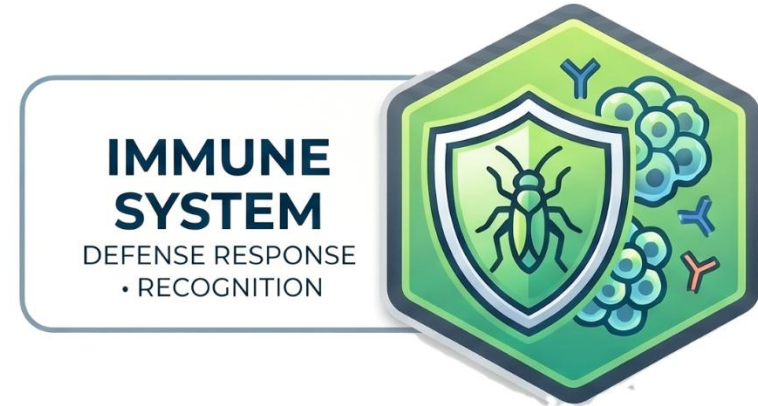
Fatty acid synthase-like → DOWN

Putative phospholipase B-like 2 → DOWN

Putative vitellogenin receptor → DOWN

Immune & proteolytic defense

Peptidoglycan-recognition protein → UP



Chemosensory components

Odorant Binding Protein 5 → DOWN

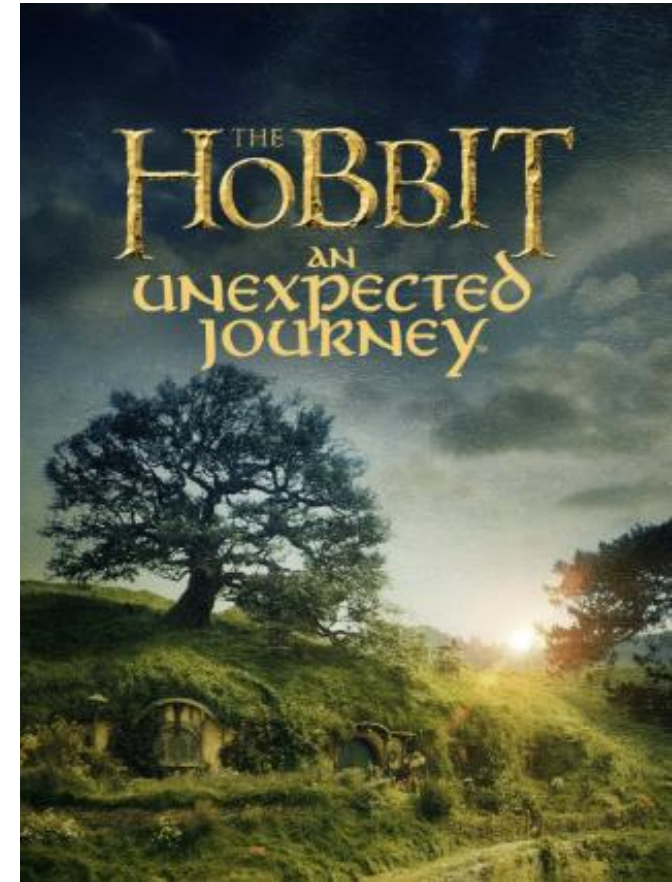
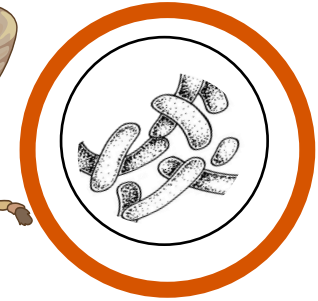
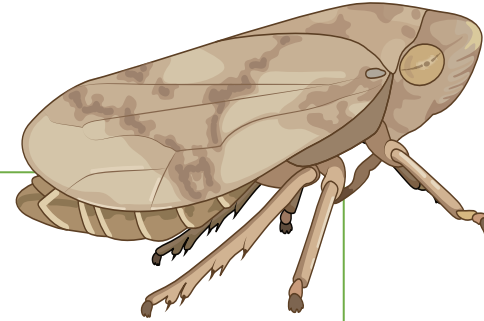


Xf impact on insect vectors: conclusions

- Feeding is more energetically costly;
- Immune evasion by Xf;
- Metabolic adjustment reflecting physiological stress;
- Shift toward “survival mode” → COMPENSATORY RESPONSE



- **Vectors are EXPLOITED → Xf pushes the insect host to its physiologic and metabolic limits**
 - **LONG TERM EFFECTS? EPIDEMIOLOGY?**





- Rodrigo Almeida (UC Berkeley, US)
- Alberto Fereres (ICA-CSIC, Spain)
- Cristina Marzachì (IPSP-CNR)





UNIVERSITY
OF BARI
ALDO MORO

D.I.S.S.P.A. – DEPARTMENT OF
SOIL, PLANT AND FOOD SCIENCES

Thanks

Bedankt

Grazie

谢谢

شكراً لك

감사합니다

Merci

Questions?

Gracias

Dziękuję

Ευχαριστώ

Danke

Hvala

ありがとうございました



daniele.cornara@uniba.it





RNA interference (RNAi) for the control of *Philaenus spumarius*, the spittlebug vector of *Xylella fastidiosa* in Europe: lights and shadows

Xylella fastidiosa

5th European conference

Bari, Italy | 22-26 June 2026

Cecilia Parise

cecilia.parise@unito.it
ceciliapalise@cnr.it

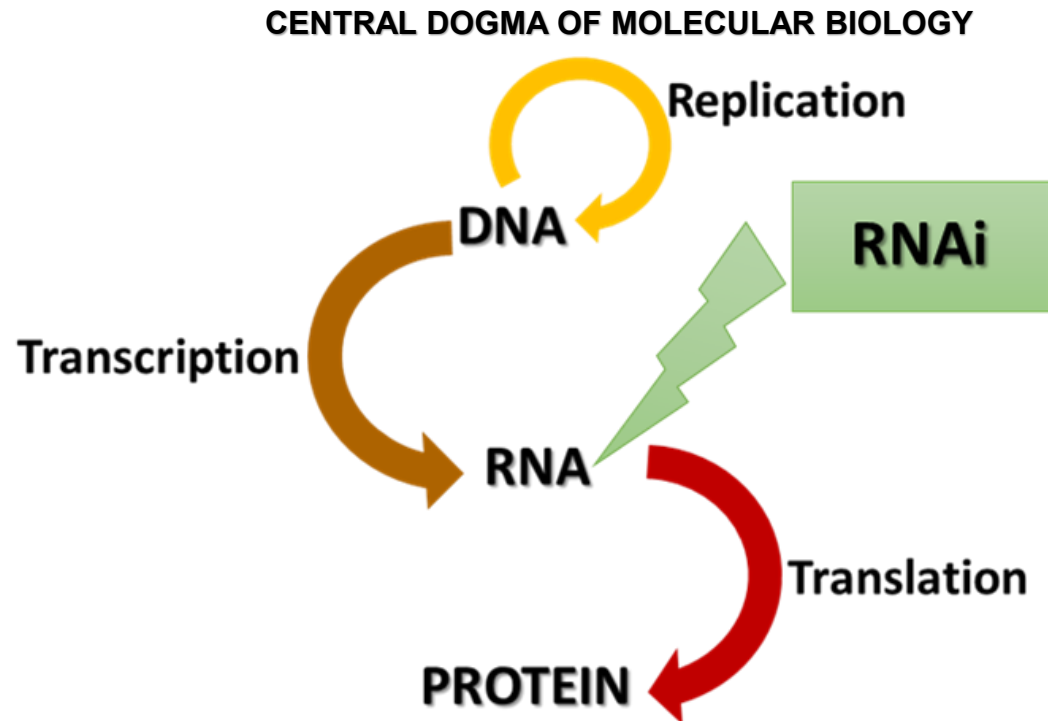


REGIONE PUGLIA

What RNAi is?

RNA interference (RNAi) is a post-transcriptional gene silencing mechanism triggered by double-stranded RNA (dsRNA). It regulates the expression of corresponding transcripts.

This mechanism is widely conserved among eukaryotes and plays a crucial role in defense against viruses and transposons.



Wingard, 1928-J. Agric. Res



Fire et al., 1998-Nature



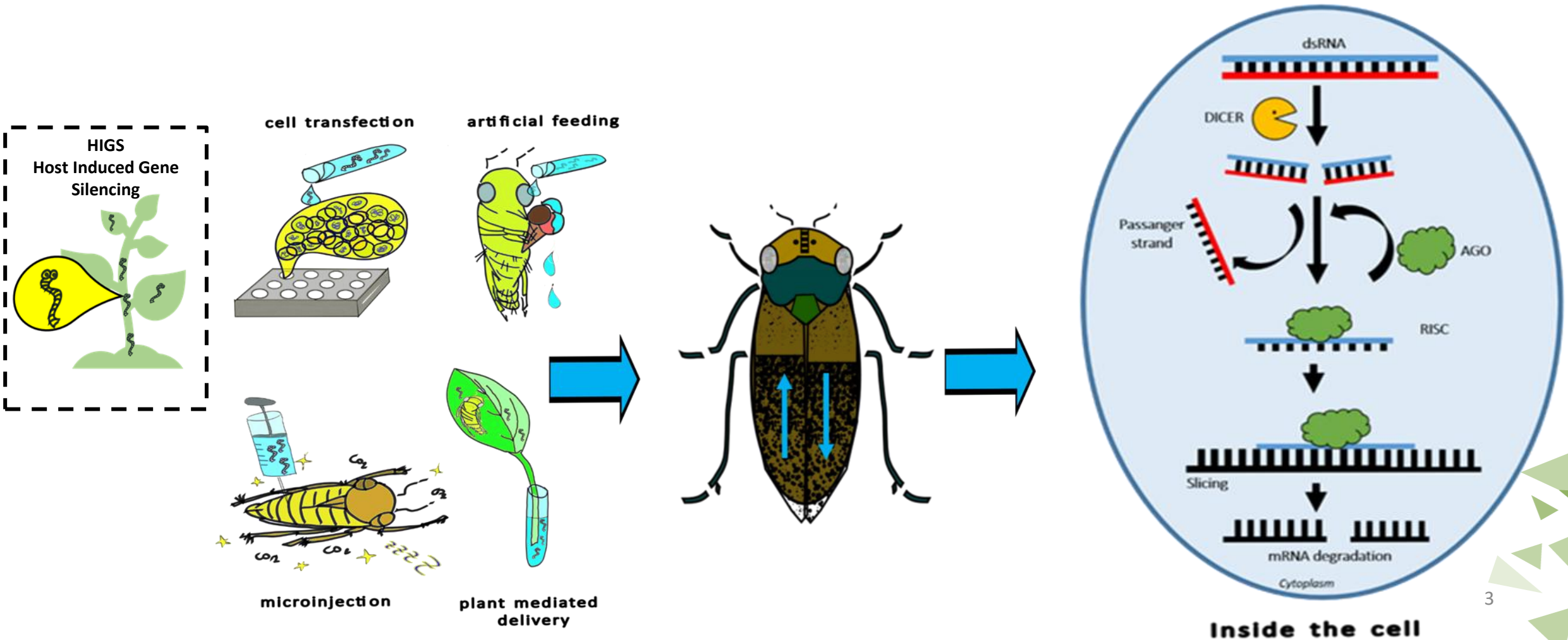
Roignant et al., 2003-*Rna*;
Saleh et al., 2009-Nature



Fujita et al., 2006-*Biochemical
and biophysical research
communications*

How does RNAi work in insects?

It is achieved by exposing the target insect to dsRNA 140-500 bp, using different delivery methods



RNAi in insects: from functional genomics to pest control tool



Exogenous dsRNA application could be a valid tool in agricultural pest management, compared to chemically synthesized pesticides

Advantages

Highly specific against target organisms

Rapid degradation in the environment

Low incidence of resistance
development

Easy to project and design

Disadvantages

Variability of RNAi efficiency in the target
organism

Target gene selection challenges

Gaps in risk assessment protocols and
legislation

Field scale dsRNA delivery

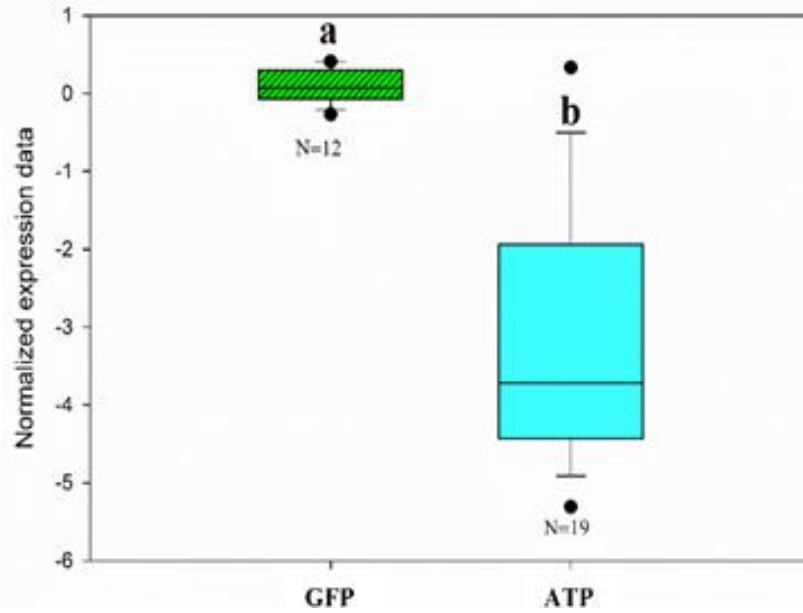
Aims of the study



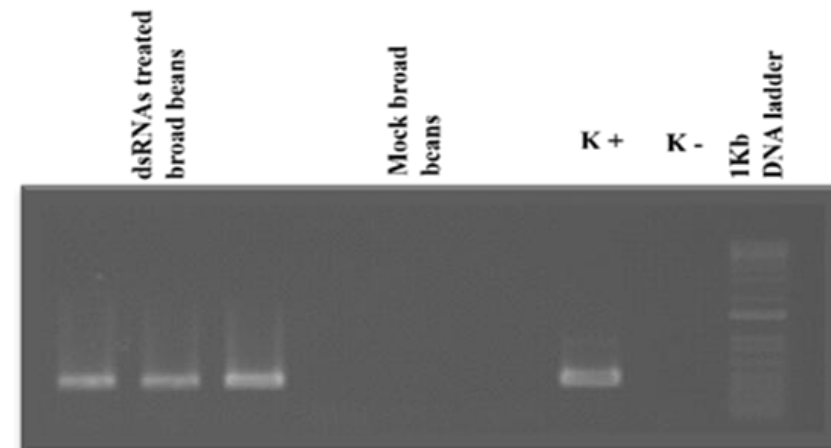
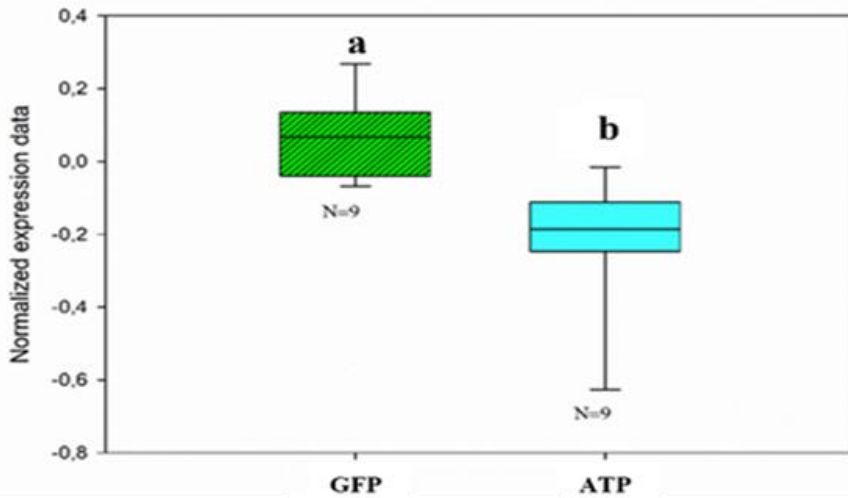
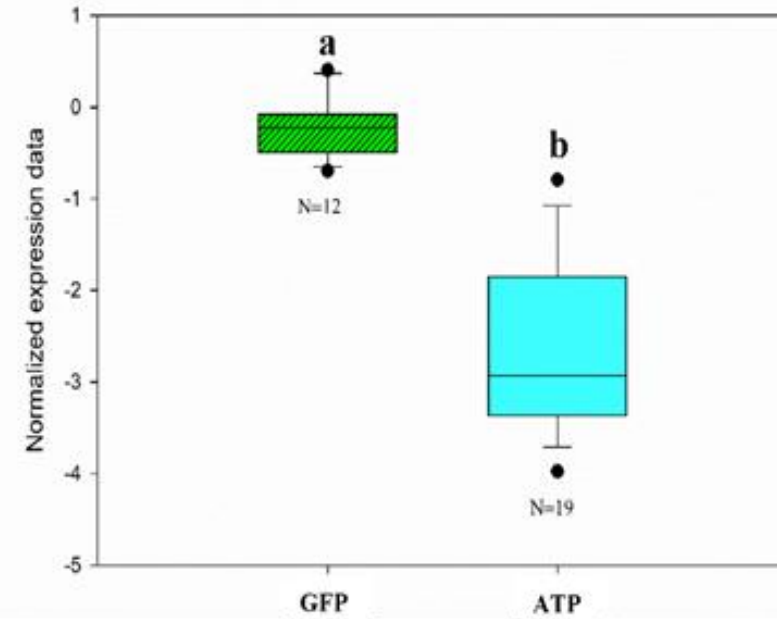
- ❑ Characterize RNA interference (RNAi) in *Philaenus spumarius*
 - ❑ Assess the occurrence and efficiency of dsRNA-mediated gene silencing in *P. spumarius*
- ❑ Identify target genes for RNAi-based control
 - ❑ Validate at least two candidate genes: one inducing mortality and one sterility
- ❑ Test different dsRNA delivery methods

Results

Torax+Abdomen



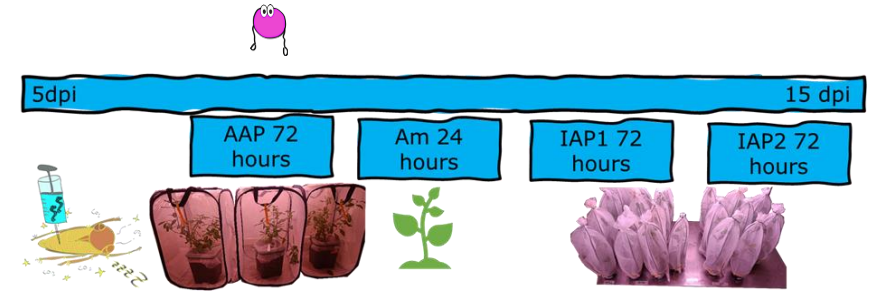
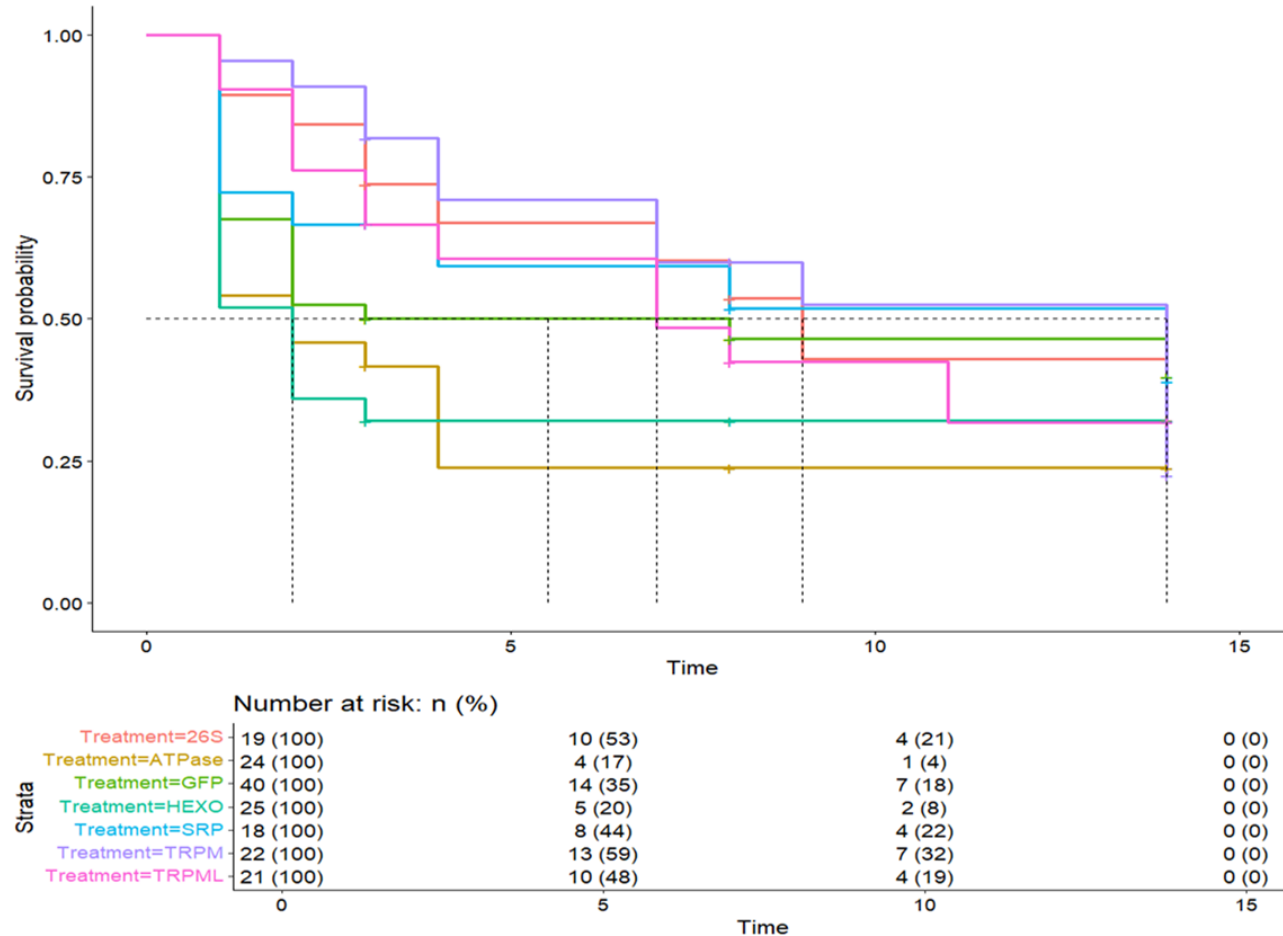
Heads



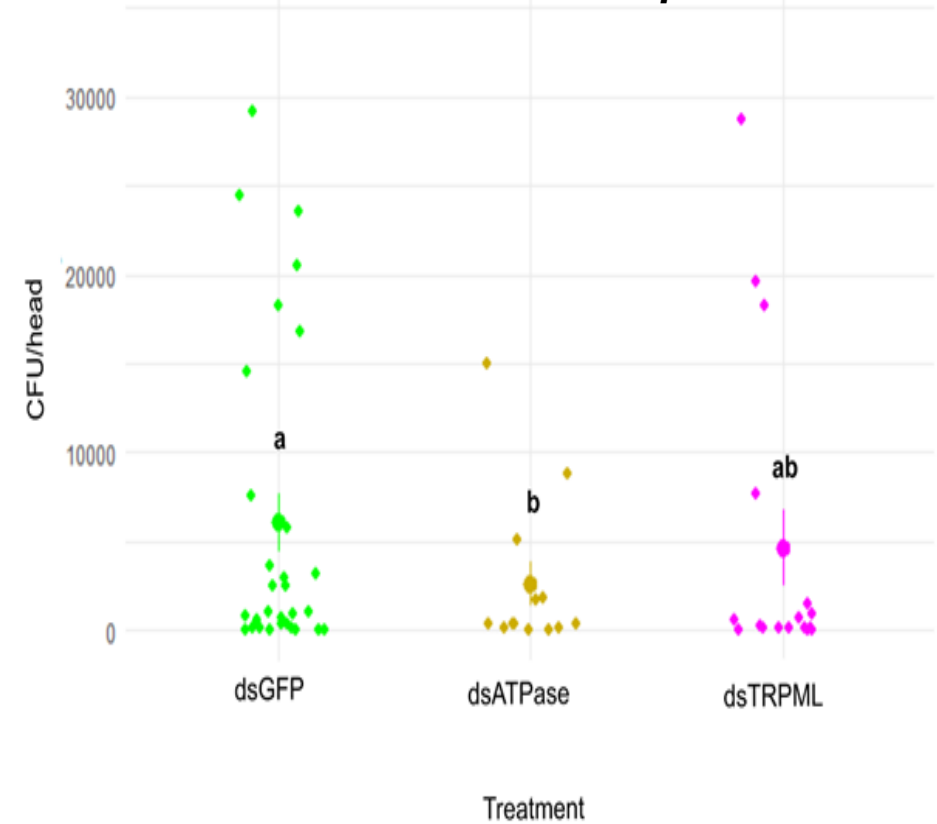
Results



Survival analyses



X. fastidiosa load in *P. spumarius*



Key results in the spotlight

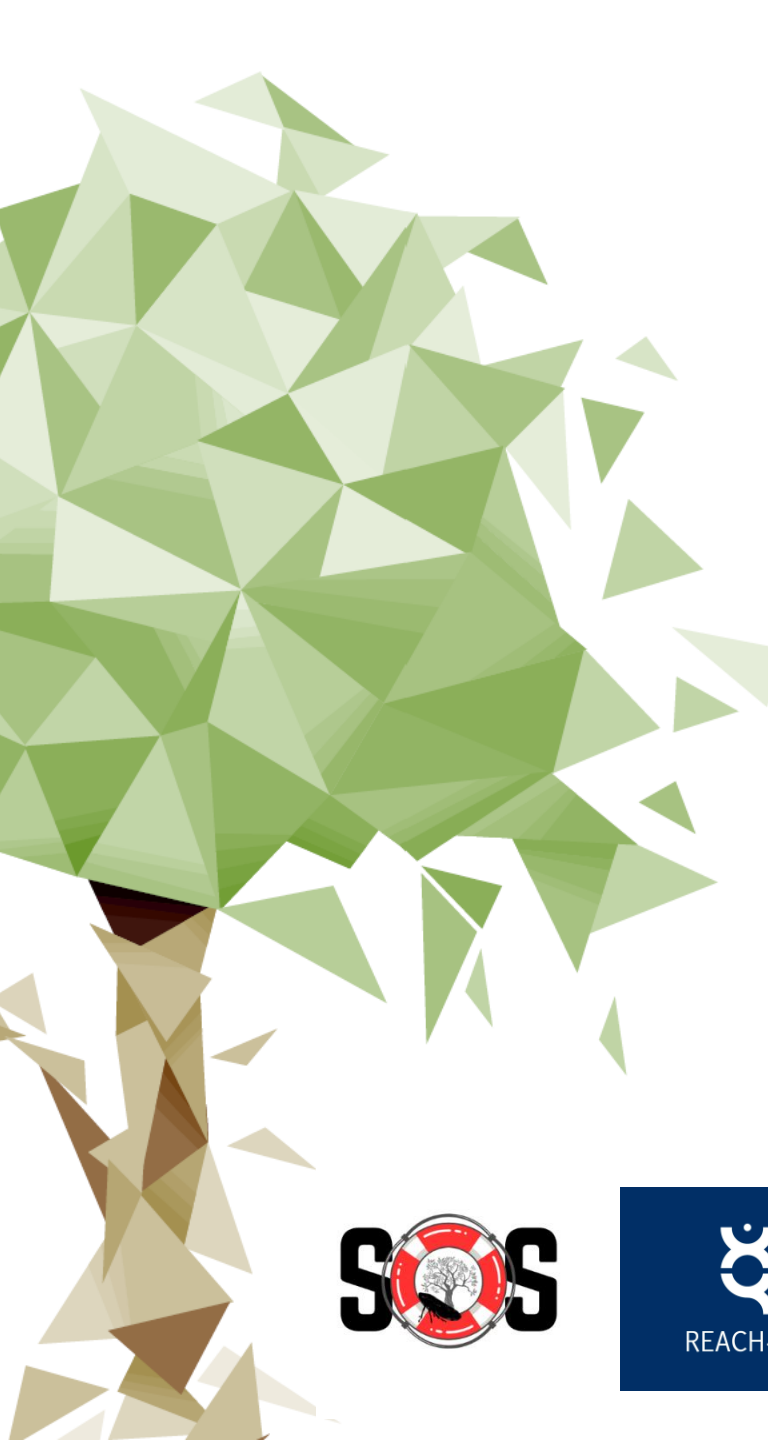


- ✓ ☐ *Philaenus spumarius* has key RNAi core machinery genes and it is capable of processing dsRNA, triggering a systemic and persistent silencing response in both nymphal and adult stages
- ✓ ☐ Among the tested genes, *V-ATPase* was the most effective target in term of induced mortality
- ✓ ☐ Silencing of *V-ATPase* followed by *Xylella fastidiosa* acquisition resulted in a significantly lower bacterial load in *P. spumarius*
- ✓ ☐ Plant mediated delivery of dsRNA proved to be a promising and effective method for targeting sap-feeding insects via xylem-mediated uptake



Final considerations

- **Induced mortality and sterility may substantially contribute to reduce vector abundance in an IPM frame**
- **Plant mediated methods showed promising results for this xylem-sap feeder, however, field dsRNA delivery for sap sucking insects remain challenging**
- **Exogenous application of dsRNA avoid GMO issues and it has been recently approved in a EU country for the control of Colorado Potato Beetle**



Thank you for your attention!

Acknowledgments

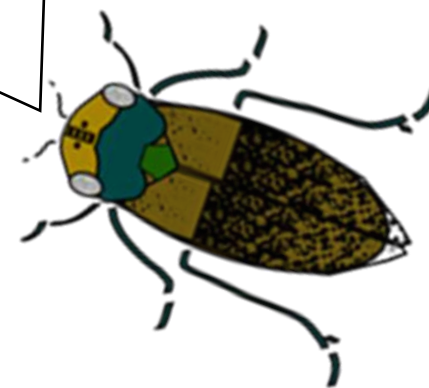
Prof. Domenico Bosco

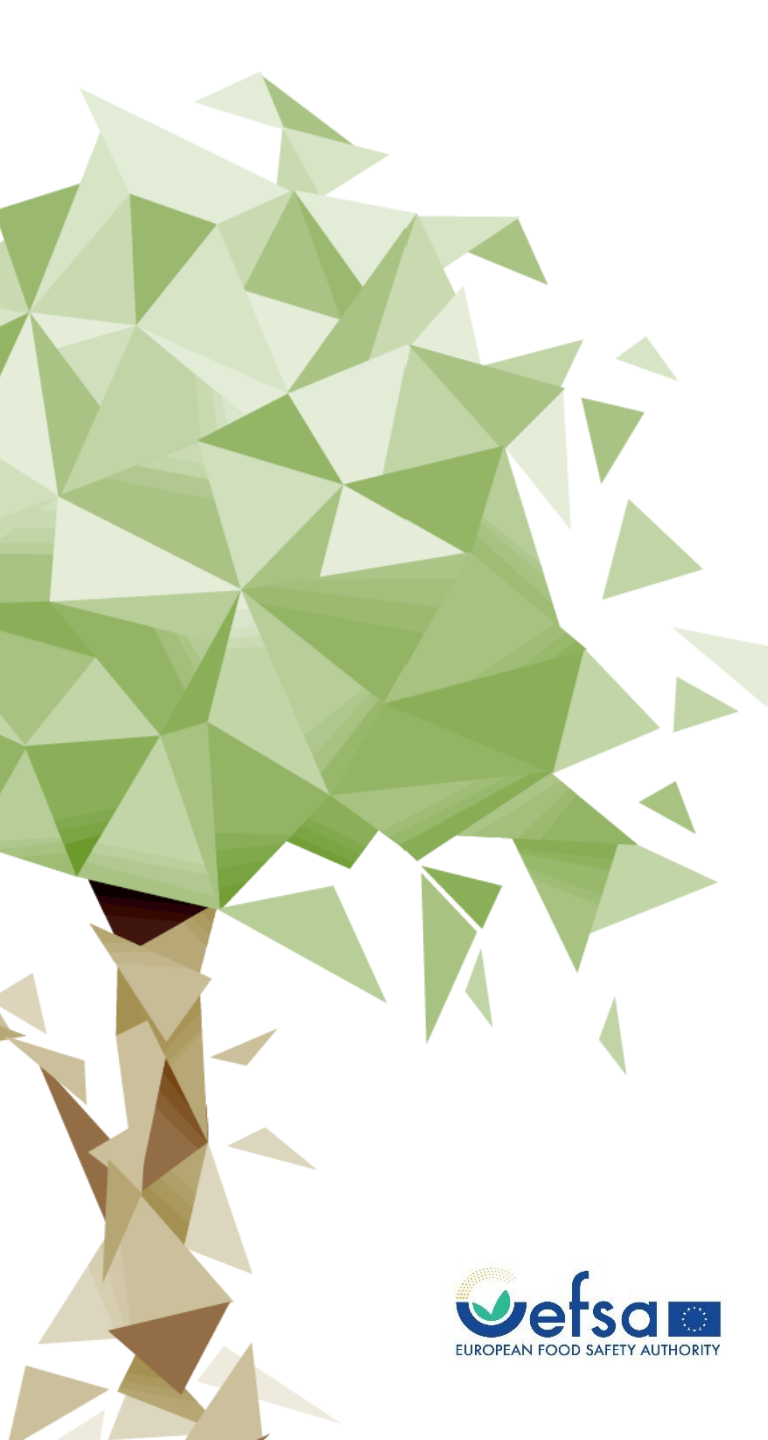
Dr. Luciana Galetto

Prof. Daniele Cornara

Dr. Monica Marra

Pierluigi Perfetto





Xylella fastidiosa

5th European conference

Bari, Italy | 22-26 June 2026

Integrated Agronomic Management Targeting the Juvenile Stages of *Philaenus spumarius*

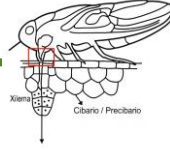
Dongiovanni C., Di Carolo M., Tagliente M., Carrieri M., Argentieri R., Casetta M.,
Cavalieri V.



REGIONE PUGLIA

Why focus on juvenile stages?

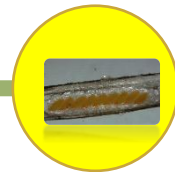
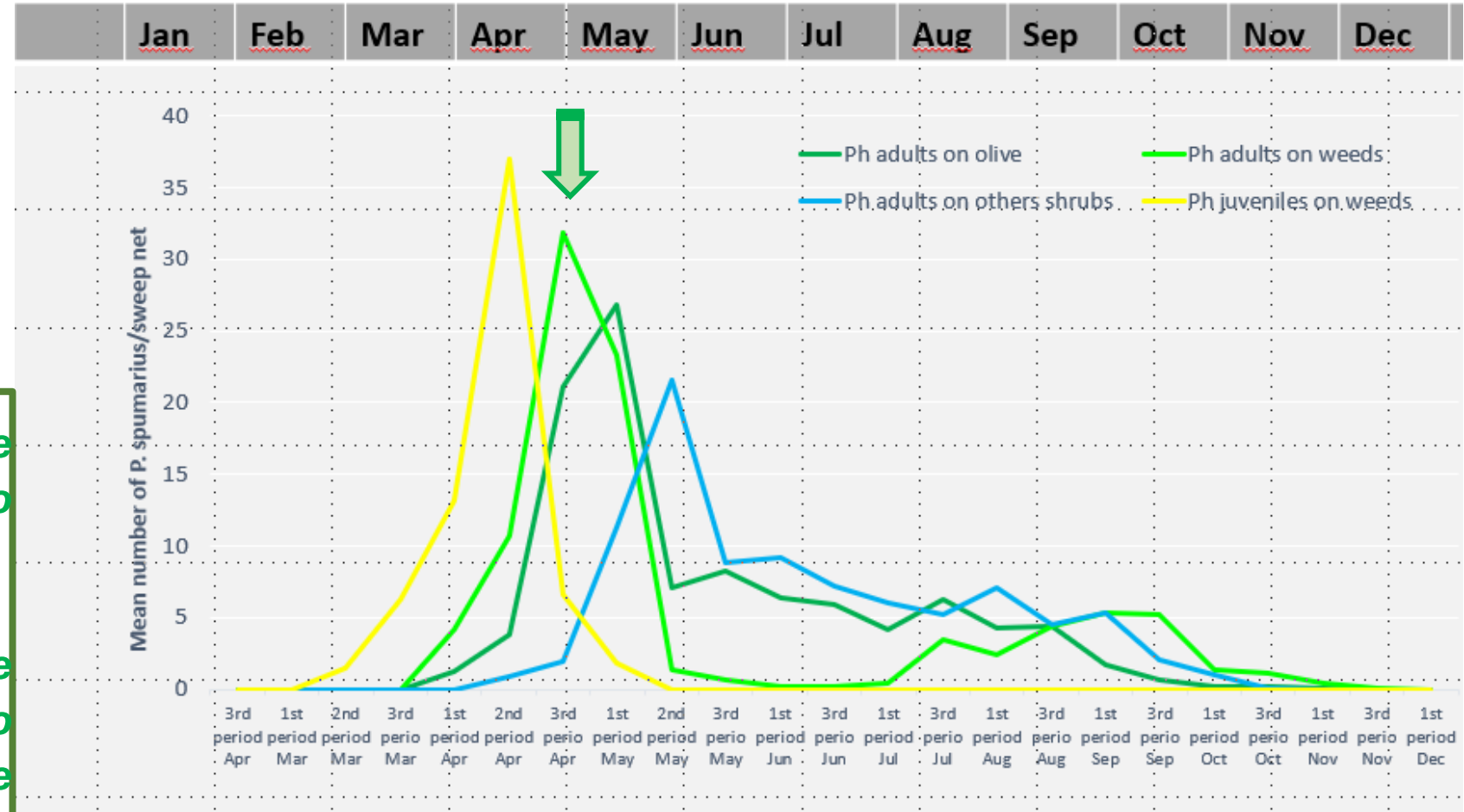
X. fastidiosa is transmitted by xylem-feeding insects; vector control remains a key pillar of containment strategies.



Key action:



- *Nymphs are the most vulnerable stages, as they are confined to herbaceous ground vegetation;*
- *Reducing juveniles reduces the future adult population able to acquire and transmit the bacterium;*
- *Reducing juvenile populations reduces vector pressure and the risk of disease spread*



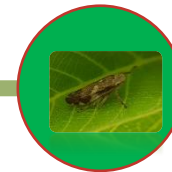
Eggs in debris

Winter diapause



Nymphs on weeds

Most vulnerable target



Adult dispersal

Acquire from infected hosts
High transmission risk

Current measures to control juvenile stages

Area-wide implementation is crucial to reduce future adult populations and transmission risk

Prefer mechanical control

Soil tillage and mulching remove herbaceous hosts and reduce nymphs. Plowing is usually more effective than mulching

Others alternatives

- Flame weeding :
- Herbicide: highly effective but generally discouraged for its environmental impact; reserve them for sites where other measures are not feasible.

Substance actually authorized in Italy

- potassium salts of fatty acids.



Alternative strategies tested for the control of juvenile stages of *spittlebugs*

GOAL: reduce juvenile populations before adult emergence and before *X. fastidiosa* acquisition.

Natural substances



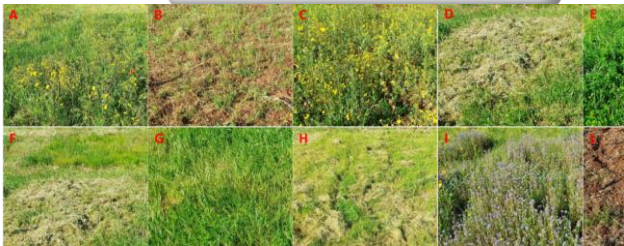
Pelargonic acid

Maltodextrin (MDX)

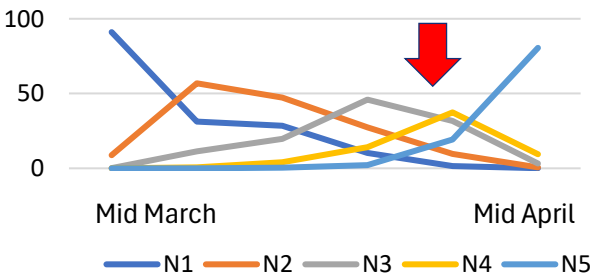
Cover crop

Entomopathogenic fungi
(Beauveria bassiana; Metharizium anisopliae)

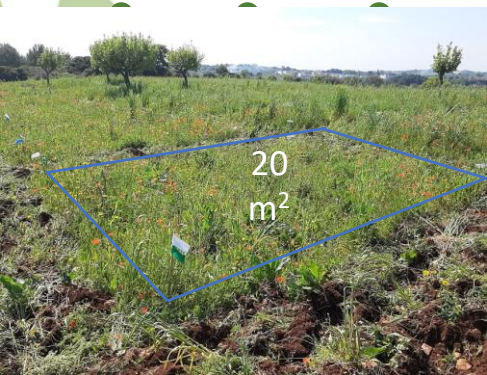
Ground cover management



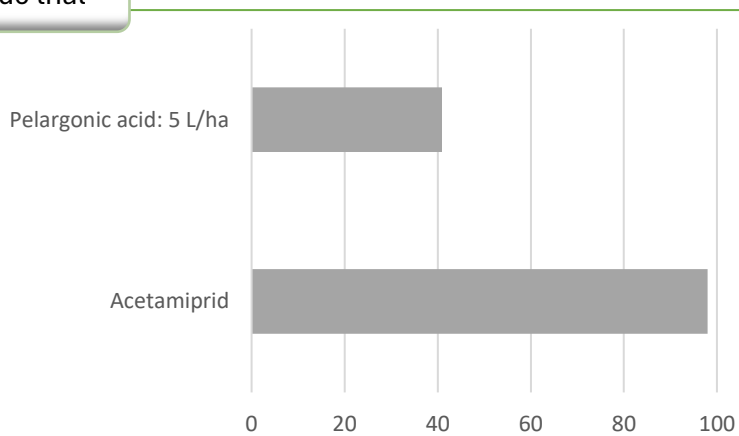
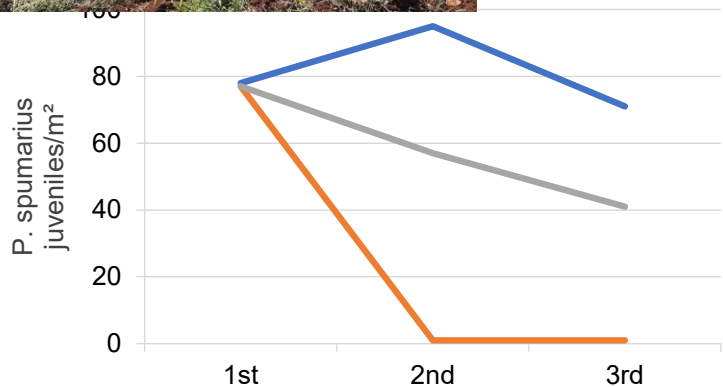
Best time to target juveniles: 3rd–4th instar peak before adults emerge



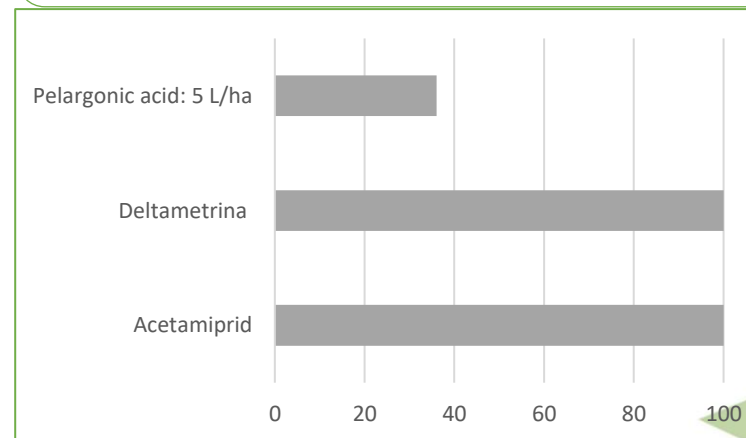
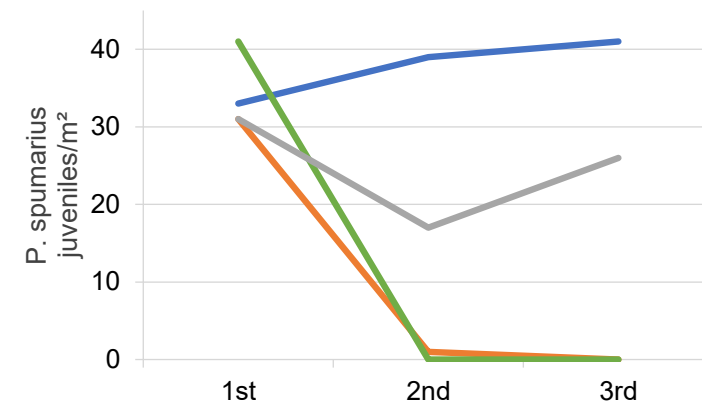
Small-scale trials evaluating pelargonic acid efficacy against juvenile *P. spumarius*



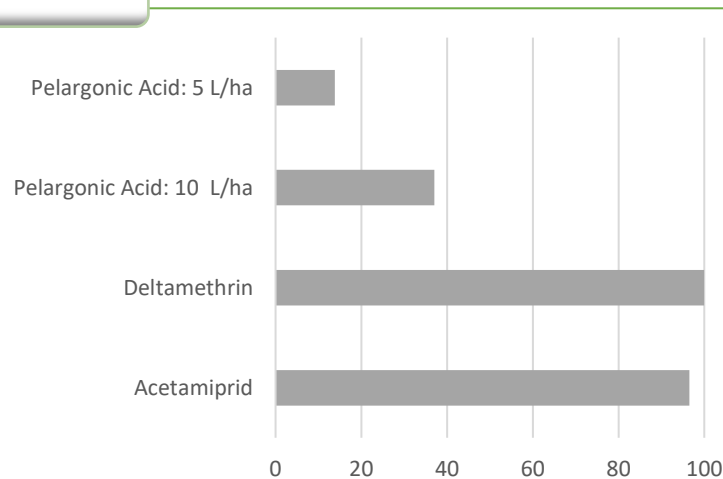
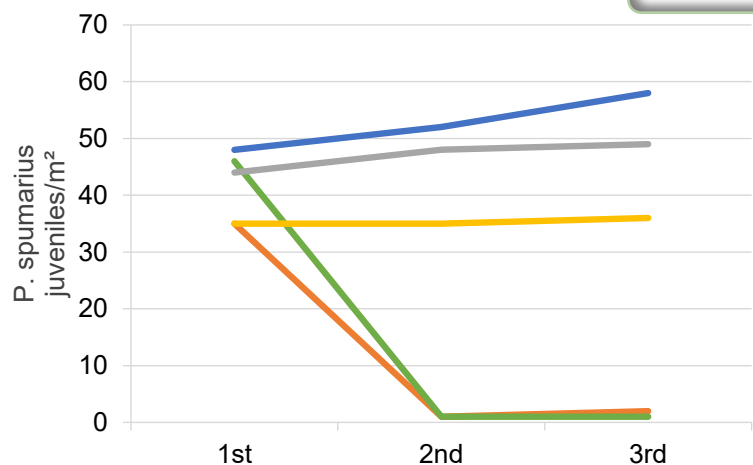
Locorotondo trial



Nardò trial



Cisternino trial

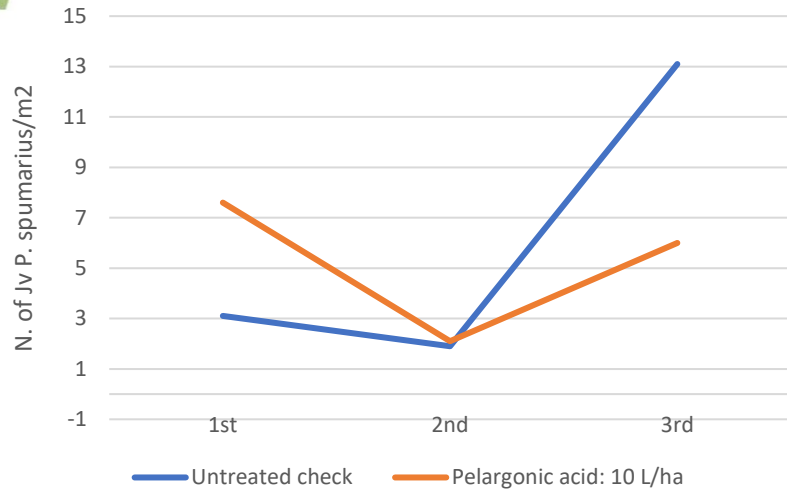


■ Untreated check ■ Acetamiprid ■ Deltamethrin
■ Pelargonic acid 5 L/ha ■ Pelargonic acid 10 L/ha

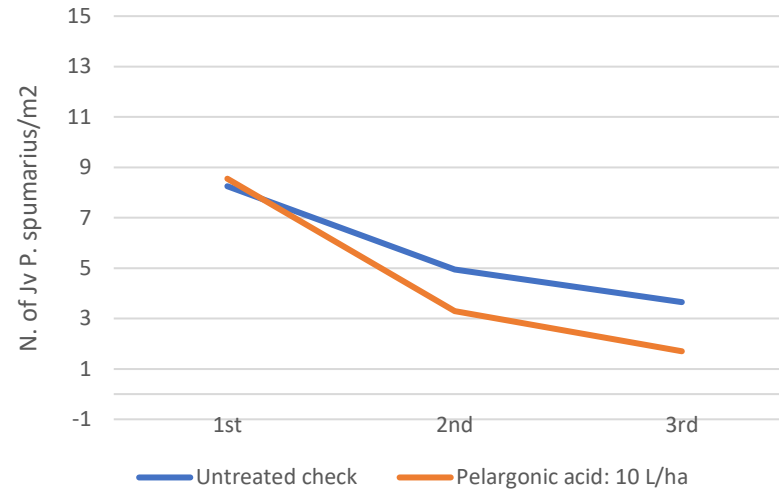
Large-scale trials evaluating pelargonic acid efficacy against juvenile *P. spumarius* in Francavilla Fontana



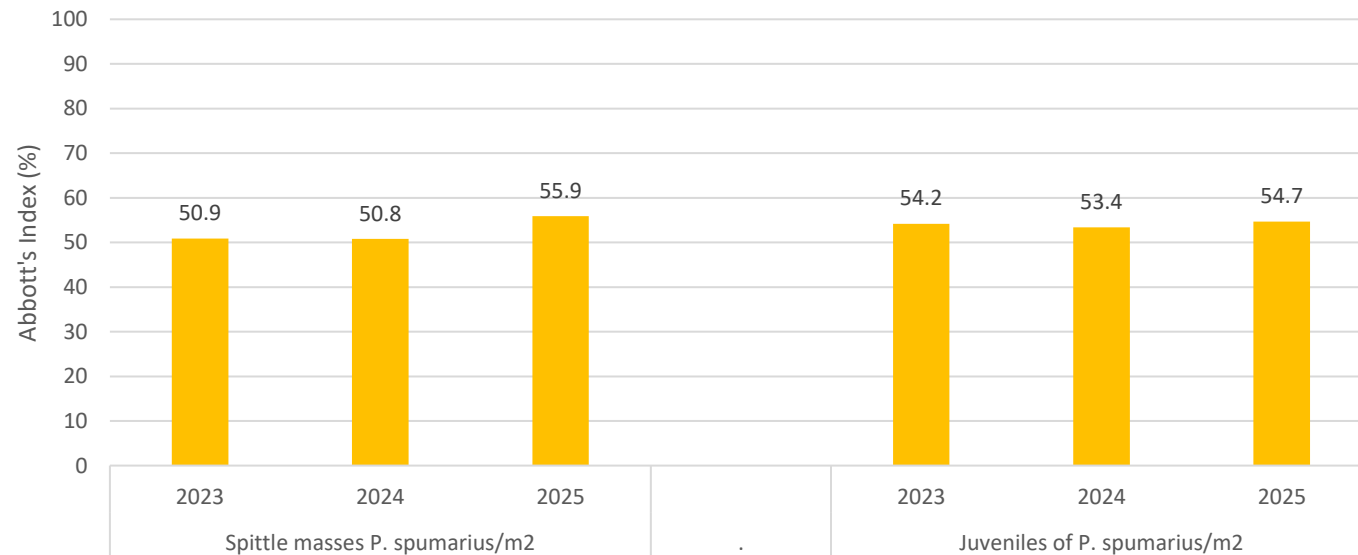
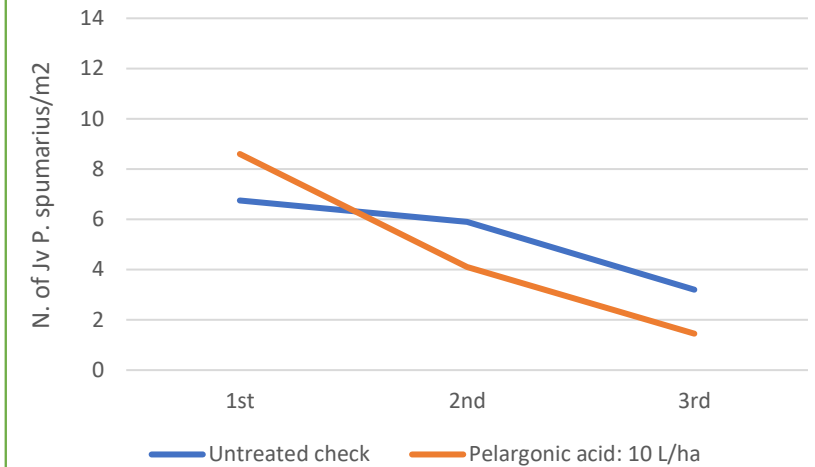
2023



2024



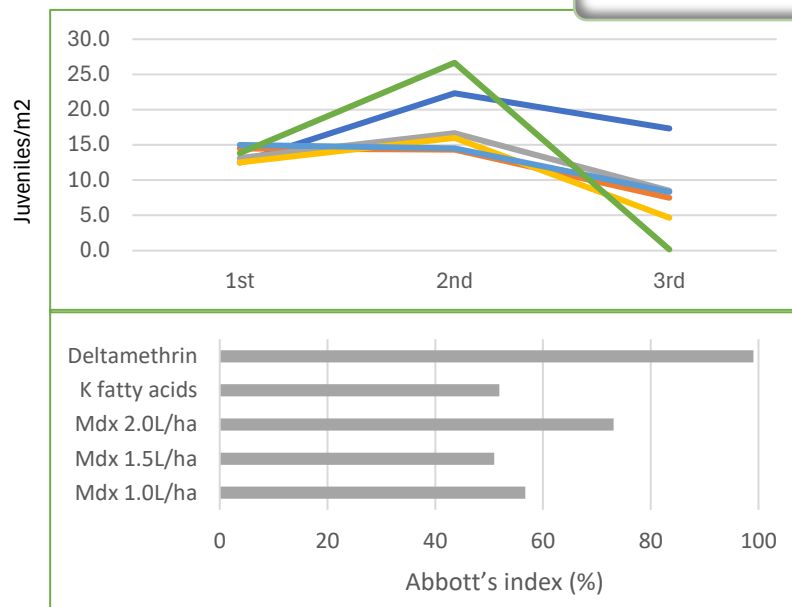
2025



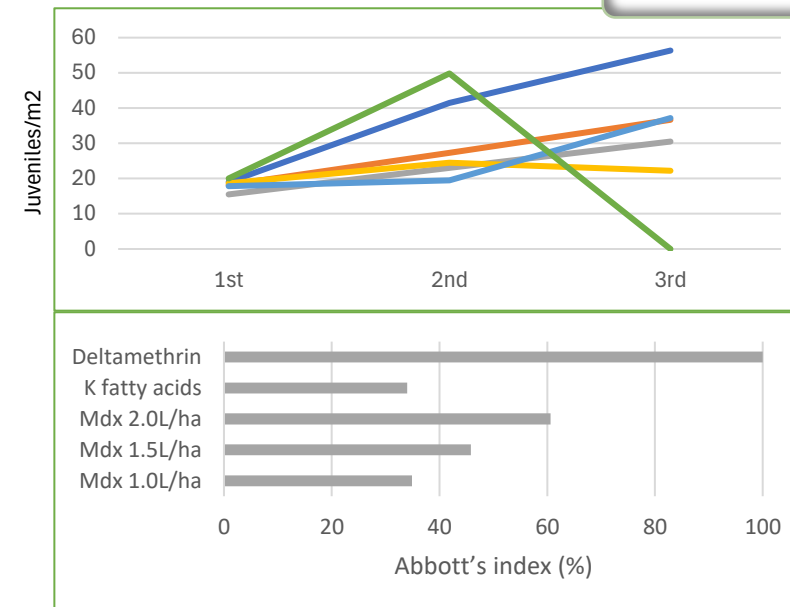
Small-scale trials evaluating maltodextrin (Mdx) efficacy against juvenile *P. spumarius* - 2025



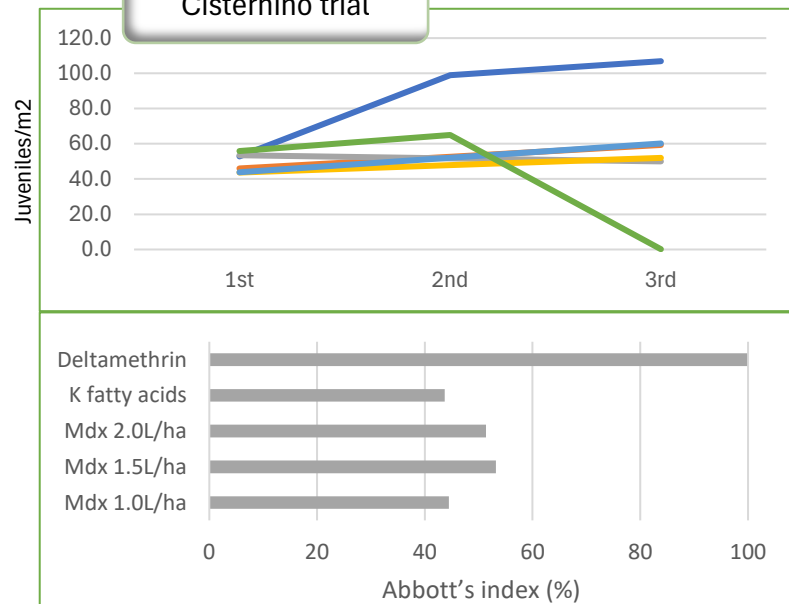
Ugento trial



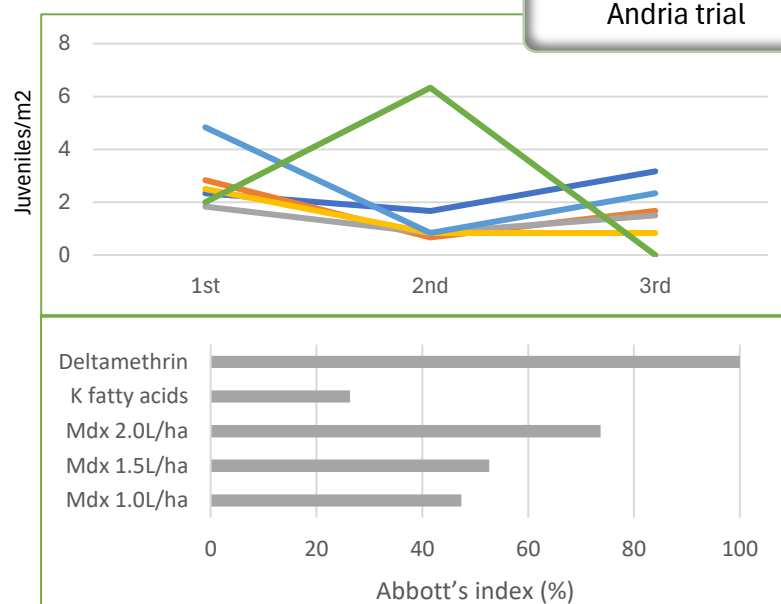
Cutrofiano trial



Cisternino trial



Andria trial

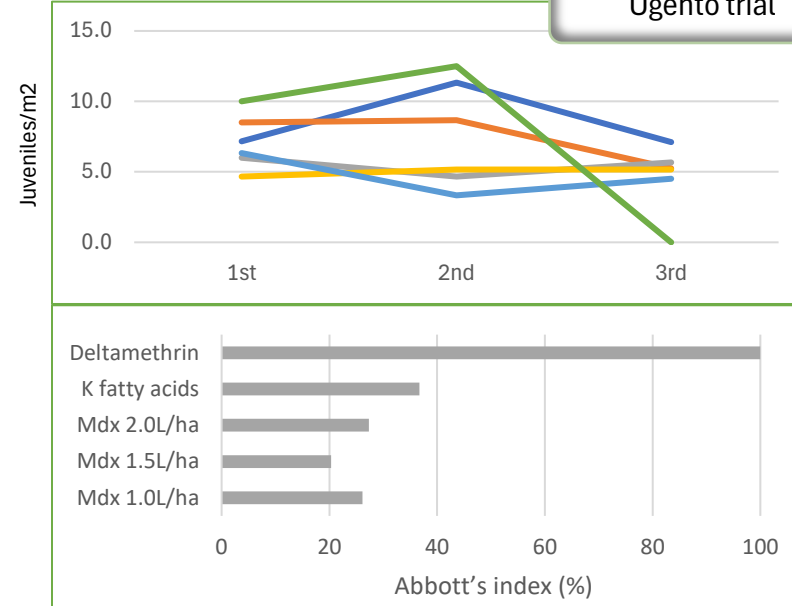


— Untreated check — Mdx 1.0L/ha — Mdx 1.5L/ha
— Mdx 2.0L/ha — K fatty acids — Deltamethrin

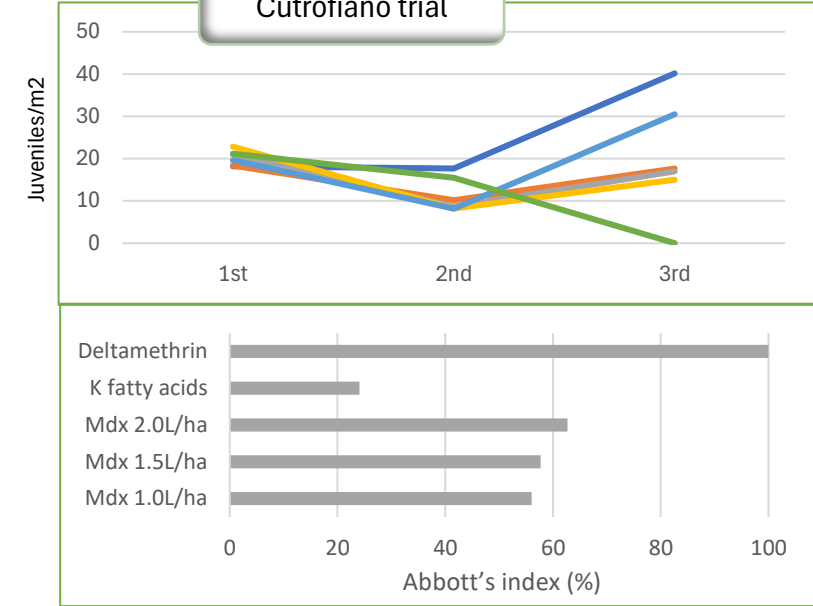
Small-scale trials evaluating maltodextrin (Mdx) efficacy against *N. campestris* juveniles - 2025



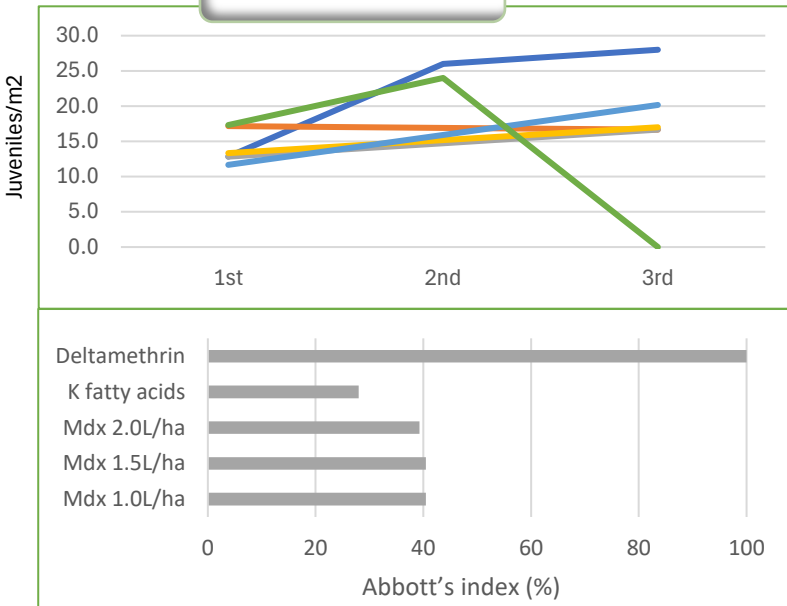
Ugento trial



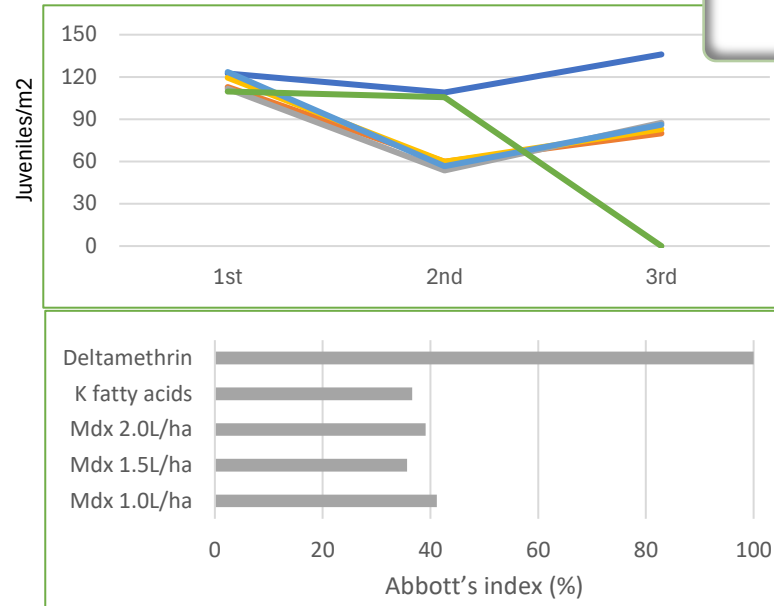
Cutrofiano trial



Cisternino trial



Andria trial



— Untreated check — Mdx 1.0L/ha — Mdx 1.5L/ha
 — Mdx 2.0L/ha — K fatty acids — Deltamethrin

Small-scale trials evaluating the efficacy of ground cover management against *P. spumarius* juveniles

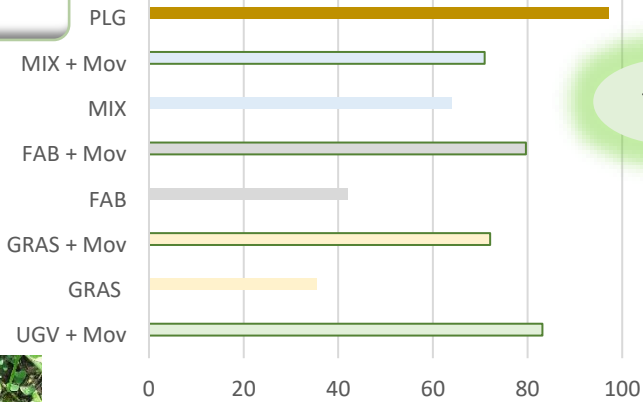


Treatment	Trials					
	Small scale				Large scale	
	2023		2024		2025	2026
	Santeramo	Locorotondo	Gallipoli	Cisternino	Andria	Lecce
Undisturbed ground vegetation (UGV)	X	X	X	X	X	X
Undisturbed ground vegetation + mulching (UGV + mov)	X	X	X	X		
Sowing Cruciferae (Sinapsis alba, Brassica Juncea, Raphanus sativus) (GRAS)	X	X	X	X		
Sowing Cruciferae + mulching (GRAS + mov)	X	X	X	X		
Sowing Fabaceae (Trifolium incarnatum, Medicago sativa) (FAB)	X		X	X		
Sowing Fabaceae + mulching (FAB + mov)	X		X	X		
Sowing (Grasses (Lolium italicum) + Cruciferae + Fabaceae) (MIX)	X	X	X	X	X	X
Sowing (Grasses + Cruciferae + Fabaceae) + mulching (MIX + mov)	X	X	X	X		
Phacelia (PHAC)			X	X		X
Phacelia + mulching (PHAC + mov)			X	X		
Ploughing (PLG)	X	X	X	X	X	X



Small-scale trials evaluating ground cover management efficacy against *P. spumarius* juveniles

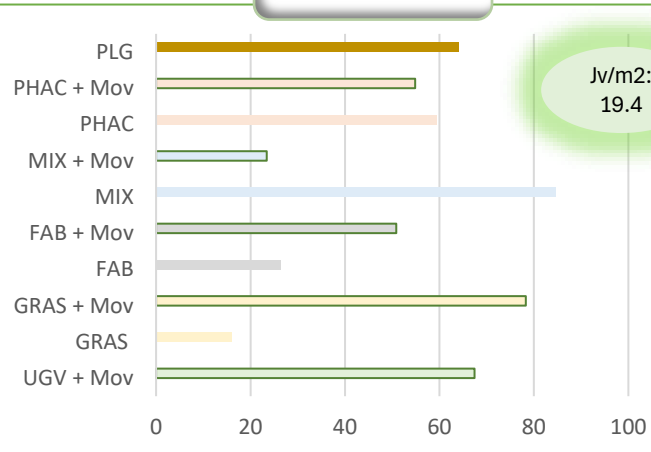
Santeramo trial
2023



Locorotondo trial
2023

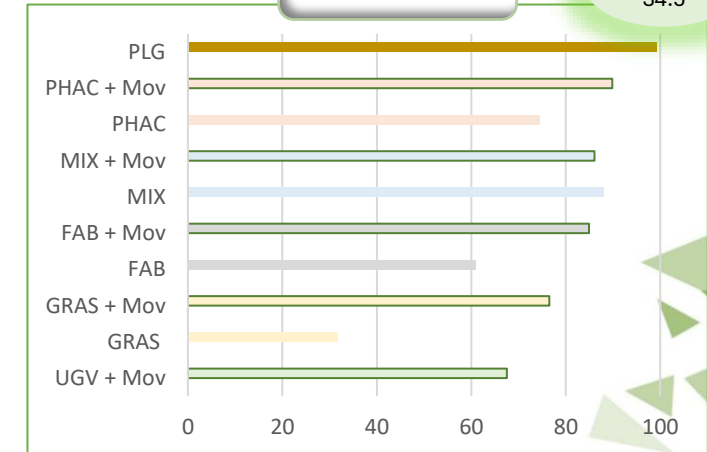


Gallipoli trial
2024



A) Undisturbed spontaneous vegetation; B) Mown spontaneous vegetation; C) Sowing of Cruciferae; D) Sowing of Cruciferae + mowing; E) Sowing of Fabaceae; F) Sowing of Fabaceae + mowing; G) Sowing of a mixture of Poaceae, Cruciferae and Fabaceae; H) Sowing of a mixture of Poaceae, Cruciferae, Fabaceae + mowing; I) Sowing of *Phacelia tanacetifolia*; L) Ploughing.

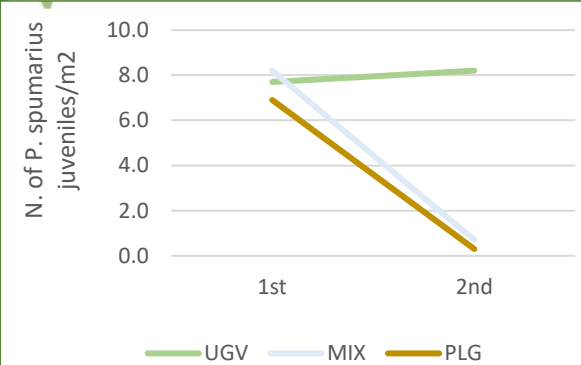
Cisternino trial
2024



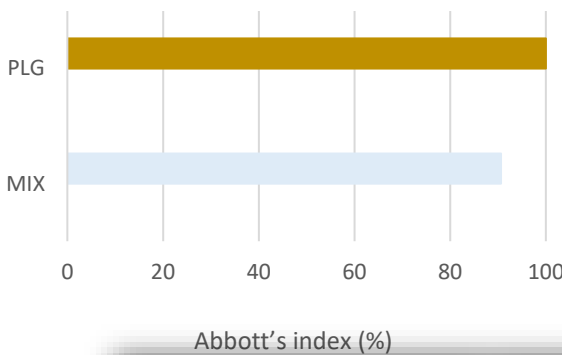
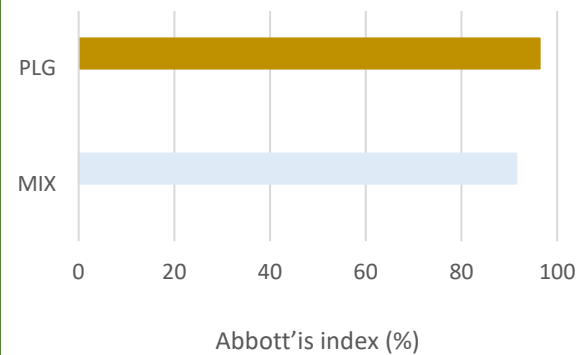
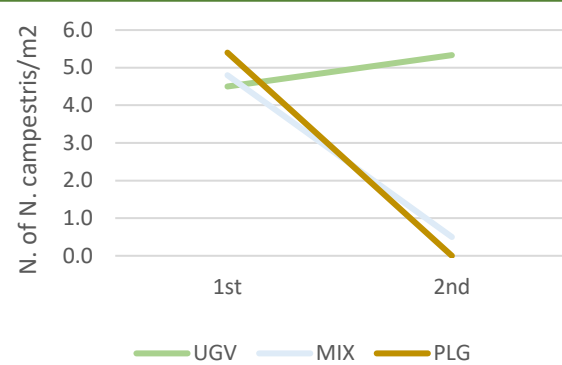
Large-scale trials evaluating ground cover management efficacy against juvenile *spittlebugs* – 2025-2026

Andria trial - 2025

P. spumarius

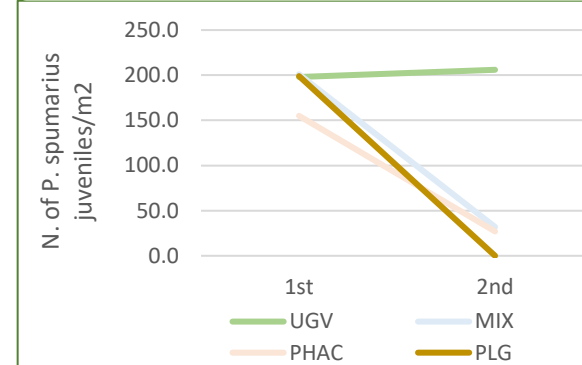


N. campestris

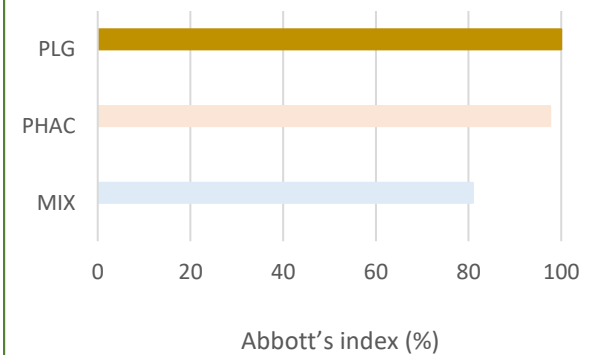
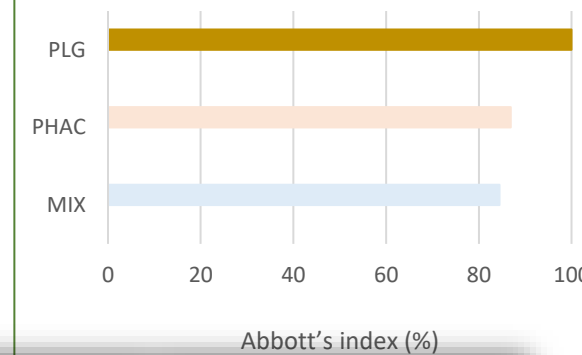
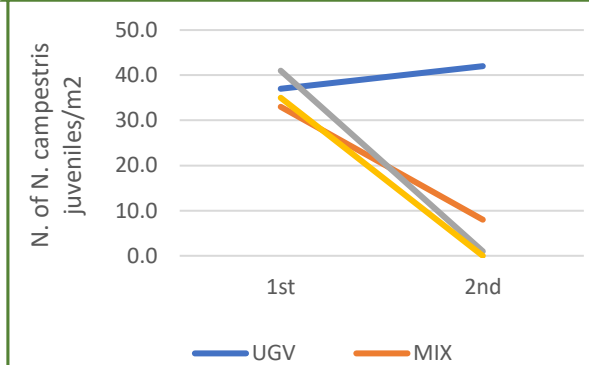


Lecce trial – 2026

P. spumarius



N. campestris



Small-scale trials evaluating Entomopathogenic fungi efficacy against *spittlebugs* – 2025-2026

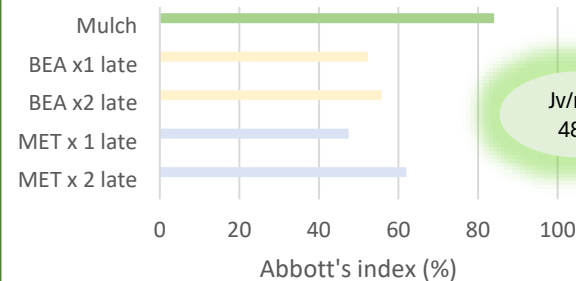


Crispiano trial

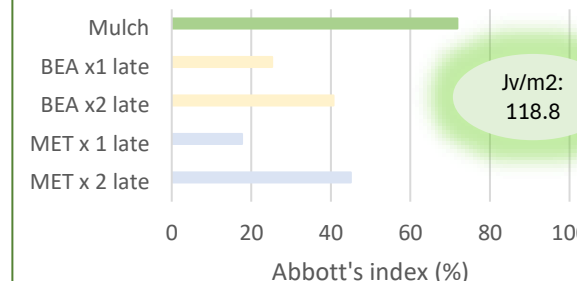
Cisternino trial

2025

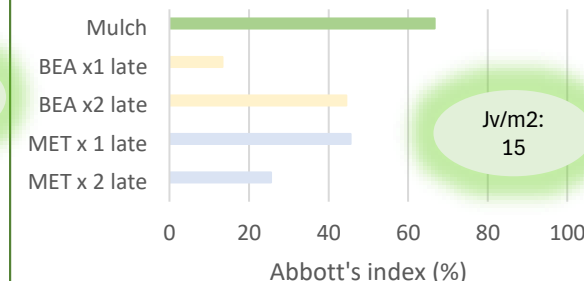
P. spumarius



P. spumarius

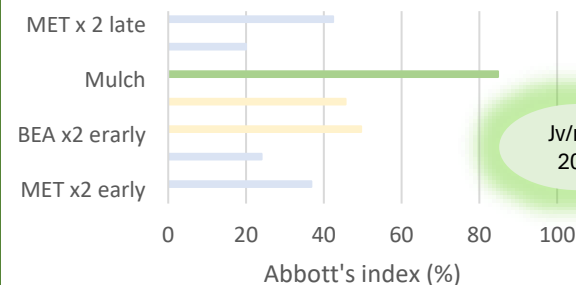


N. campestris

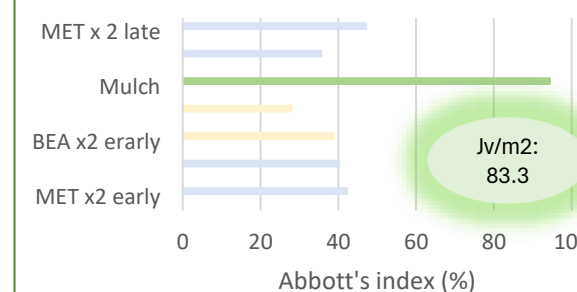


2026

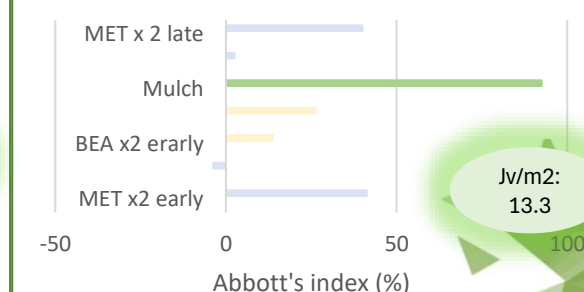
P. spumarius



P. spumarius



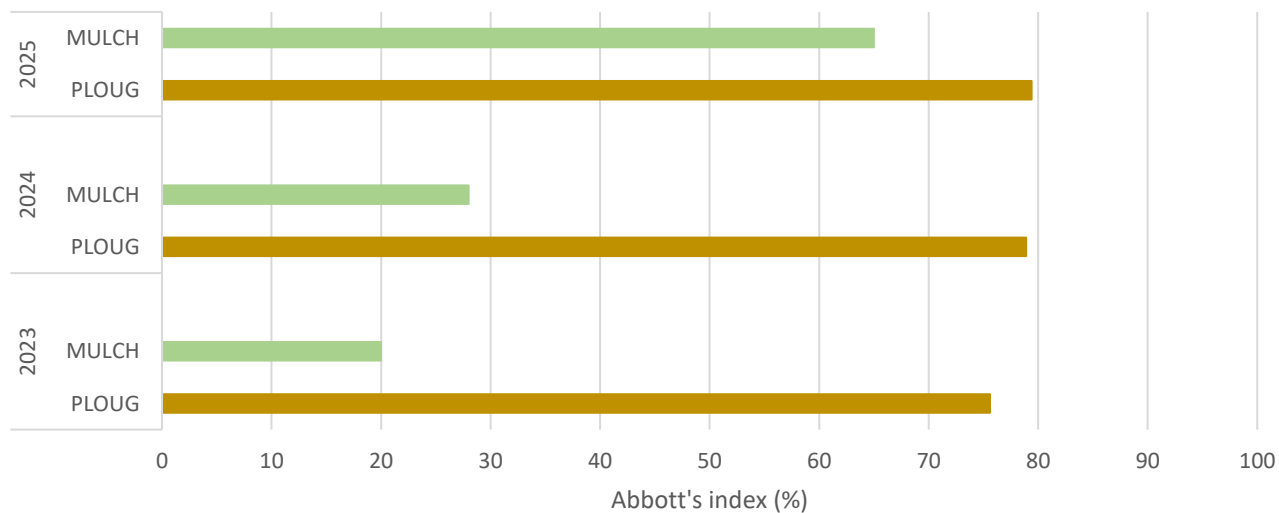
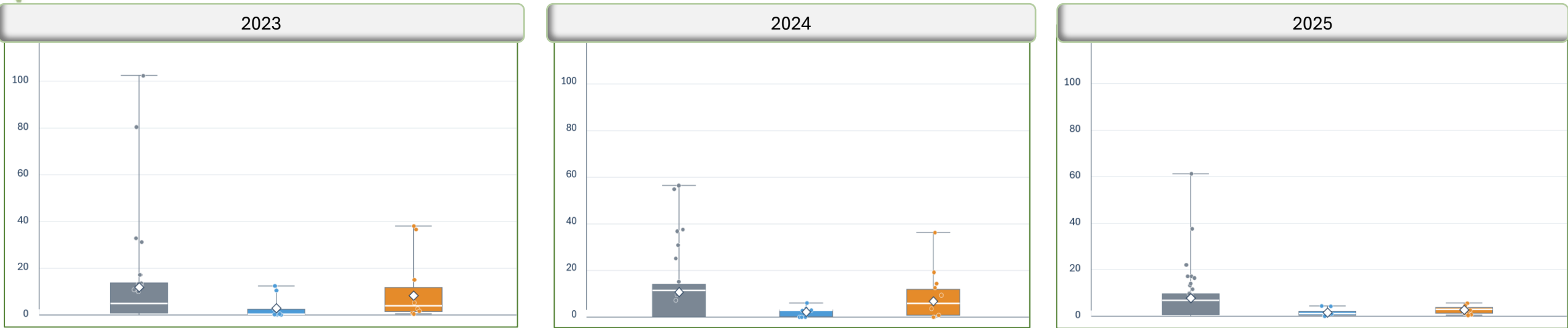
N. campestris



Metharizium anisopliae strain BP1q (**MET**); *Beauveria bassiana* (**BEA**)

M. anisopliae selected by the groups of Prof. Bosco - University To.
Produced by Agrifutur srl

Farmer-scale evaluation of mulching and plowing for the control of *P. spumarius* juvenile stages in 16 newly planted olive Fs17 and Leccino olive orchards (2023-2025)





Conclusion

- **Plowing** provided the strongest reduction in juvenile populations of spittlebugs, also under farmer-scale conditions. However, its repeated use may adversely affect soil structure and the sustainability of agroecosystems;
- **Mulching** represents more conservative soil-management strategies, but their effectiveness was generally lower and strongly influenced by the botanical composition of the ground vegetation. In particular, rosette-forming weed species may provide suitable refuges for juvenile stages, reducing the impact of these practices;
- **Alternative low-impact solutions**, including natural substances such as **pelargonic acid** and **maltodextrin**, **entomopathogenic fungi**, and **cover crops**, showed variable performance. Their efficacy appeared to be highly dependent on application timing, microclimatic conditions, and vector population pressure;
- Overall, these tools should be considered as complementary components of an **integrated management strategy**. Combining low-impact products with conservative soil practices, or using them to support mowing and mulching, may help improve control efficacy while reducing reliance on intensive plowing and preserving soil structure.



Centro di Ricerca
Sperimentazione e Formazione
in Agricoltura "BASILE CARAMIA"



Consiglio Nazionale delle Ricerche
Istituto per la Protezione Sostenibile delle Pianta

Thanks for your attention

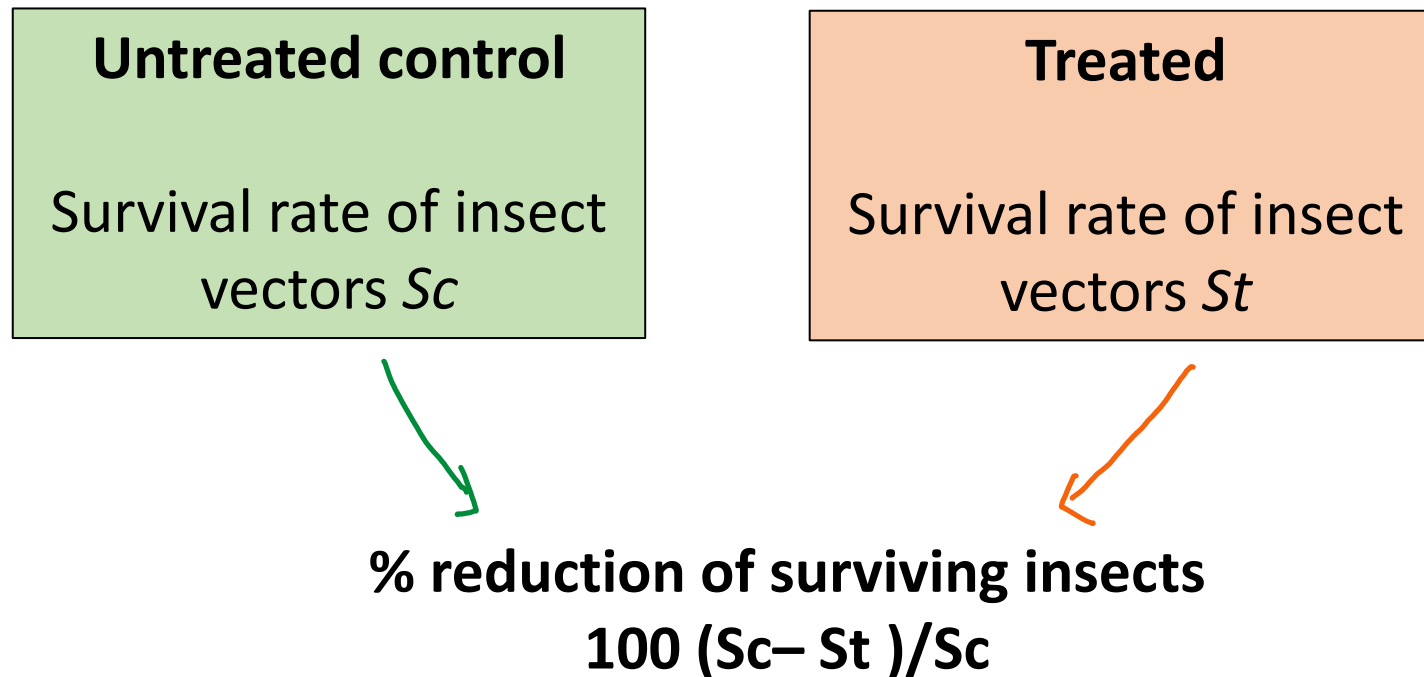


Direct control of insect vectors of *Xylella fastidiosa*: a systematic review and meta-analysis

David Makowski
INRAE, France

Objective

Systematic review and meta-analysis of experimental data to evaluate control measures against insect vectors of *X. fastidiosa*



Outline

**Literature search
(31/03/2026)**

**Paper selection (title,
abstract screening)**

**Critical methodological
appraisal**

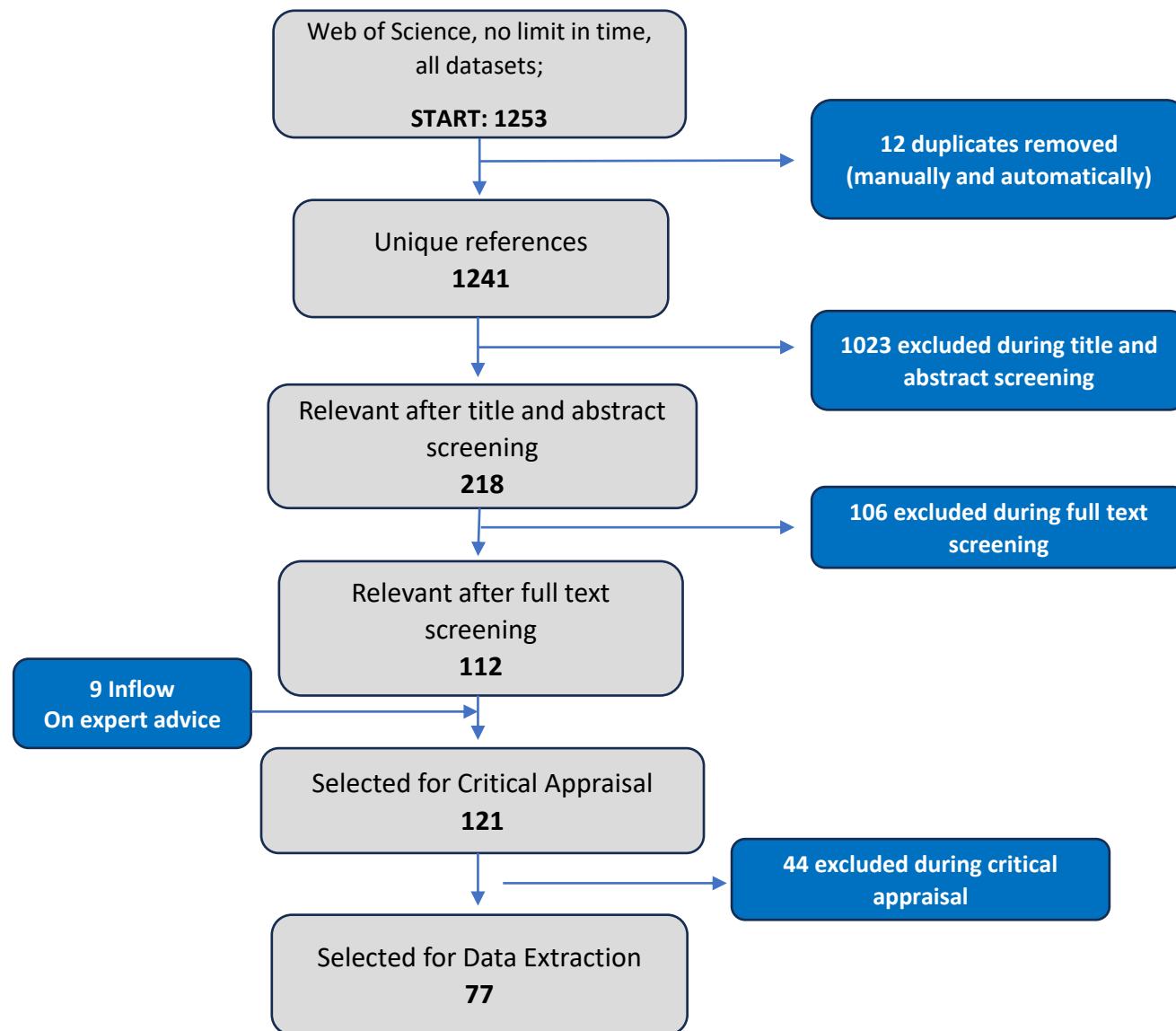
Data extraction

Statistical analysis

Bias and uncertainty

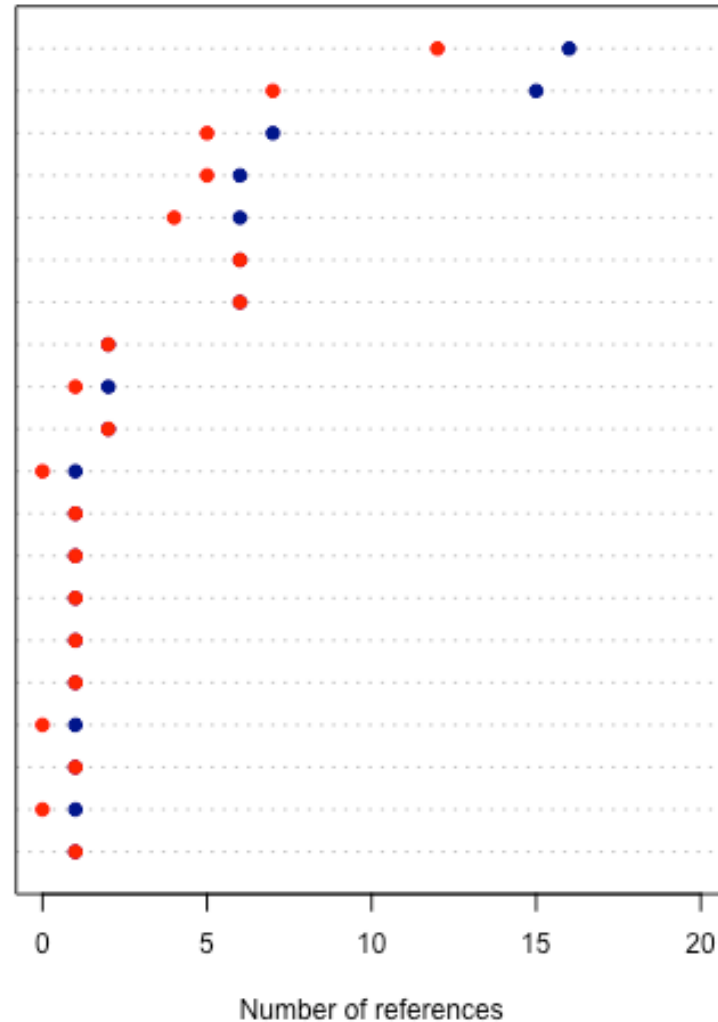


Paper selection



Number of references by species

Philaenus spumarius
Mahanarva fimbriolata
Oncometopia facialis
Homalodisca vitripennis
Homalodisca coagulata
Mahanarva spectabilis
Aeneolamia varia
Mahanarva andigena
Neophilaenus campestris
Deois flavopicta
None (mechanical inoculation)
Aenoelamia varia
Zulia enteriana
Mahanarva spectabilis/ Deois schach
Dilobopterus costalimai
Prosapia bicincta
Deois flavopicta and Zulia enteriana (Cercopidae)
Aeneolamia/Prosapia
Graphocephala atropunctata
Bucephalogonia xanthophis



Number of references by vector species in the full dataset (blue points) and in the dataset used for the meta-analysis MA (red points).

Identical numbers appear in red.

Full dataset=77 references

Dataset for MA=57 references

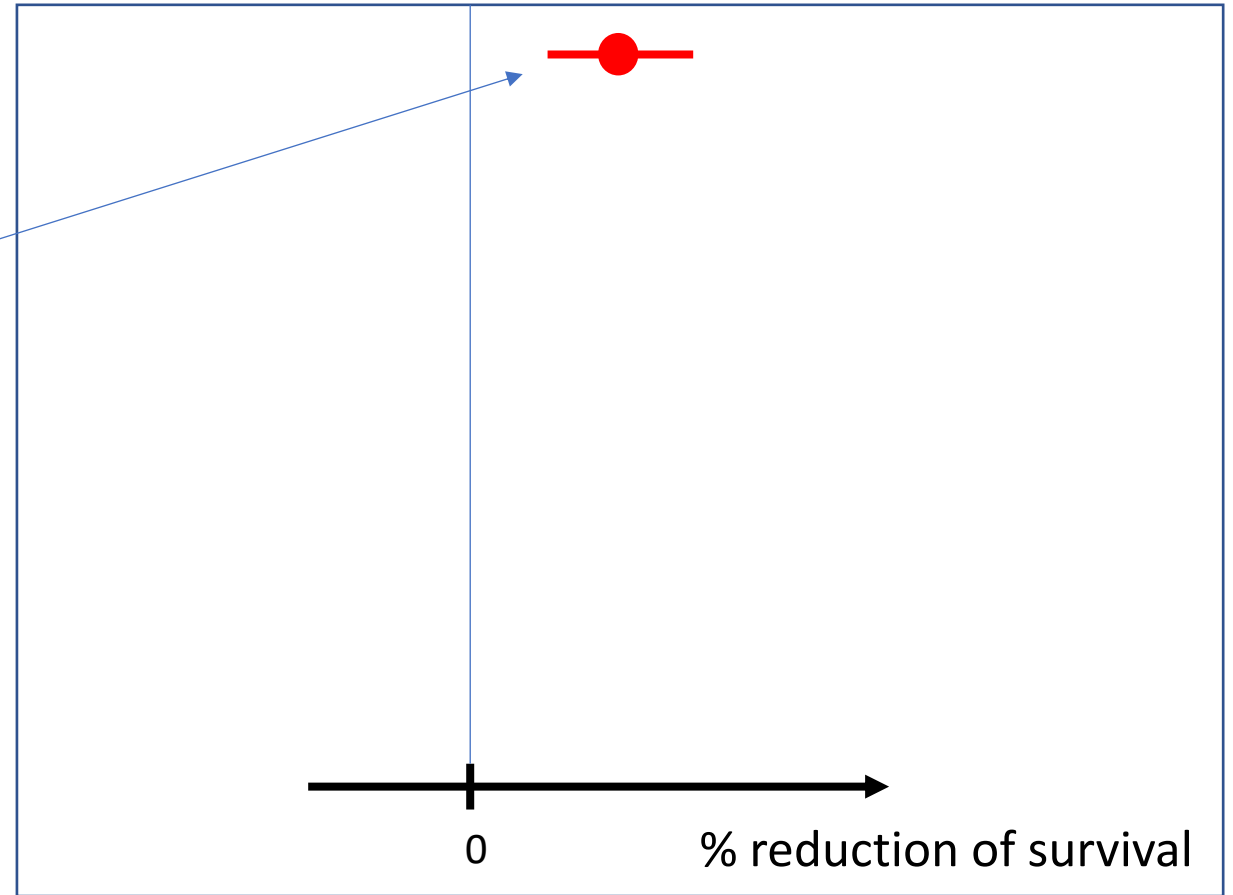
Lower number of references for MA due to absence of data or missing data in several references.



Selected studies



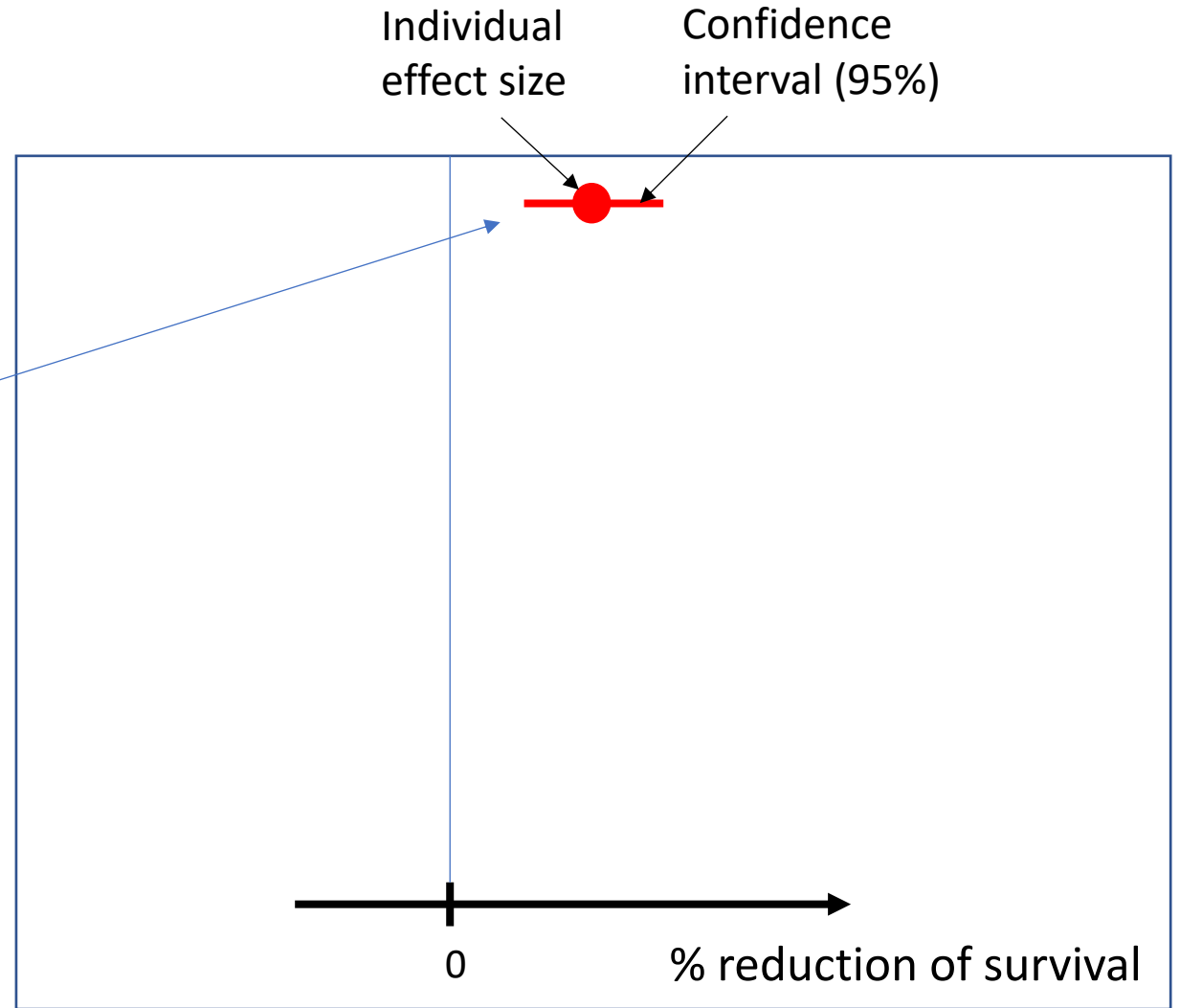
Study 1
Study 2
Study 3
Study 4
...
Study N



Selected studies



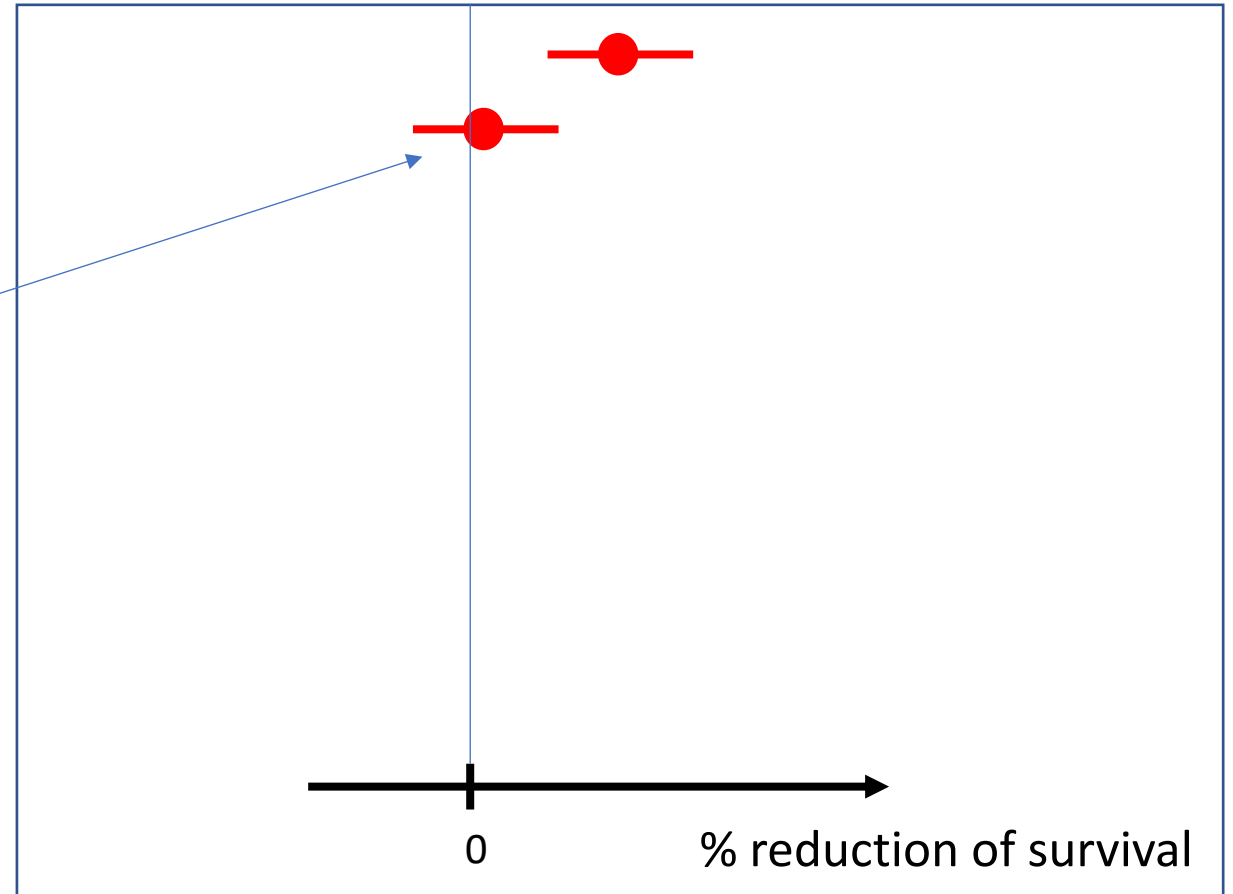
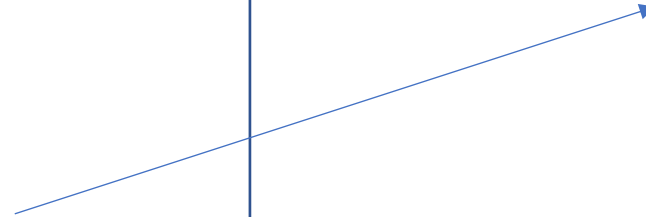
Study 1
Study 2
Study 3
Study 4
...
Study N



Selected studies



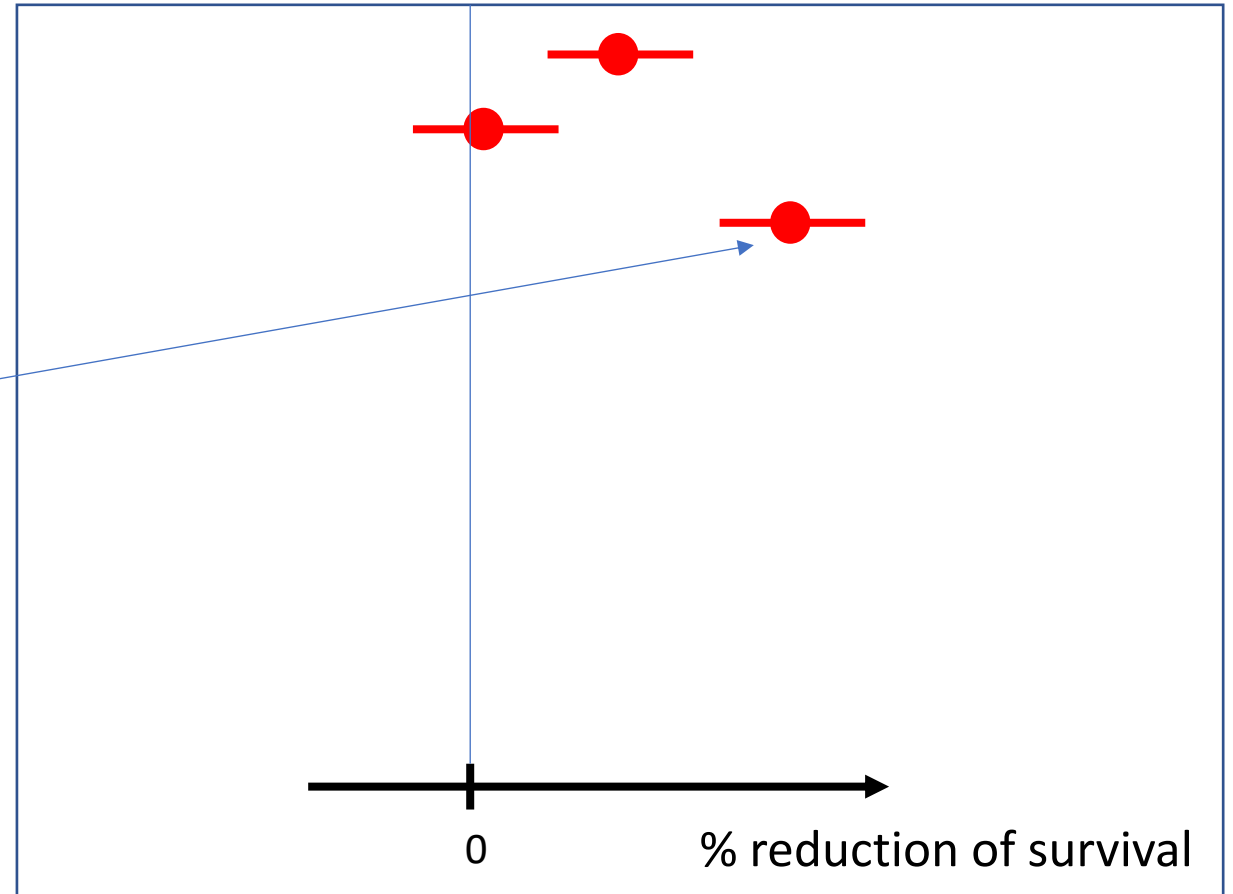
Study 1
Study 2
Study 3
Study 4
...
Study N



Selected studies



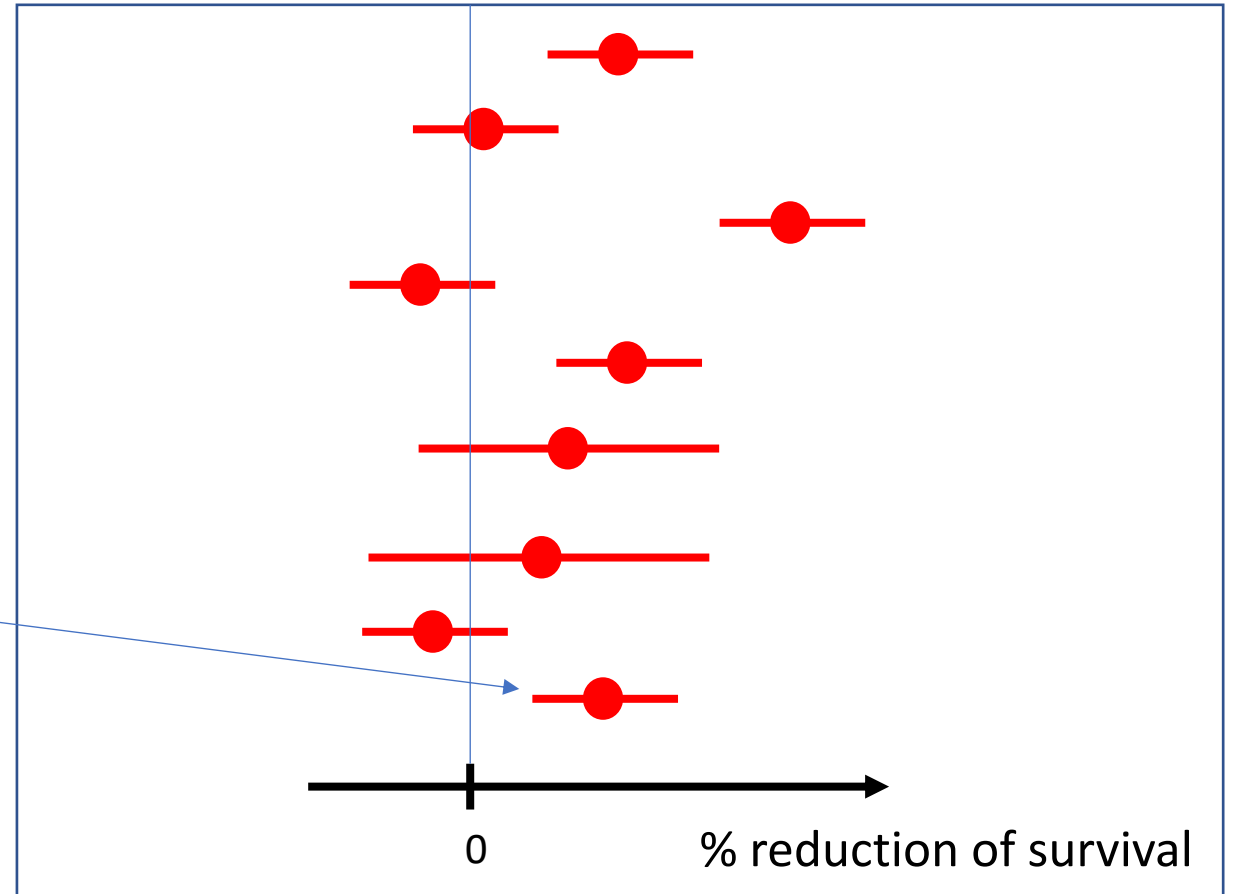
Study 1
Study 2
Study 3
Study 4
...
Study N

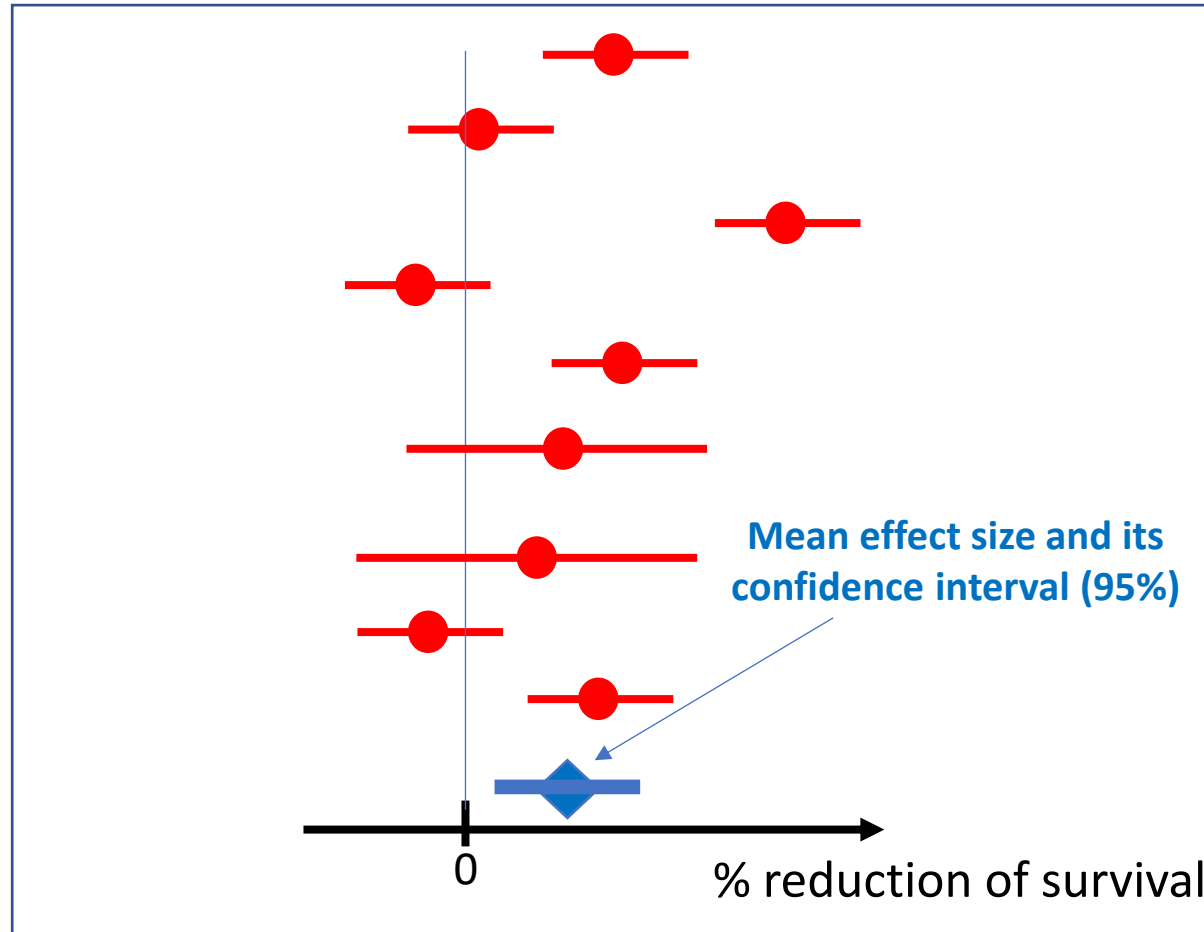


Selected studies



Study 1
Study 2
Study 3
Study 4
...
Study N





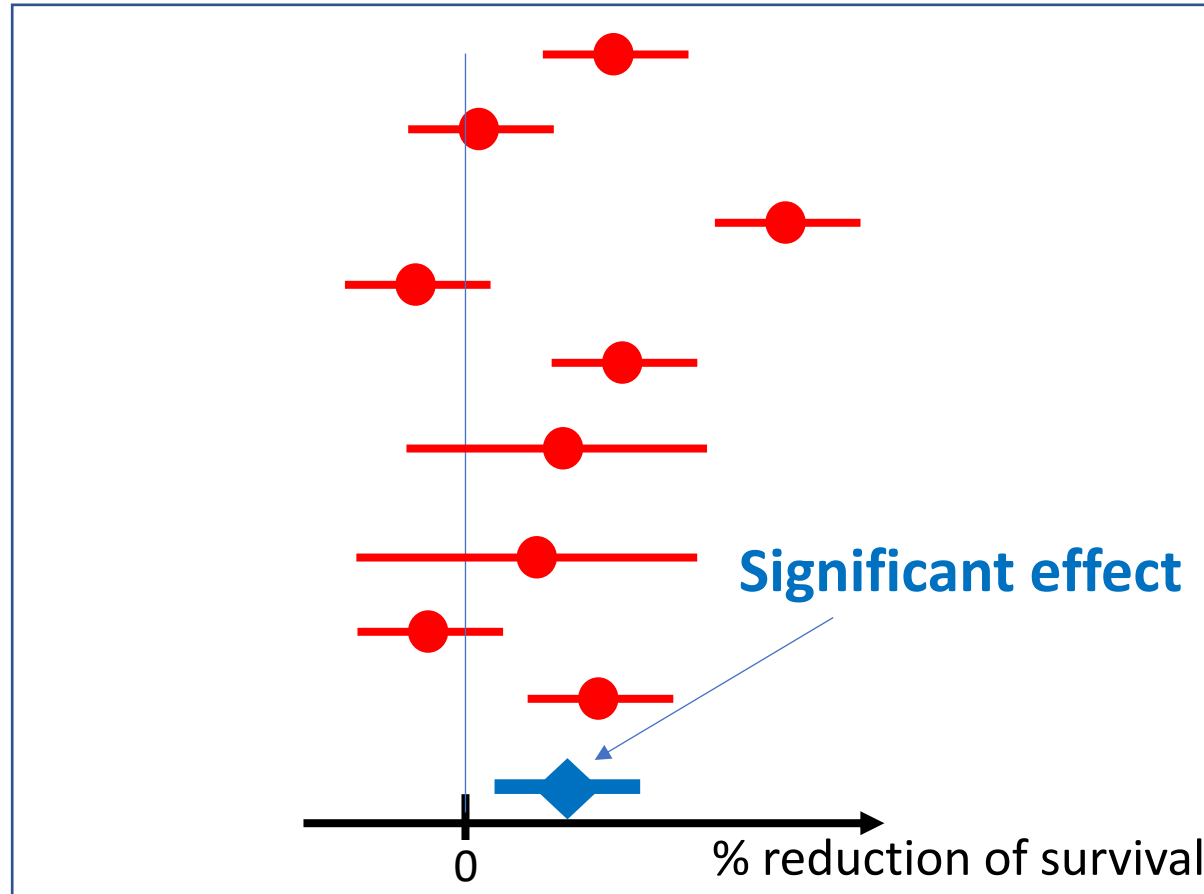
Statistical analysis

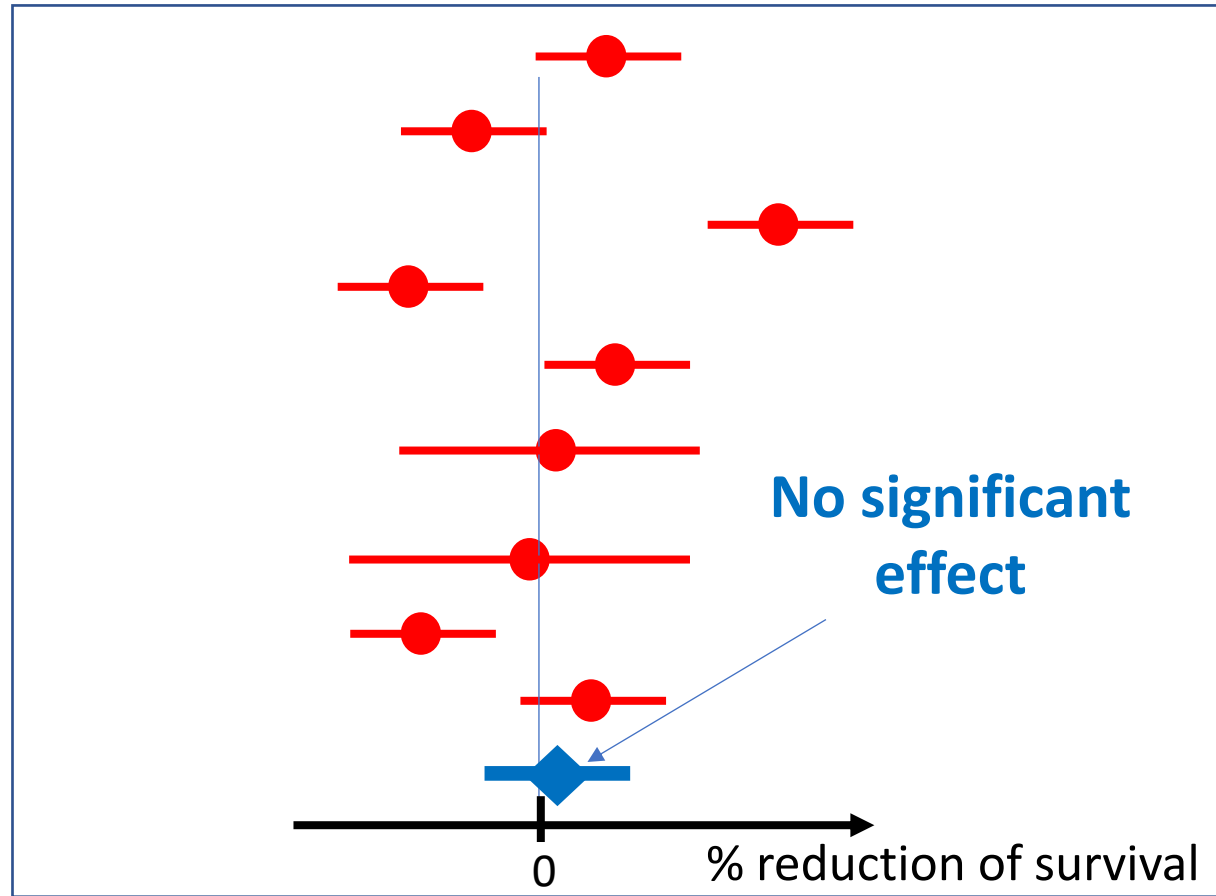
- Random-effect model
- Individual studies weighted according to their accuracy

Analysis done for six categories of control measures

1. Synthetic substances approved,
2. Synthetic substances non-approved,
3. Non-synthetic substances,
4. Entomopathogenic fungi (EPF),
5. Entomopathogenic nematodes (EPN),
6. Predators







Category of
control measure

Number of data

All

Group of trials

Synth. substance appr. (100)

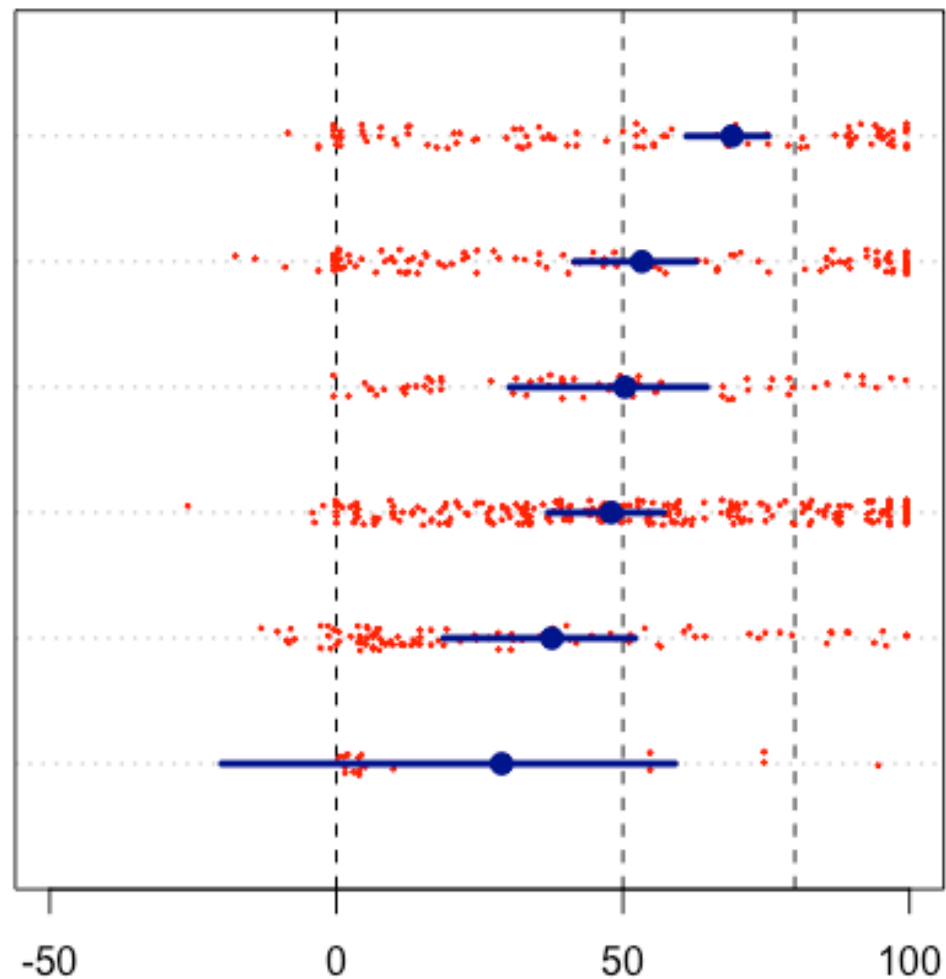
Synth. substance non appr. (130)

EPN (68)

EPF (292)

Non-Synth. substance (101)

Predator (19)



% of reduction of surviving insects

Category of
control measure

Number of data

Synth. substance appr. (100)

Synth. substance non appr. (130)

EPN (68)

EPF (292)

Non-Synth. substance (101)

Predator (19)

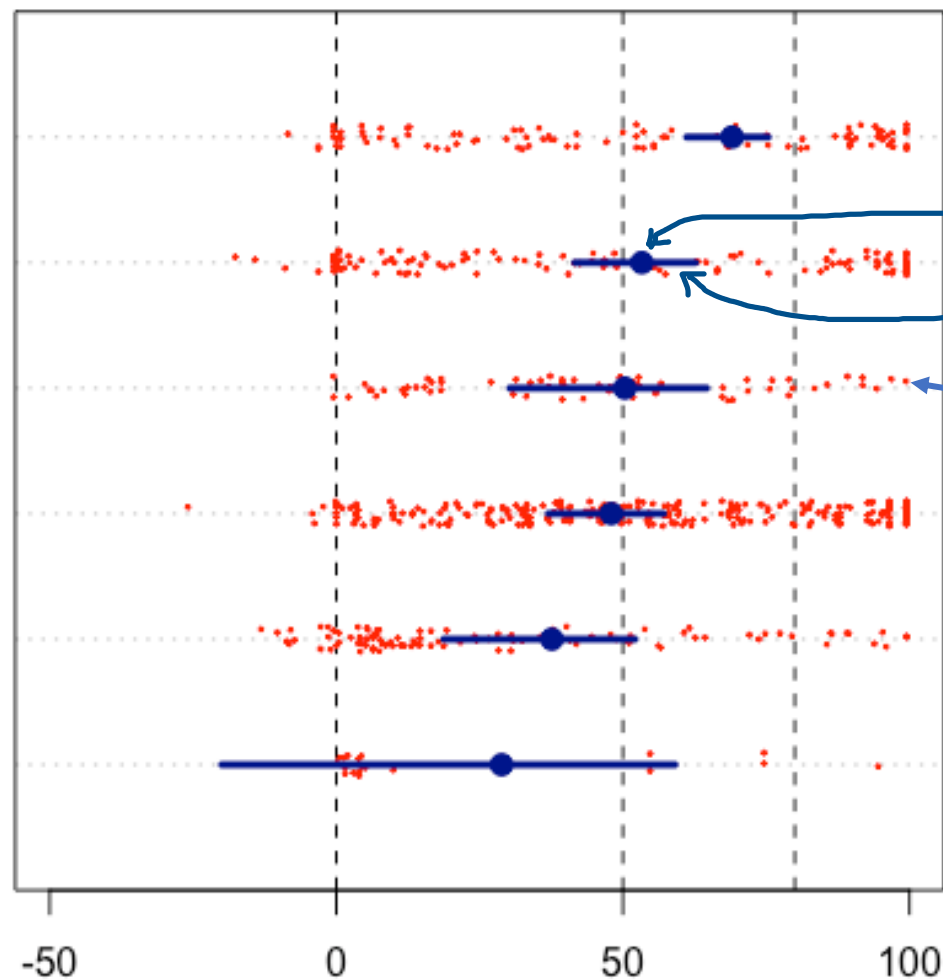
All

Group of trials

Estimated mean survival reduction

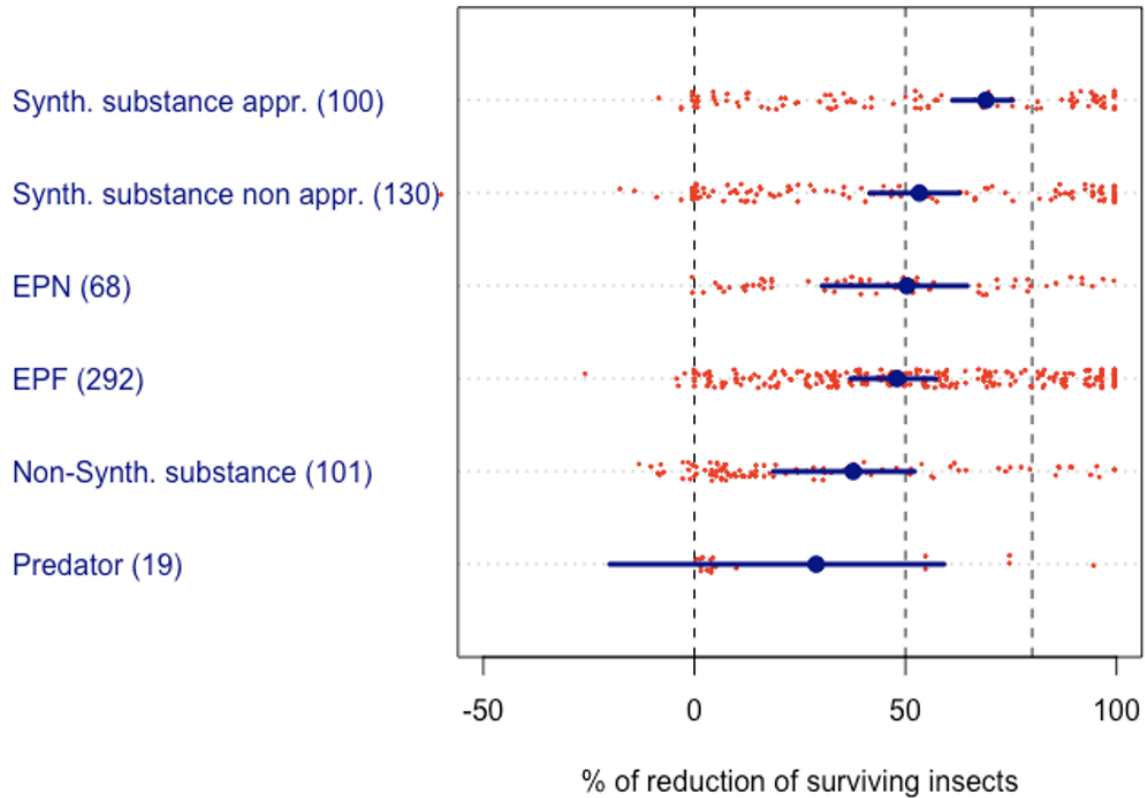
95% confidence interval

Individual data

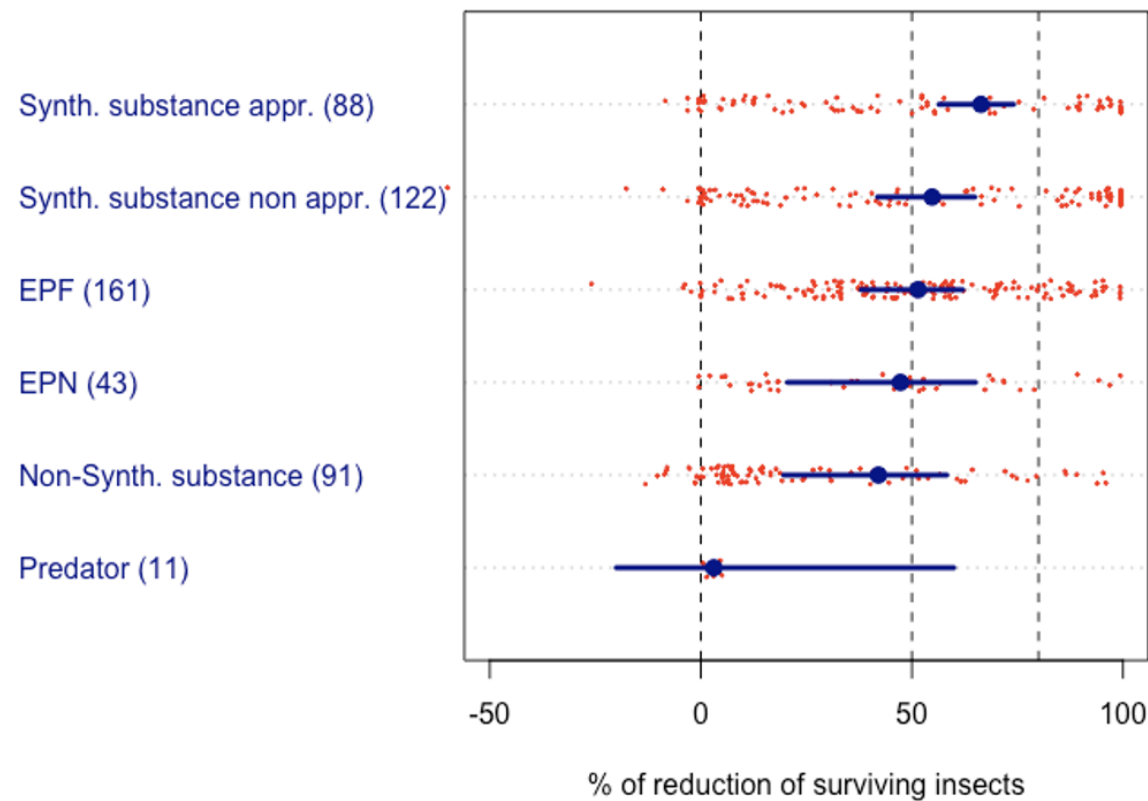


% of reduction of surviving insects

All



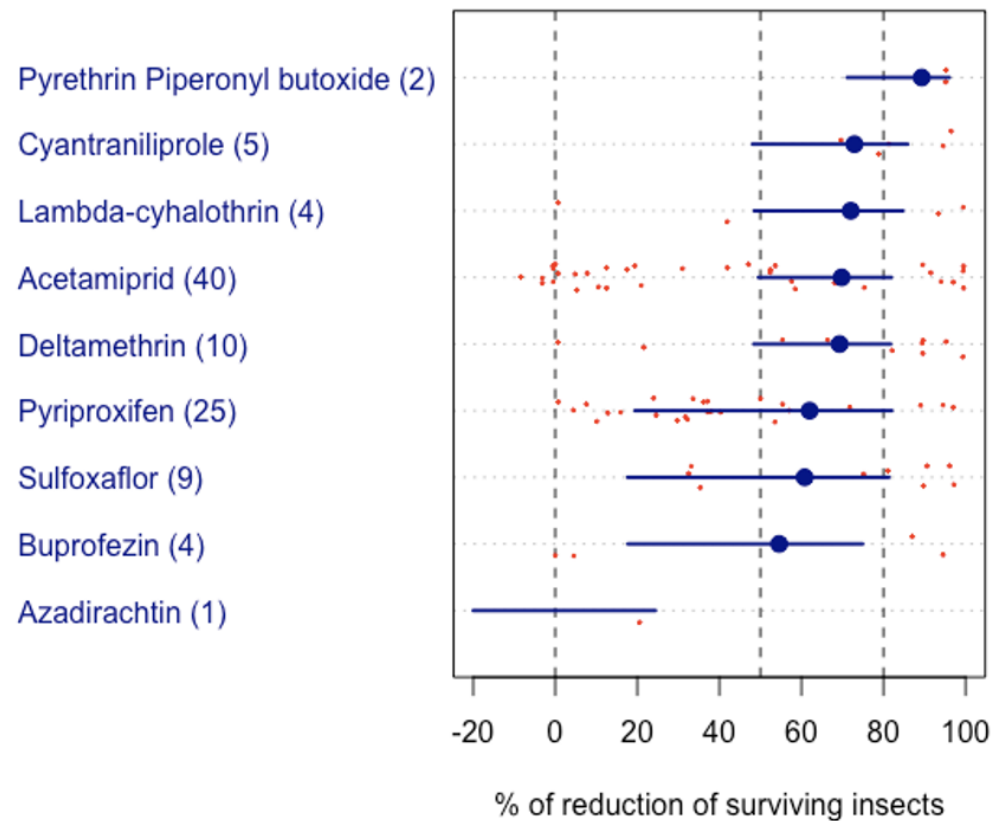
No lab data



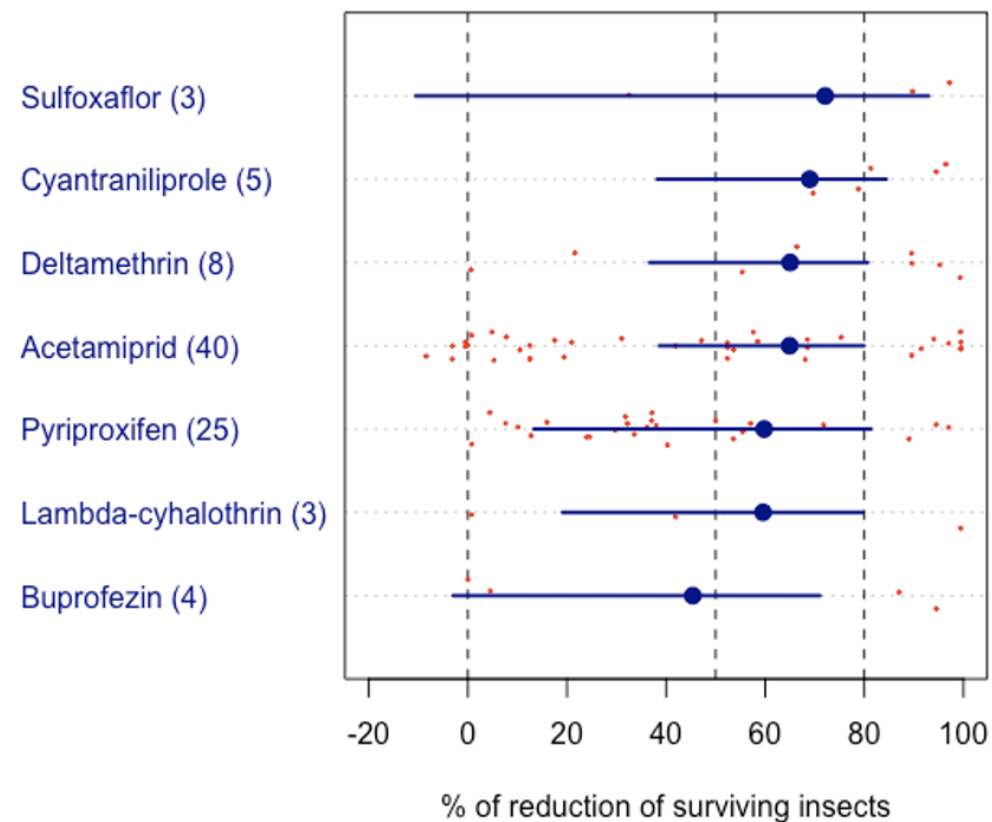
No lab. data

Synthetic substances approved in the EU

All



No lab data



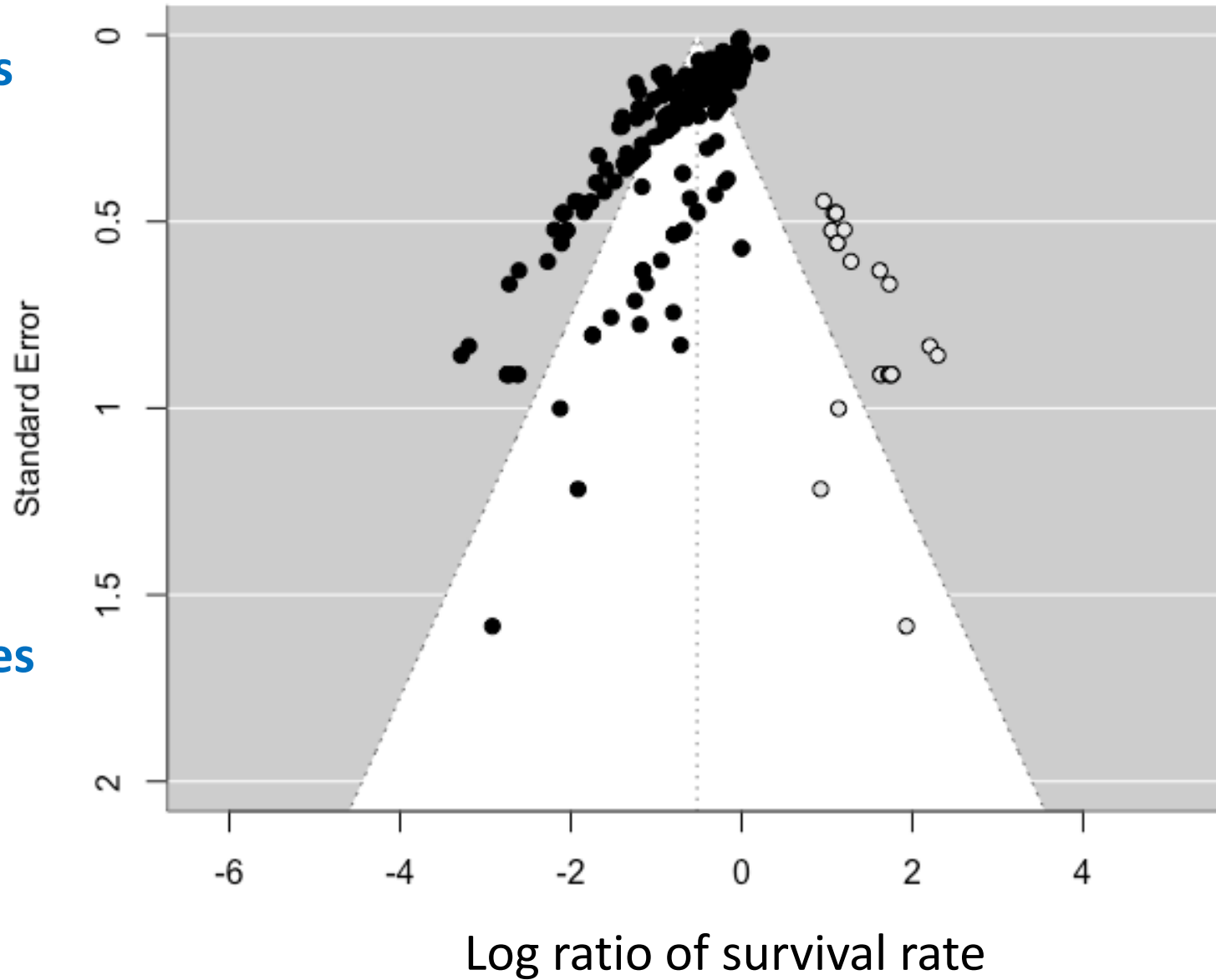
Publication bias

Accurate studies

+++



Inaccurate studies



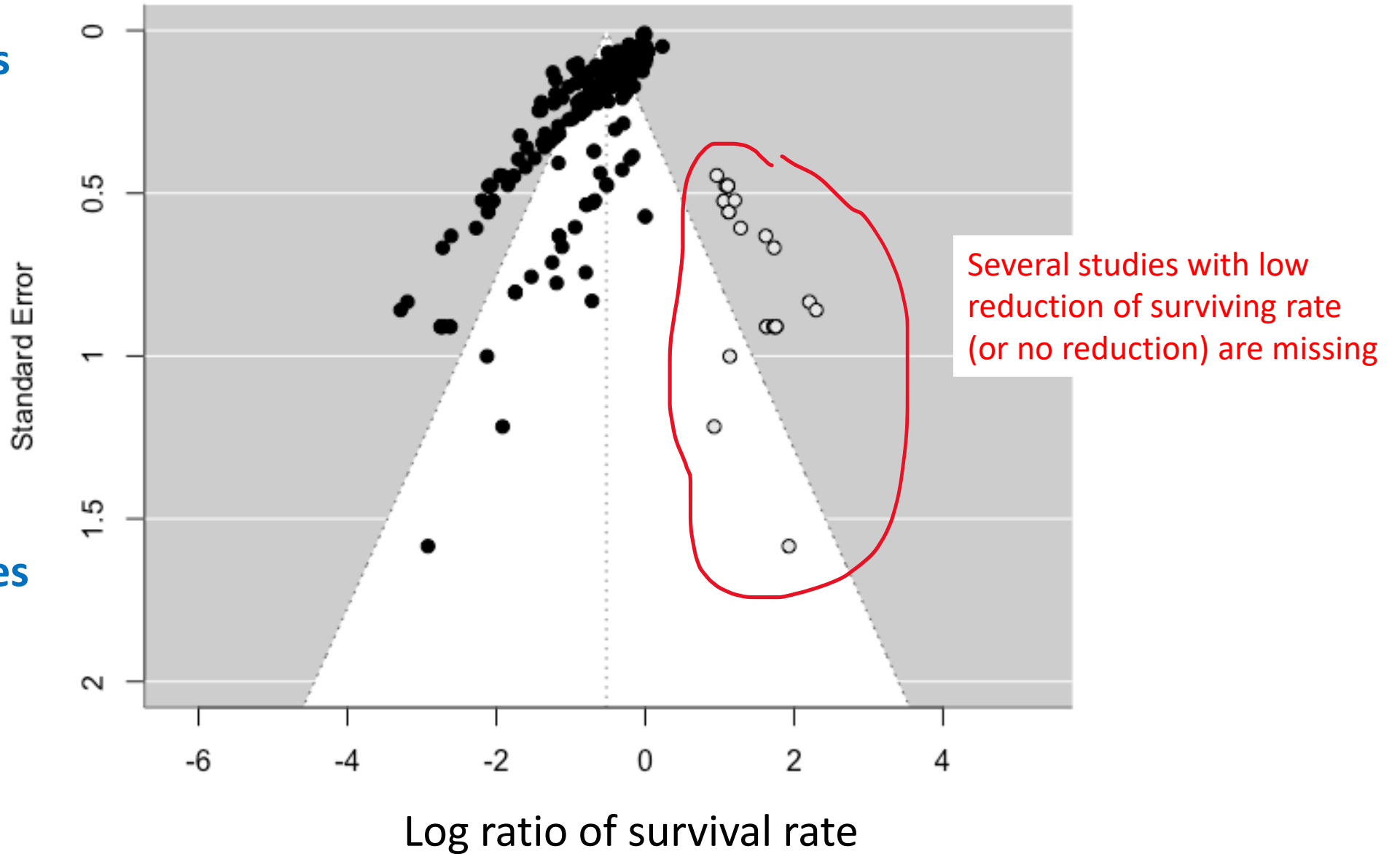
Publication bias

Accurate studies

+++



Inaccurate studies



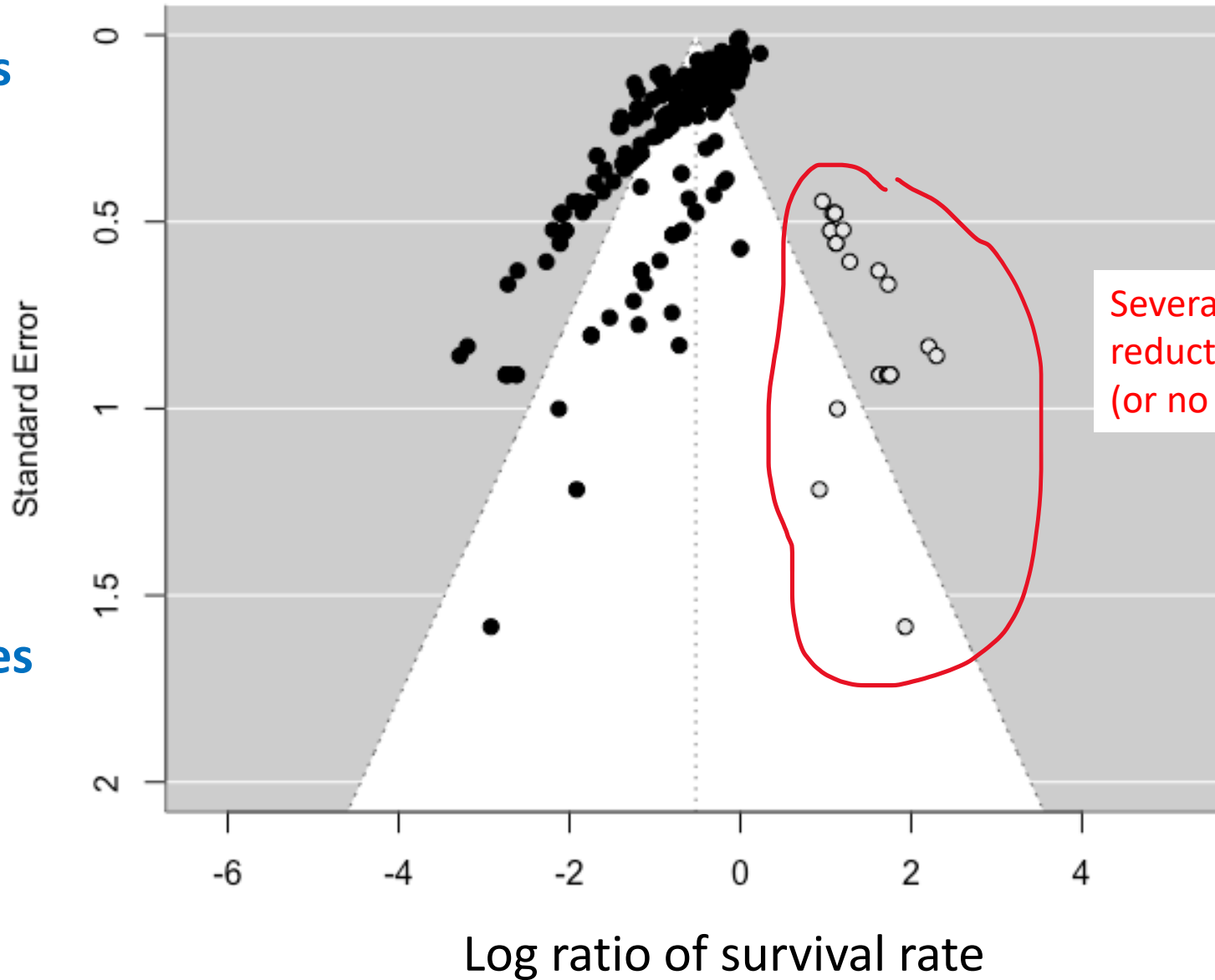
Publication bias: Overestimation of about 4% for EPF

Accurate studies

+++



Inaccurate studies



Conclusion

- Mean reduction of insect survival significantly higher than 50% with several control measures,
- Highest reduction levels achieved with authorized synthetic substances,
- Other types of control measure (other substances, nematode, fungi) show reductions significantly higher than zero, but their estimated efficacy levels are lower,
- Effects of predators and of several specific substances are highly uncertain,
- Evidence of publication bias, i.e. some effect sizes are probably overestimated.



WG members

Domenico Bosco
Daniele Cornara
Matteo Crotta
Ewelina Czwieniczek
Oumayma Jemei
David Makowski
Tarla Murphy
Giuseppe Stancanelli
Anastasia Terzidou





Thank you!

Grazie mille !





Xylella fastidiosa

5th European conference

Bari, Italy | 22-26 June 2026



REGIONE PUGLIA



Extreme polyphagy in the vector *Philaenus spumarius* – Overview and implications for *Xylella* spread

Vinton Thompson¹, Claire Harkin^{2,3}, Alan Stewart³

¹American Museum of Natural History, NYC, USA

²Ancient Tree Forum, London, UK

³University of Sussex, Brighton, UK

RESEARCH ARTICLE

The most polyphagous insect herbivore? Host plant associations of the Meadow spittlebug, *Philaenus spumarius* (L.)

Vinton Thompson^{1*}, Claire Harkin^{2,3*}, Alan J. A. Stewart^{2*}

1 Division of Invertebrate Zoology, American Museum of Natural History, New York, New York, United States of America, 2 School of Life Sciences, University of Sussex, Falmer, Brighton, East Sussex, United Kingdom, 3 Ancient Tree Forum, London, United Kingdom

* vthompson@mcny.edu (VT); claire.harkin@ancienttreeforum.org.uk (CH); a.j.a.stewart@sussex.ac.uk (AJAS)





Claire Harkin
University of
Sussex, UK



Co-authors of the original work



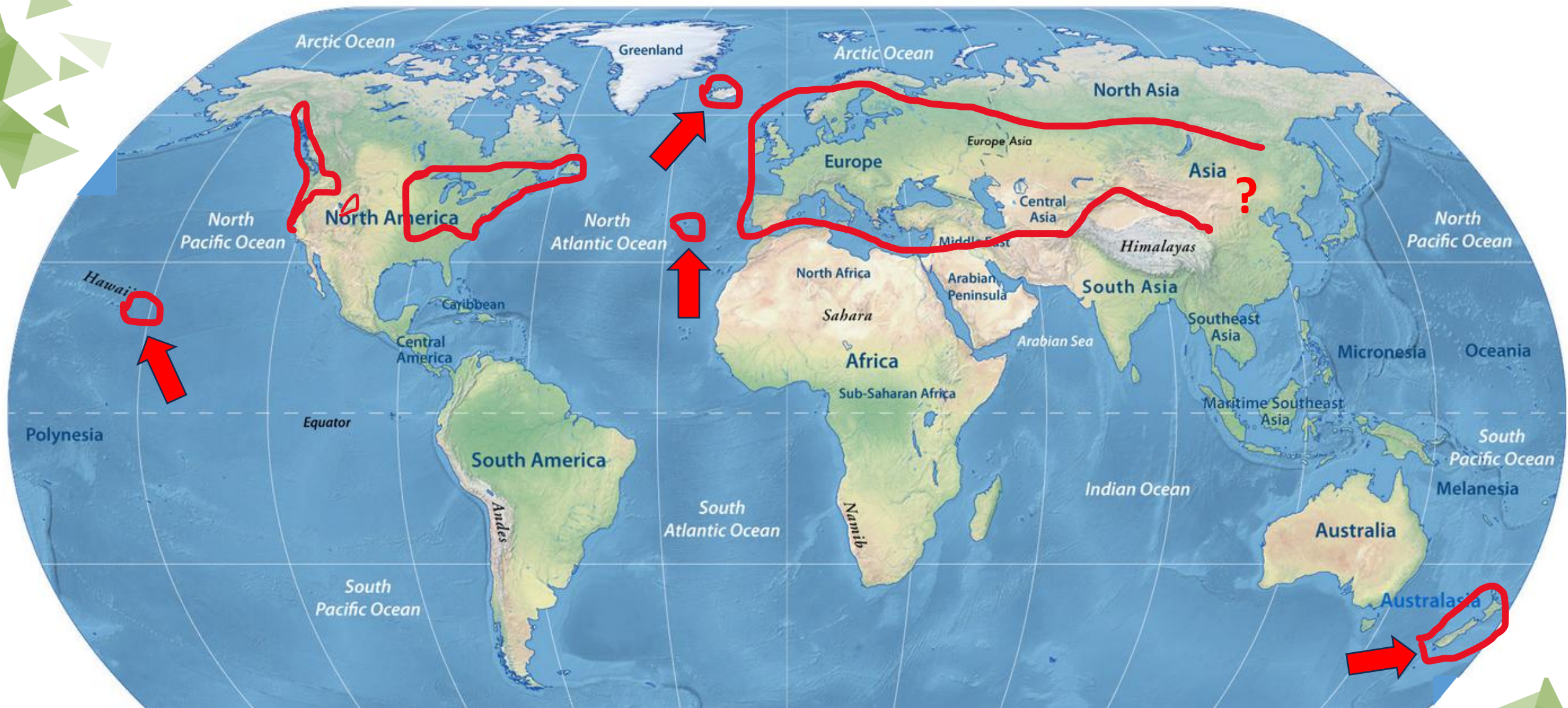
Alan Stewart
University of
Sussex, UK



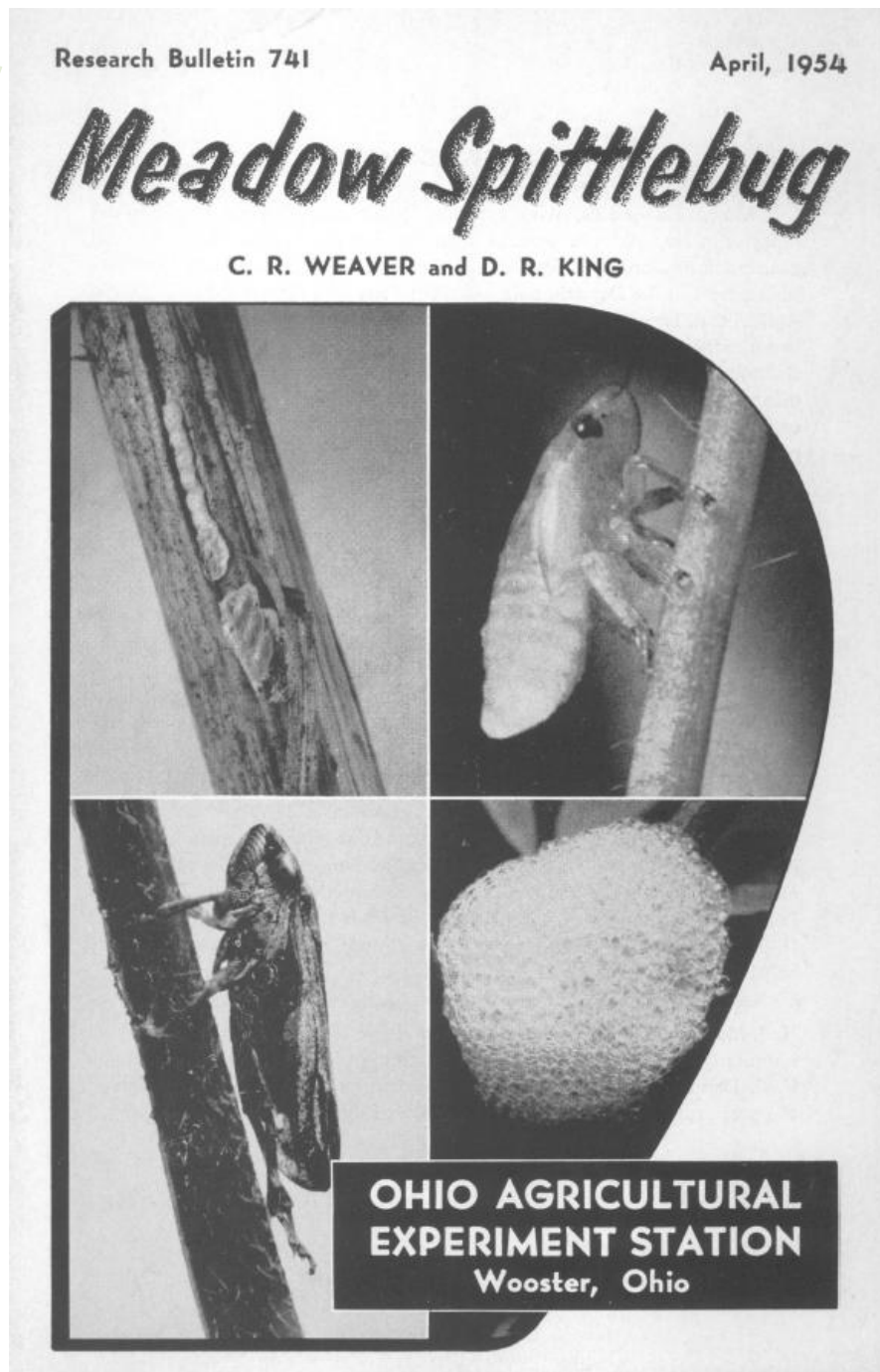


Philaenus spumarius
– World's most
widespread spittlebug





Geographical distribution of *Philaenus spumarius*. Palearctic populations are native, the rest of the world introduced (with possible exception of Azores).



Previously reigning host list

Weaver & King
(1954) – now
over 70 years old

Listed 383 hosts



Sources for new, comprehensive *P. spumarius* host list

Primary source #1: Unpublished world data base of Cercopoidea hosts

- As of June 2026, **9975 records for all species**
- **2842 *P. spumarius* records**
- **Not complete for *P. spumarius*** – still missing most BRIGIT records, for example

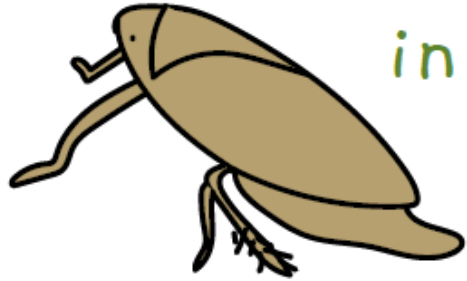
Excluded: lab records and adult host records based on single specimens (to minimize issue of “sitting” records)

Primary source #2: **The UK BRIGIT Project**

- Ran from **2019 to 2021**
 - British residents solicited to submit photographic records – **received thousands online**
 - Evaluated for inclusion by trained scientists (primarily Claire Harkin) – **nymp~~h~~s only**
 - Driven by concern for potential *Xylella* introduction to British Isles
- 

Garden spittlebug hunt

how to hunt for spittlebugs
in your garden



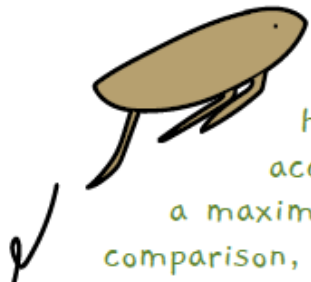
**Example
of simple
promotional
material for
BRIGIT Project**

Fun facts about spittlebugs

Spittlebugs have mouths a bit like needles which they use to suck sap out of plants. Because their mouths are so small, plants can usually recover from this without any serious problems.



Spittlebugs make spittle by mixing up plant sap in their tummies and then blowing bubbles with it by squirting it out of their bums!



Adult spittlebugs are amazing jumpers. The Meadow Spittlebug holds the record for the fastest acceleration of any jump reaching a maximum g-force of up to 550! For comparison, astronauts normally experience a g-force of only around 3 during a rocket launch!

Spittlebugs have huge muscles in their heads to help them suck sap from their food plants. This makes their faces look bulgy, a bit like a tiny frog, giving them their other name - froghoppers.



More sophisticated promotional material for the BRIGIT Project



What insect is inside that spittle?

FACTS:

- The 'spittle' or foam that is seen in spring on many sorts of plants is produced by the immature or juvenile stages (usually referred to as nymphs) of spittlebugs, often known as froghoppers or cuckoo-spit insects.
- These insects, both as nymphs and adult insects, feed by sucking liquid sap out of the plants.
- The nymphs produce the spittle by blowing air into the fluid (excess plant sap) that they excrete.
- After about a month, the nymph moults into an adult insect that leaves the spittle and can hop and fly.
- There are ten species of these spittlebugs in Britain.



How can I tell what species of spittlebug it is?

It is usually straightforward to place a spittlebug nymph into one of the three groups (or genera) below, but deciding which species it belongs to may not always be possible.

If you gently tease the nymph out of its spittle mass (this won't harm it), you need to see whether or not it has any dark markings on its body.

Project benefitted from the fact that in Britain can rule out alternative species based on simple nymphal characteristics – not true everywhere



If it is pale yellow or lime green with no dark markings and is feeding on herbaceous plants, it is the **Meadow Spittlebug, *Philaenus spumarius***.



If it has a dark band across its body behind the head (the thorax) and is feeding on grasses, sedges or rushes, it is one of the ***Neophilaenus* species**.



If the front half of its body is mostly dark/black (i.e. the head and thorax) and is feeding on trees or other woody plants, it is one of the ***Aphrophora* species**.



Once you have decided which of these your spittlebug is, don't forget to report it via our website: <https://www.spittlebugsurvey.co.uk/>

Summary Results



- **1,311** host plant species in:
 - 613 genera
 - 117 families
- *P. spumarius* is the **world champion polyphage** – double number of hosts as nearest insect herbivore competitor (636)
- **BRIGIT survey** caught almost half of all known hosts, including **358 new to science**

What do the detailed results look like?

The head of the first page of 29-page primary table!

PLOS ONE

Host plants of *Philaenus spumarius*

Table 1. *Philaenus spumarius* host plants, by plant family, life stage, geographic occurrence, and BRIGIT project status. See footnotes for a key to and explanation of abbreviations.

Host species by family	Stage	Geographic area(s)	Cit. sci. obs.	Selected record source(s)
Acanthaceae				
<i>Acanthus mollis</i>	N	B&I	•••	
Adoxaceae				
<i>Sambucus canadensis</i>	N	ENA		[58]
<i>Sambucus nigra</i>	N	B&I WE WNA	••	[25, 26, 29]
<i>Sambucus racemosa</i>	N	F&S WE		[35, 36]
Aizoaceae				
<i>Carpobrotus chilensis</i>	N	B&I	•••	
<i>Carpobrotus edulis</i>	N,A	B&I MED WNA	••	[59, 60]
<i>Cleretum bellidiforme</i>	N	B&I	•••	
<i>Sesuvium portulacastrum</i>	N	HI		[27]

Plant
family

Plant
species

Stage –
adult or
nymph

Geographic
area(s)

Citizen science status
●●● = new to science
●● = new to Britain
● = British duplication

Selected
reference(s)

PLOS ONE

Host plants of *Philaenus spumarius*

Table 1. *Philaenus spumarius* host plants, by plant family, life stage, geographic occurrence, and BRIGIT project status. See footnotes for a key to and explanation of abbreviations.

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<i>Acanthus mollis</i>	N	B&I	●●●	
Adoxaceae				
<i>Sambucus canadensis</i>	N	ENA		[58]
<i>Sambucus nigra</i>	N	B&I WE WNA	●●	[25, 26, 29]
<i>Sambucus racemosa</i>	N	F&S WE		[35, 36]
Aizoaceae				
<i>Carpobrotus chilensis</i>	N	B&I	●●●	
<i>Carpobrotus edulis</i>	N,A	B&I MED WNA	●●	[59, 60]
<i>Cleretum bellidiforme</i>	N	B&I	●●●	
<i>Sesuvium portulacastrum</i>	N	HI		[27]

Eleven highest ranking host families by species number

Together the top 4 families account for more than 1/3 of all host species

Composites are a major host group, accounting for 1 of 6 host species

P. spumarius thrives on legumes but they are not top host group

P. spumarius does not favor grasses but lives on a diverse set none-the-less

Rank	Family	Number of host plant genera	Number of host plant species	Percent host species
1	Asteraceae	104	222	16.9%
2	Rosaceae	31	110	8.4%
3	Fabaceae	33	76	5.8%
4	Poaceae	49	73	5.6%
5	Lamiaceae	24	62	4.7%
6	Apiaceae	35	50	3.8%
7	Brassicaceae	27	43	3.3%
8	Caprifoliaceae	16	34	2.6%
9	Caryophyllaceae	11	32	2.4%
10	Plantaginaceae	6	27	2.1%
11	Polygonaceae	8	26	2.0%



Where is the host count now? An update since the compilation closed in May 2023

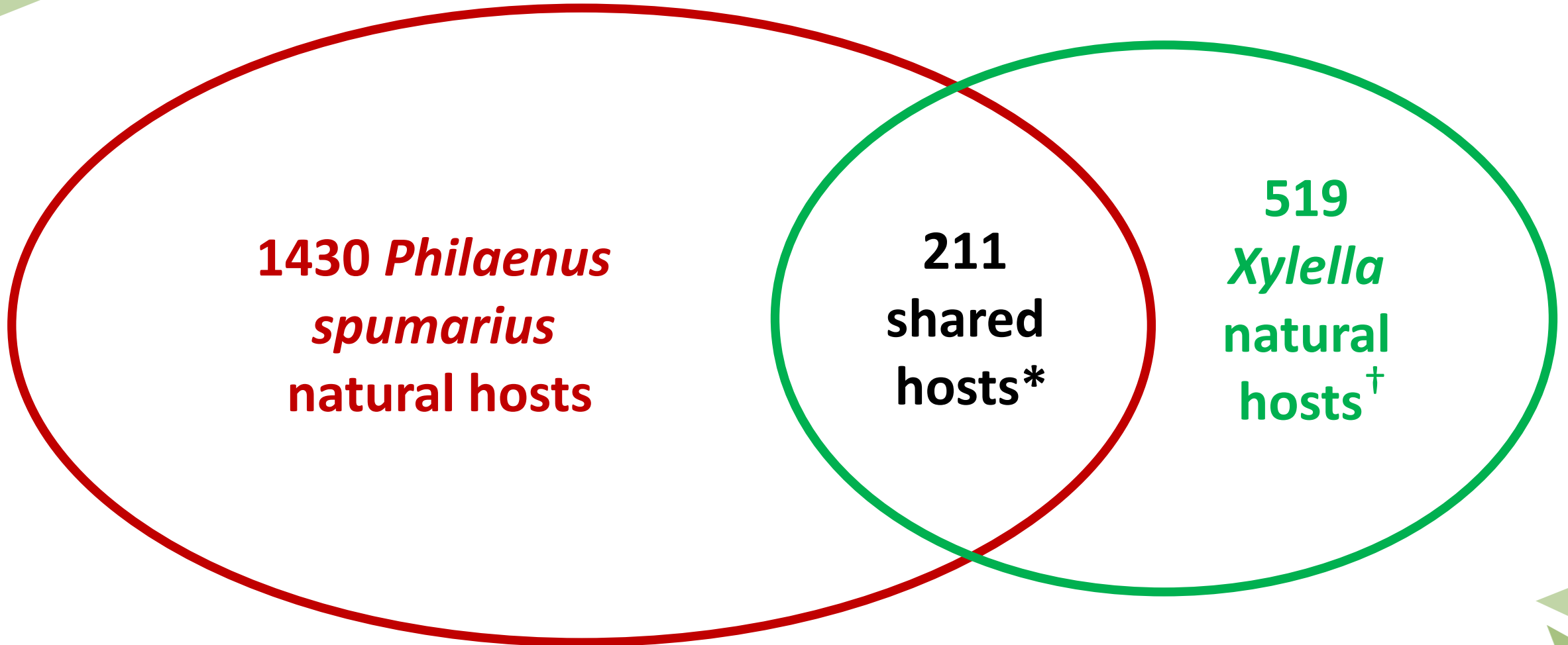
There have been many additions, most from the Mediterranean area:

Llompart et al. 2025
Avivar-Lozano 2025 (Dissertation)
Mesmin et al. 2025

Husein et al. 2026
Sanna et al. 2026
Puzzovivo et al. 2026

	Species	Genera	Families
Thompson et al. 2023	1311	631	117
Present	1430	671	119

What is the observed host overlap between these two extreme polyphages?



*155 species specific matches plus 56 matches at the genus level

[†]from *Xylella* host plant database natural infection_ABCDE_v13 2026



Implications

- ***Philaenus spumarius* feeds on an extraordinarily wide range of hosts, with no obvious limits.**
 - **Wherever *P. spumarius* and *Xylella fastidiosa* overlap in nature they will find many shared hosts.**
 - ***P. spumarius* is likely to function as a vector wherever it co-occurs with *X. fastidiosa*.**
- 



An important source of uncertainty

- Nymphs are relatively immobile and shed *X. fastidiosa* infection with every molt.
 - As a result, spittlebug nymphs are not significant vectors.
 - About 85% of recorded spittlebug host plants are based solely on observations on nymphs.
 - We do not have nearly as clear a picture of adult host patterns, but the adults are the vectors.
- 

Extreme polyphagy in the
vector *Philaenus spumarius*
– Overview and implications
for *Xylella* spread

Vinton Thompson

American Museum
of Natural History

Thank you!





Entomopathogenic fungi as a multi-target strategy for the control of *Philaenus spumarius*

The main Xylella fastidiosa vector in Europe

*Volpe, F., Dongiovanni, C., Bodino, N., Demichelis, S.,
Bosco, D., & Dolci, P.*

Xylella fastidiosa

5th European conference

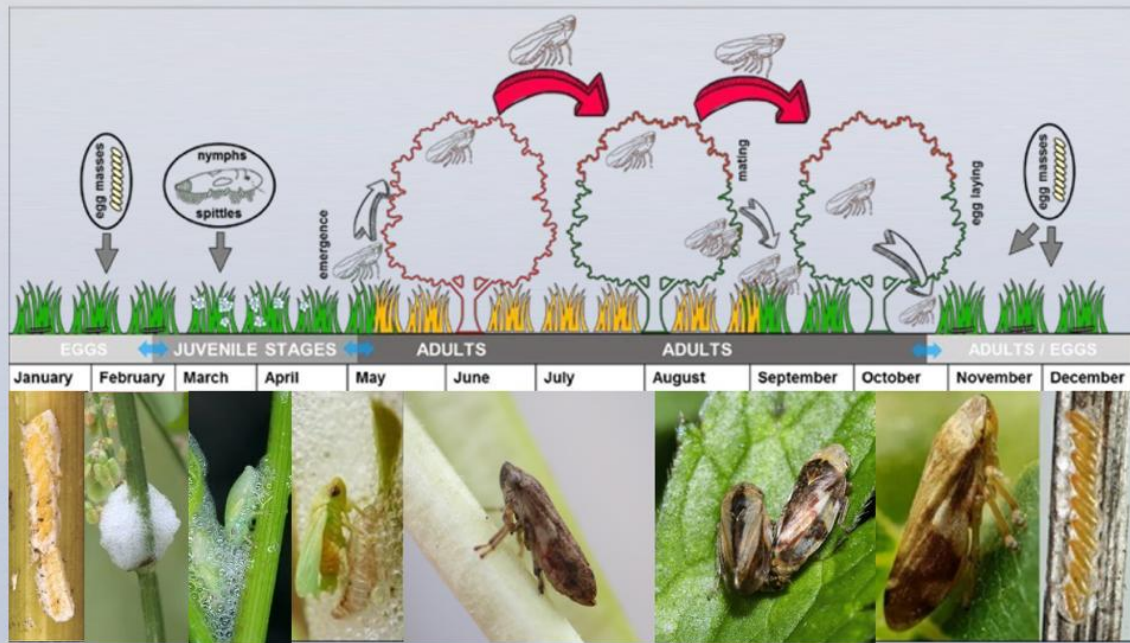
Bari, Italy | 22-26 June 2026



Philaenus spumarius L. Life cycle

Philaenus spumarius L.
(Hemiptera: Aphrophoridae)

Main vector of *Xylella fastidiosa* in Europe



Neanids (3 stages)

Nymphs (2 stages)

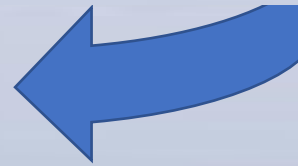
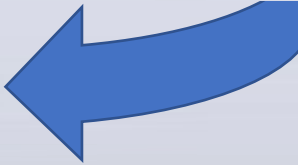
(EFSA Supporting publication, 2019, mod.)



Vector management



Vector management



Journal of Economic Entomology, 114(4), 2021, 1716–1721
doi: 10.1093/jeet/toab116
Advance Access Publication Date 17 June 2021
Research



OXFORD

Horticultural Entomology

Ground Cover Management in Olive Groves Reduces Populations of *Philaenus spumarius* (Hemiptera: Aphrophoridae), Vector of *Xylella fastidiosa*

Francesco Sanna,¹ Nicola Mori,^{2,4,*} Giacomo Santolemma,^{1,6} Domenico D'Ascenzo,³ Maria Assunta Scottillo,³ and Lorenzo Marini¹

SCIENTIFIC
REPORTS

OPEN Phenology, seasonal abundance and stage-structure of spittlebug (Hemiptera: Aphrophoridae) populations in olive groves in Italy

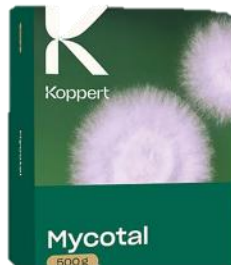
Nicola Rodino¹, Vincenzo Cavaliere², Crescenzo Dringovanni⁶, Elisa Piacitelli², Matteo Alessandro Saladin², Stefania Volani², Anna Simonetta², Giulio Fumagalli², Michele Di Camillo², Francesco Porceddu², Gianni Ghisolfi², Domenico Bonaguidi²

Entomopathogenic fungi

Can entomopathogenic fungi reshape the battle against the *Xylella* vector?

Recent studies report the activities of some **EPF strains** against *Philaenus spumarius*

- *Lecanicillium laecanii*
- *Trichoderma* spp.
- *Metarhizium brunneum* strain EAMa 01/58-Su
- *Beauveria bassiana* strain EABb 01/33).



DIRECT PATHOGENICITY



Pathogenicity trials (nymphs)

Treatments: 20 EPF strains

Trials: 2 trials with 10 EPFs

Plant: *Vicia Faba*

Replicates: 5 plants

Insects: 10 PS nymphs /plant

Conidial suspension: 1×10^8 conidia/mL

Treatment: 5mL/ plant

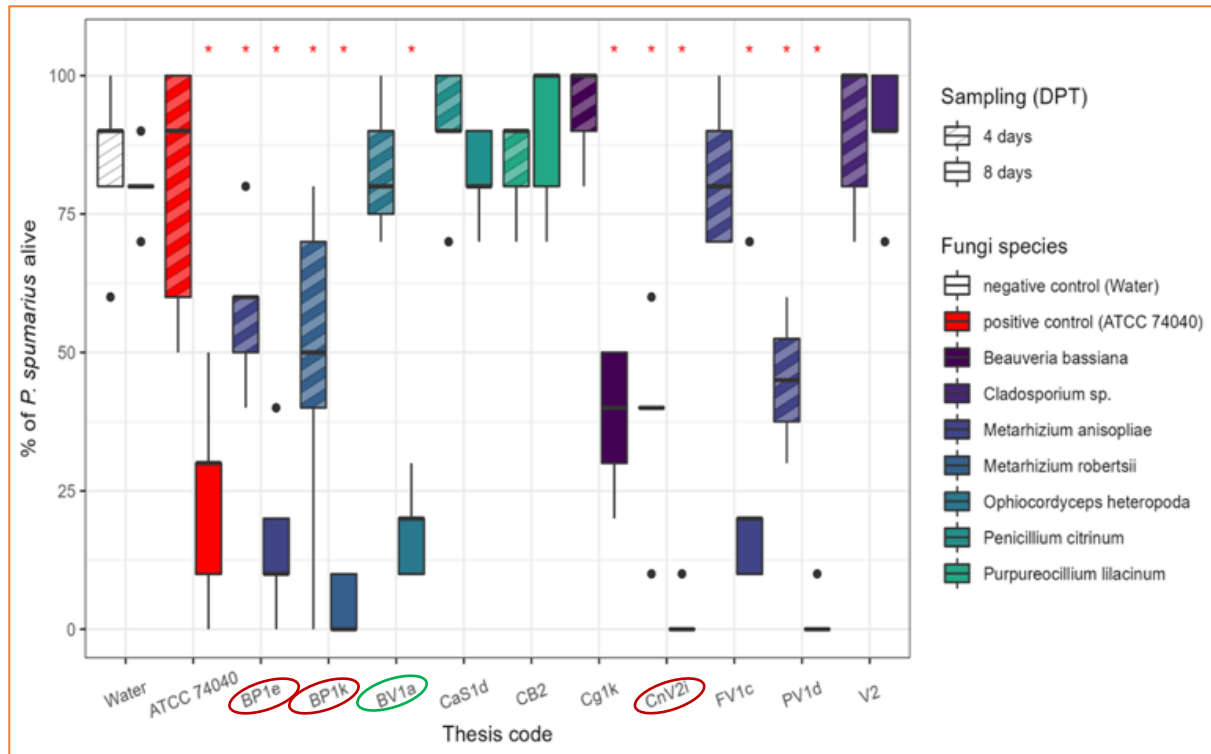
Survival control: 4 and 8 days after the treatment

Positive control: *Beauveria bassiana* ATCC 74040

Negative control: Ringer solution + Tween 80

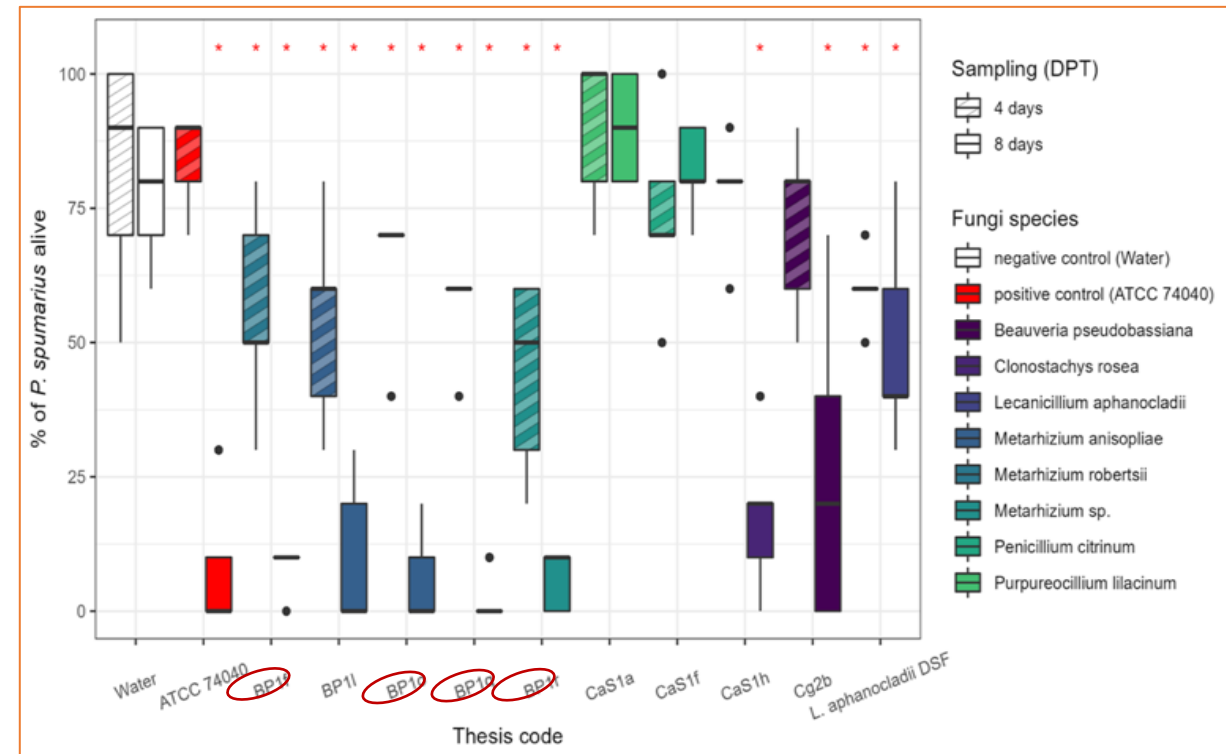


Pathogenicity trials (nymphs)



- *Metarhizium anisopliae* BP1e (16 %)
- *Metarhizium robertsii* BP1k (4 %)
- *Ophiocordyceps heteropoda* BV1a (18 %)
- *Metarhizium anisopliae* CnV2i (2%)

- *Metarhizium robertsii* BP1f (8 %)
- *Metarhizium anisopliae* BP1o (6 %)
- *Metarhizium anisopliae* BP1q (2 %)
- *Metarhizium* spp. BP1r (6%)



Pathogenicity trials (adults)

Treatments: 10 EPF strains

Plant: *Vicia Faba*

Replicates: 5 plants

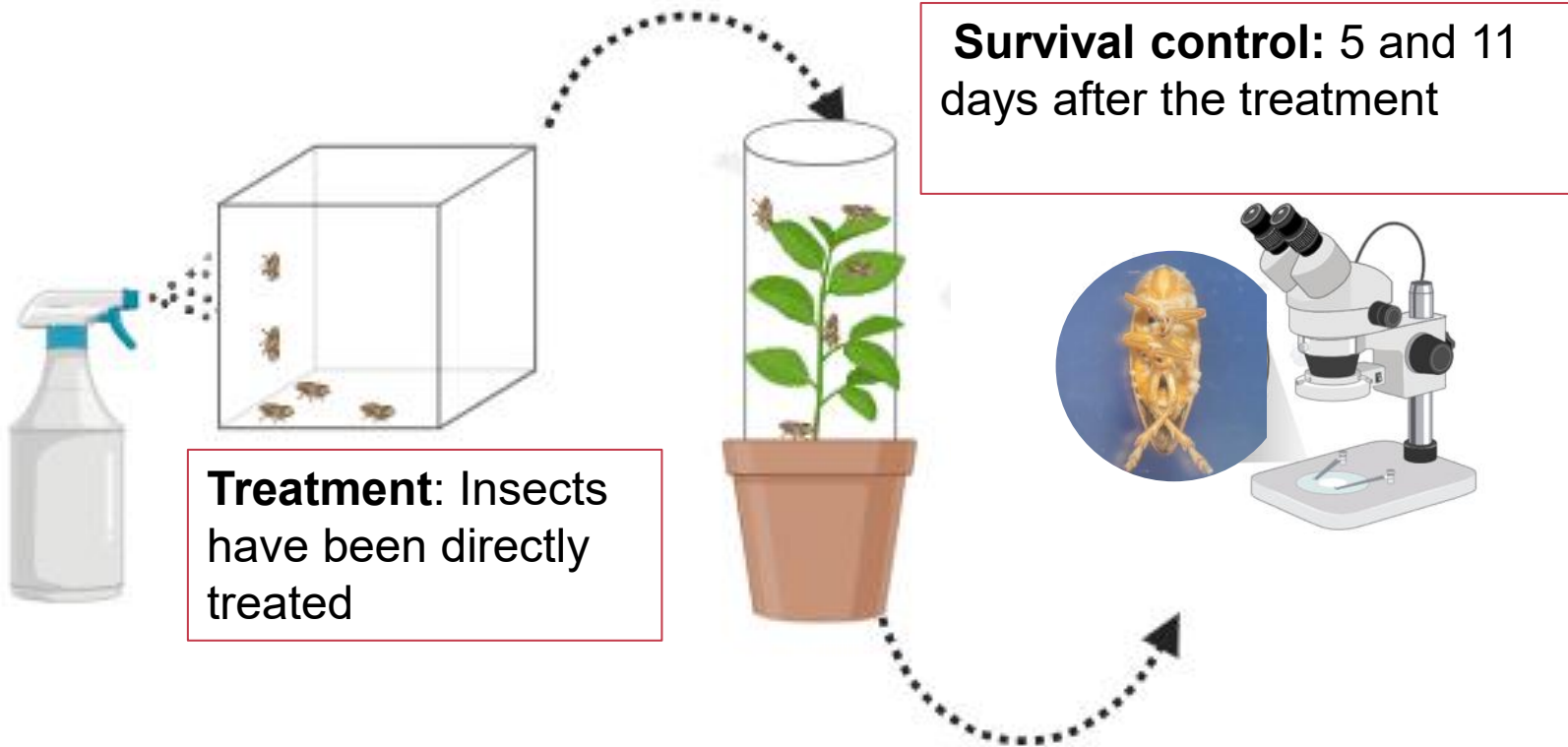
Insects: 5 PS adults/plant

Conidial suspension: 1×10^8 conidia/mL

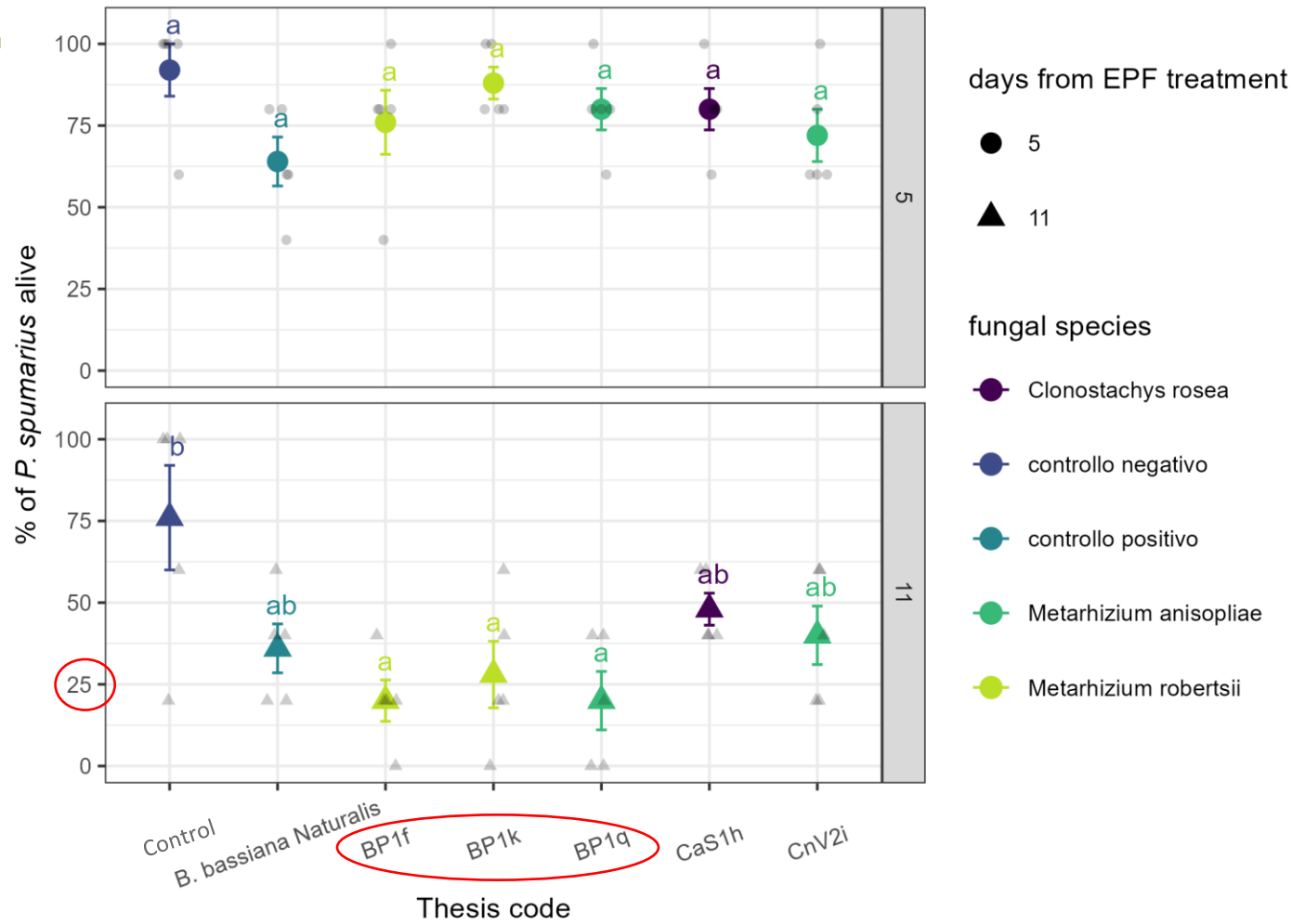
Treatment: 5mL/plant

Positive control: *Beauveria bassiana* ATCC 74040

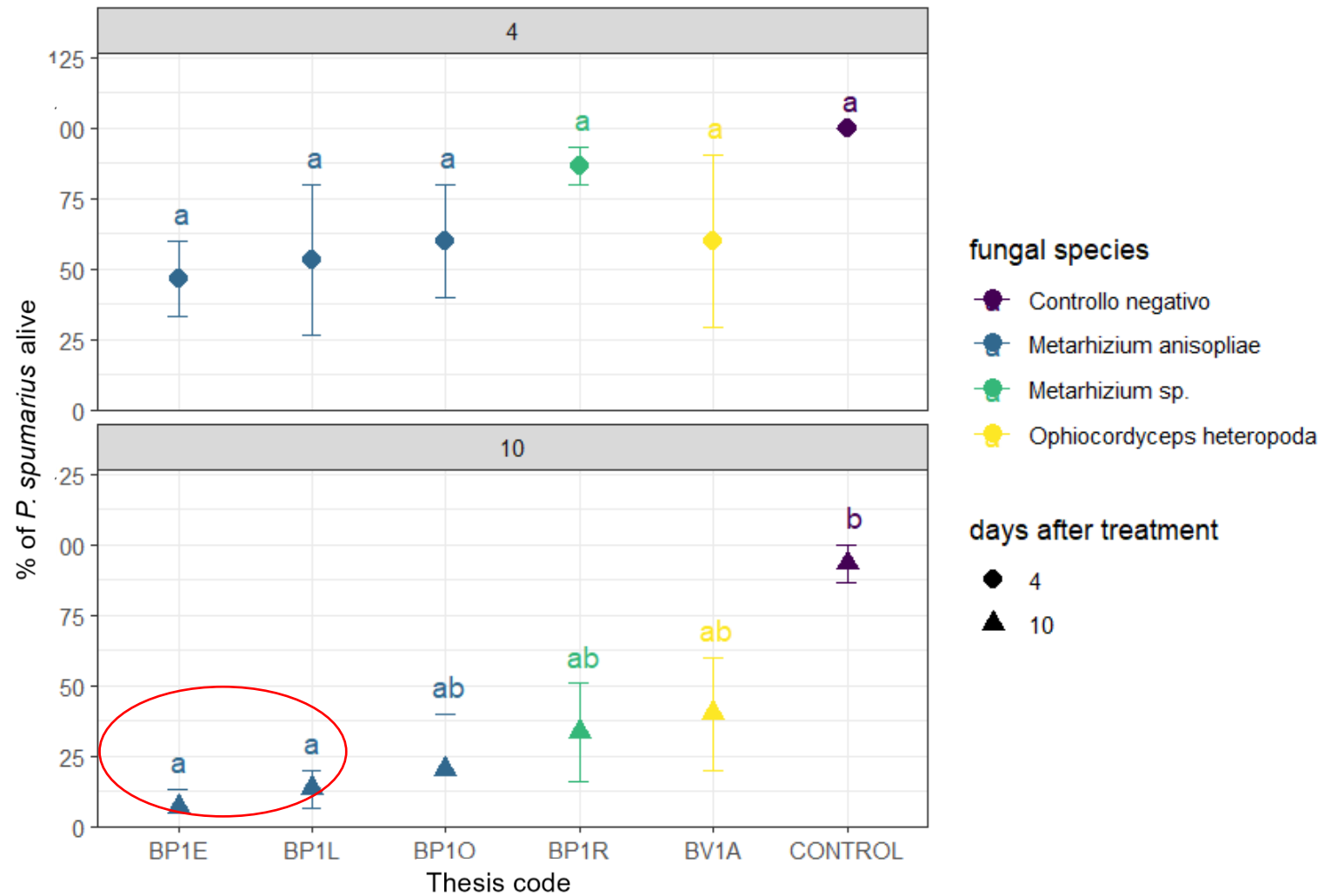
Negative control: Ringer solution + Tween 80



Pathogenicity trials (adults) – trial 1



Pathogenicity trials (adults) – trial 2



Pathogenicity trials (Eggs)

Time: February

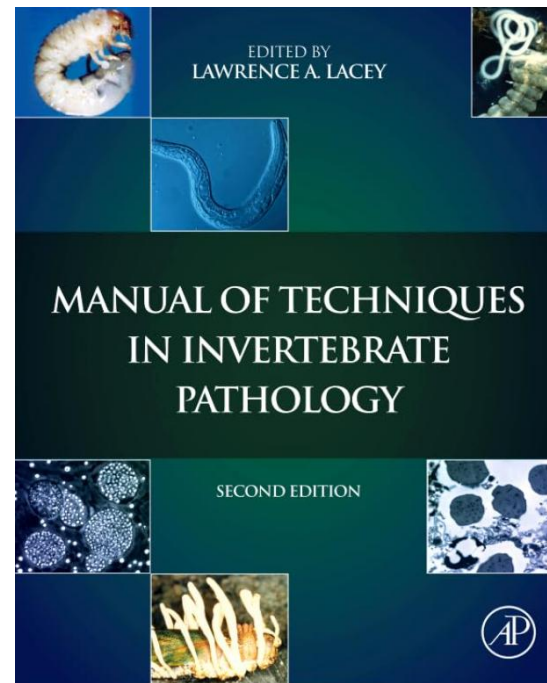
Treatments: Two EPF and a negative control

Replicates: Five egg masses

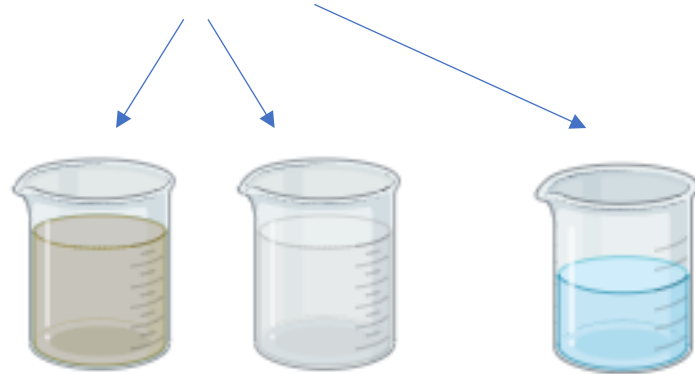
Eggs: 10 eggs per egg mass

Conidial concentration: 1×10^8 conidia/mL

Treatment method: 10 seconds dipping



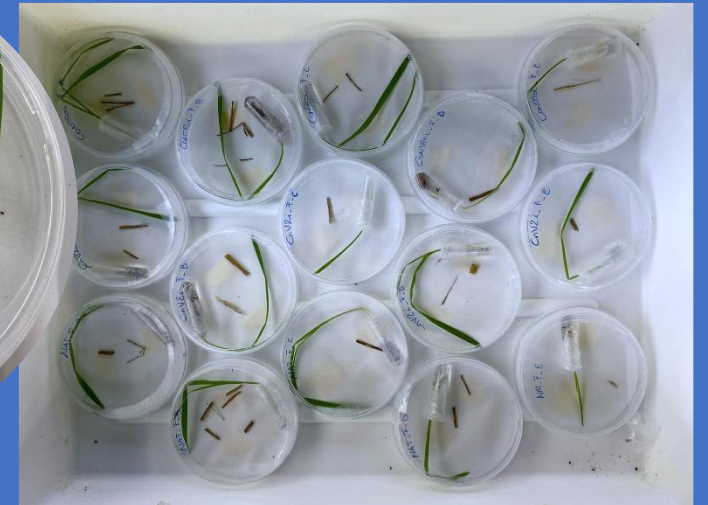
P. Spumarius eggs



M. anisopliae
CNV2i

B. Bassiana
ATCC74040

Ringer solution +
Tween 80



- Kept in growing conditions
22:20 °C; 16:08 L:D
- Checked every day



Pathogenicity trials (Eggs)



Control



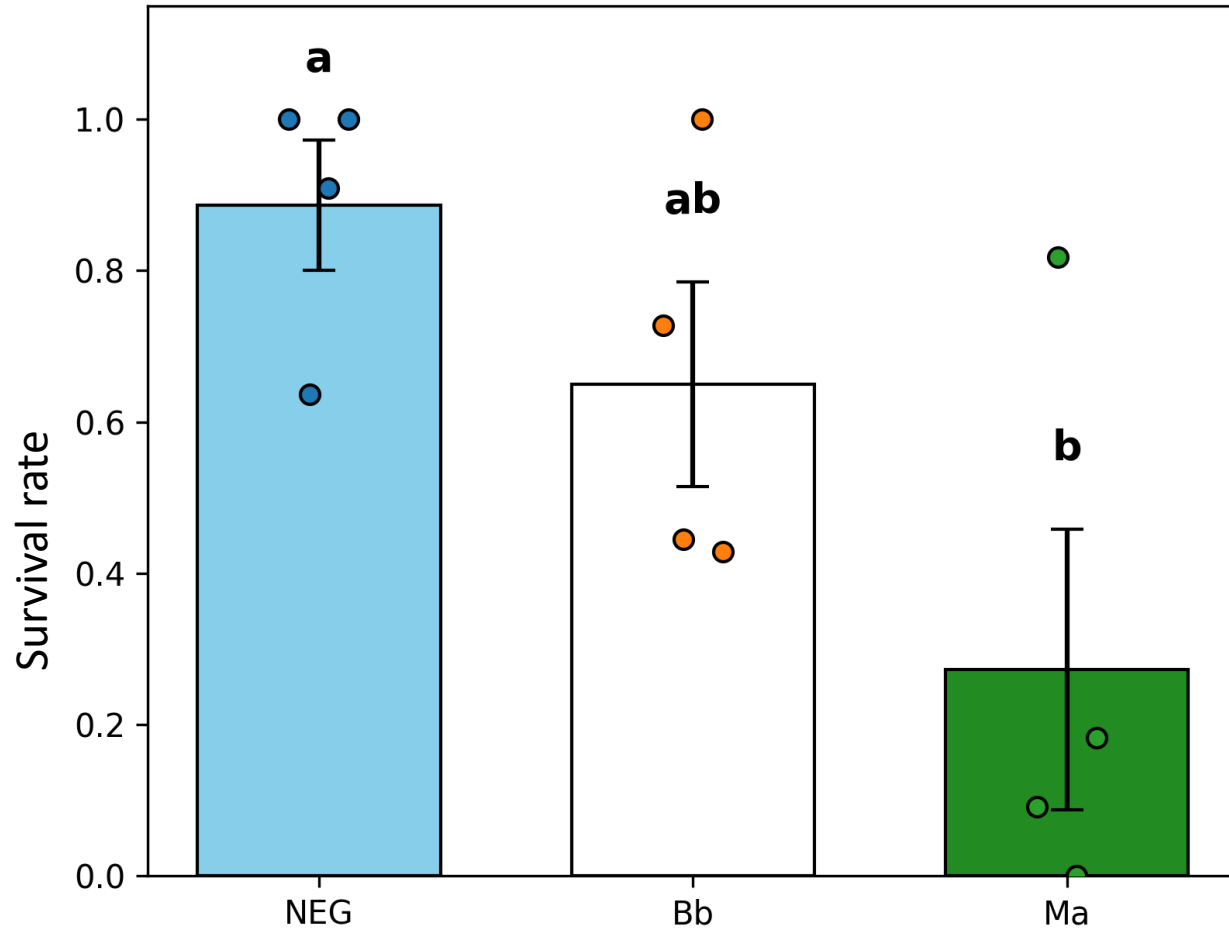
B. bassiana
ATCC 74040



M. anisopliae
CNV2i

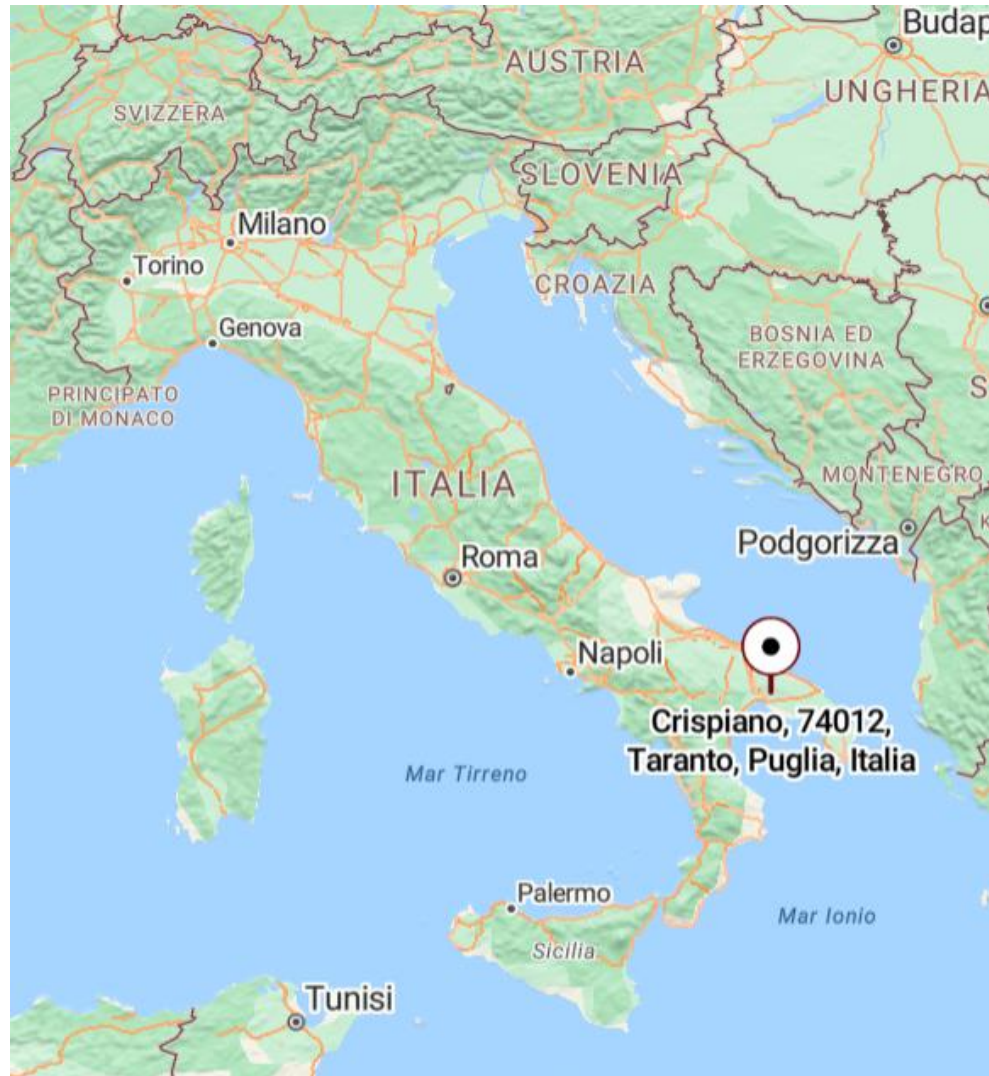


Pathogenicity trials (Eggs)



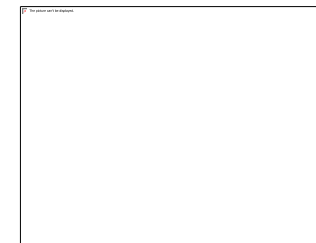
M. anisopliae CNV2i significantly reduced the survival

Field trial (nymphs)



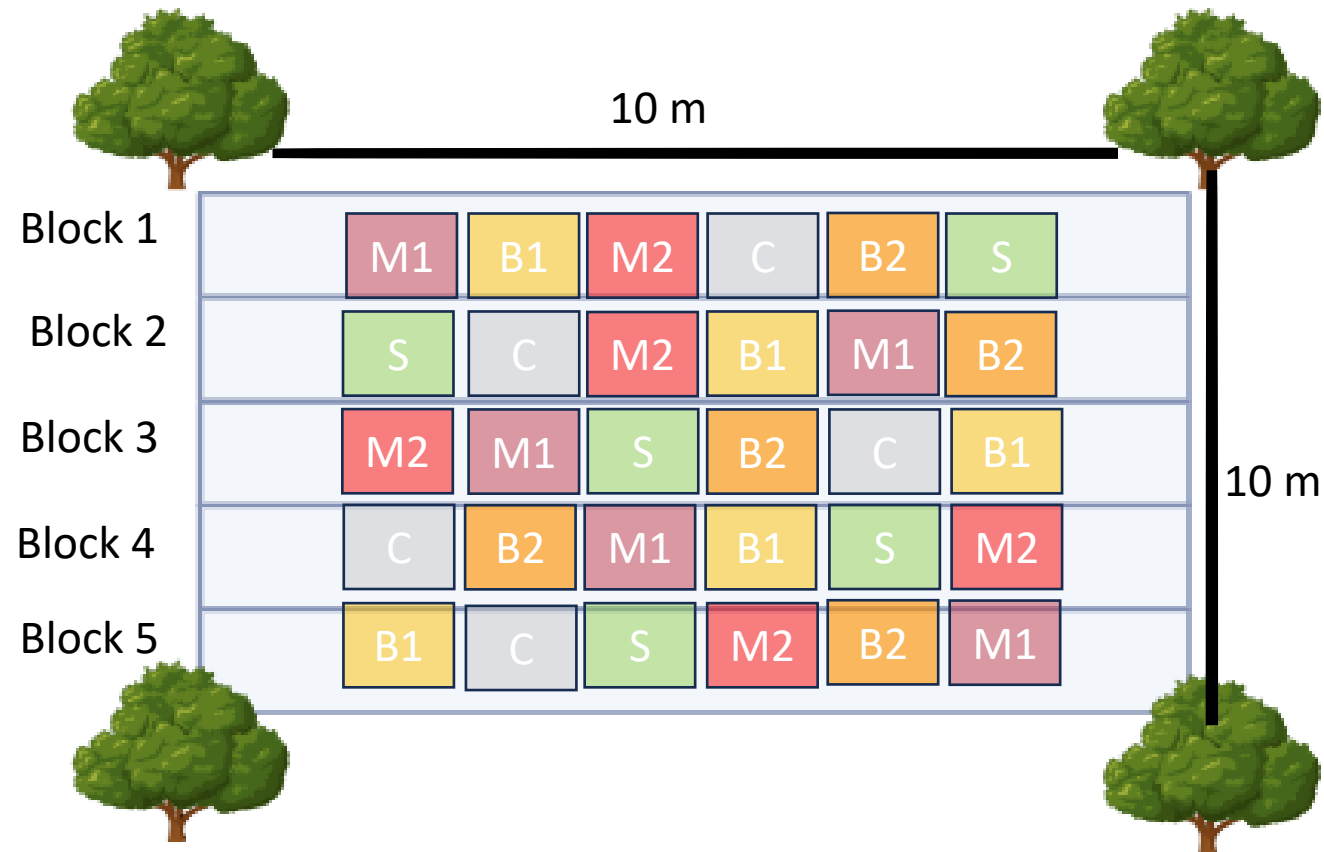


Field trial (nymphs)



Six thesis:

1. *Metarhizium anisopliae* Bp1q (1 treatment)
2. *Metarhizium anisopliae* Bp1q (2 treatment)
3. Naturalis[®] (1 treatment)
4. Naturalis[®] (2 treatment)
5. Negative control
6. Mowing

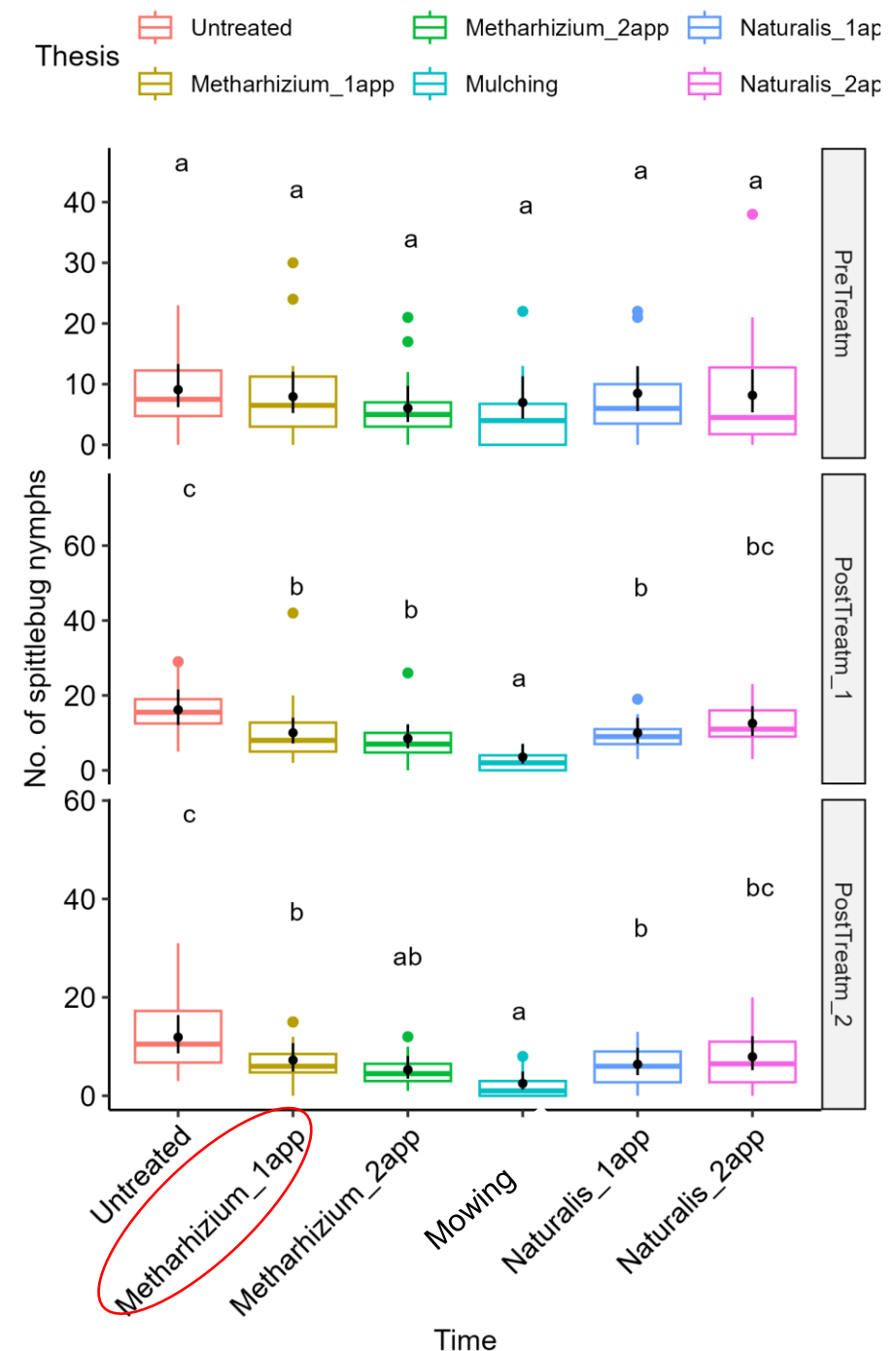


The *M. anisopliae* strain was sprayed with a backpack sprayer (2×10^8 conidia/m²)

Field trial (nymphs)

The results showed that already one week after the treatment

- **all EPFs treatments significantly reduced the vector population abundance** ($\approx 20\text{--}30$ nymphs/m²) compared to control thesis (≈ 65 nymphs/m²).
- **mowing was the most efficient treatment** in reducing spittlebug nymphal population (≈ 8 nymphs/m²)
- **two EPF applications didn't significantly reduce vector abundance compared to one application**
- Naturalis effect require further investigations

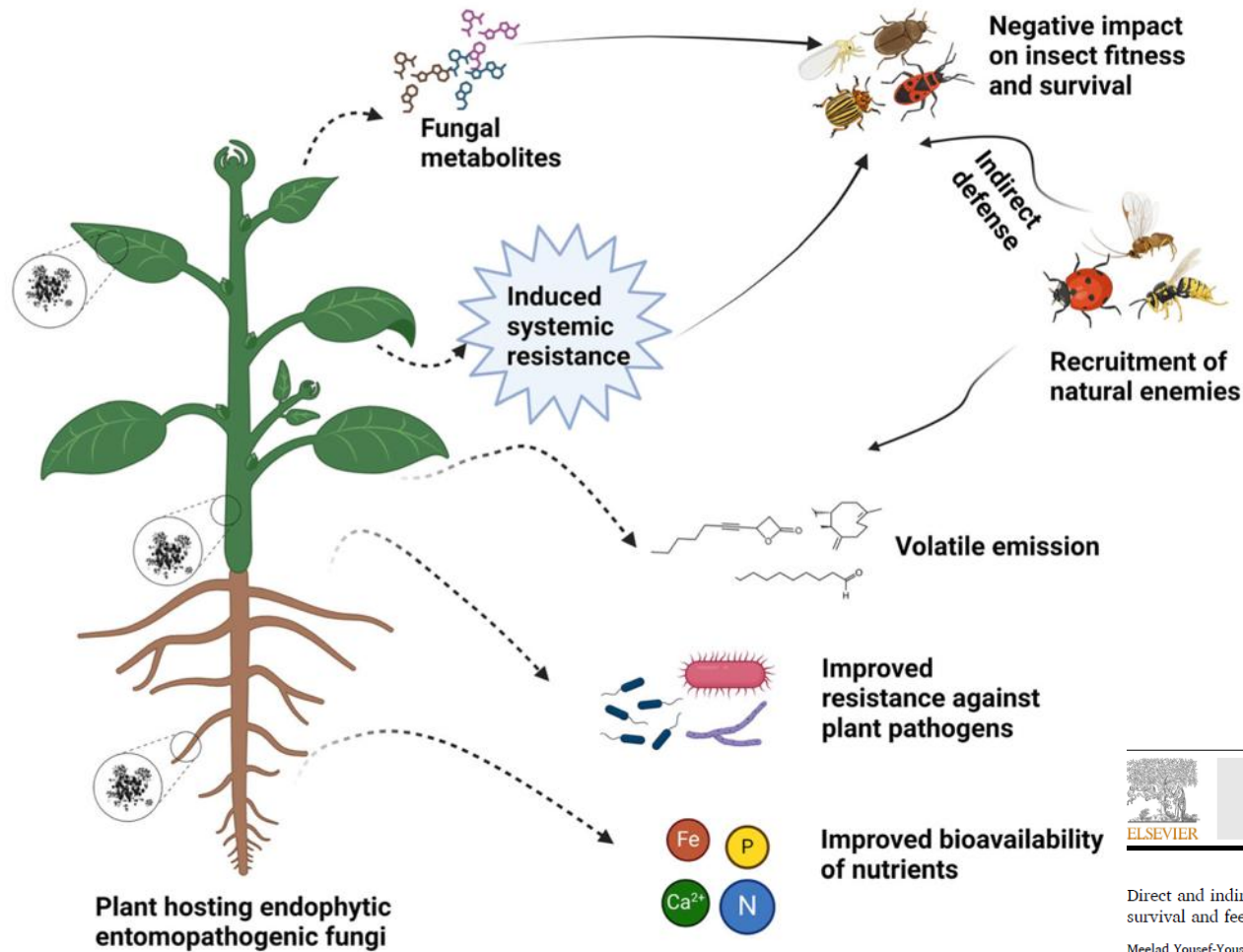




ENDOPHYTIC CAPABILITY



Entomopathogenic fungi indirect effects



(Panwar and Szczepaniec, 2024)

Does EPF colonisation of host plant tissues cause indirect effects in *Philaenus spumarius*?



ADULTS



NYMPHS



Direct and indirect effects of two endophytic entomopathogenic fungi on survival and feeding behaviour of meadow spittlebug *Philaenus spumarius*

Meelad Yousef-Yousef^{a,1}, Marina Morente^{b,1}, Natalia González-Mas^a, Alberto Ferreres^b, Enrique Quesada-Moraga^a, Aranzazu Moreno^{b,2}

^a Departamento de Agronomía (DAUCC) María de Maza Unit of Excellence 2021-2023), Campus de Rabanales, Universidad de Córdoba, Rdif. CA. 14071 Córdoba, Spain

^b Instituto de Ciencias Agrarias. Consejo Superior de Investigaciones Científicas (CSIC-CSIC), C/ Serrano, 115 dpto., 28006, Madrid, Spain



Journal of Pest Science (2026) 99:54
https://doi.org/10.1007/s10340-026-02015-3

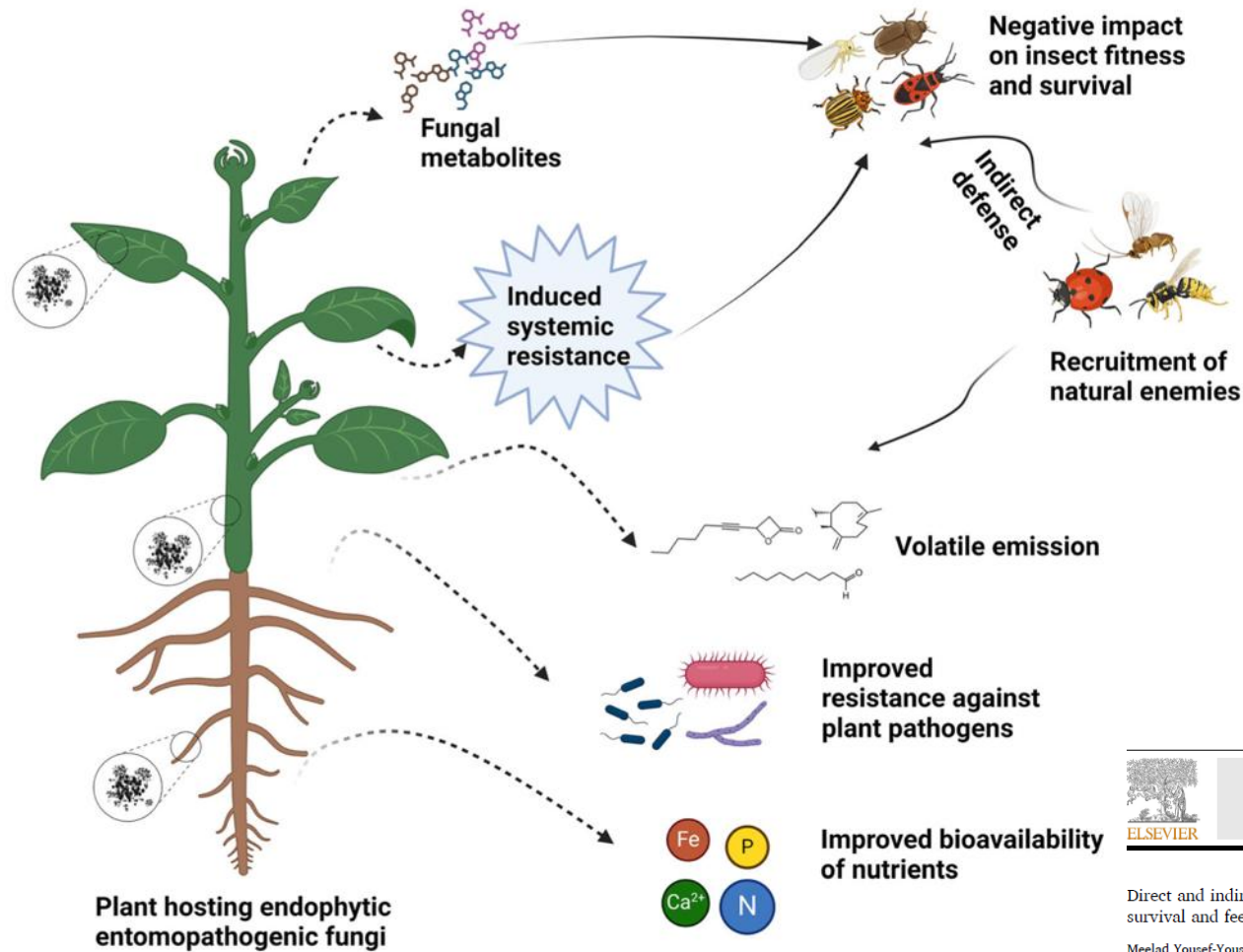
RESEARCH

Endophytic colonization and epiphytic presence of *Metarhizium brunneum* alter the feeding behavior of the *Xylella fastidiosa* vector *Philaenus spumarius*

Clara Lago^{1,2} · Meelad Yousef Yousef¹ · Alberto Ferreres¹ · Enrique Quesada-Moraga¹ · Aranzazu Moreno¹ · Natalia González-Mas¹

Received: 7 October 2025 / Revised: 21 December 2025 / Accepted: 9 January 2026
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Entomopathogenic fungi indirect effects



(Panwar and Szczepaniec, 2024)

Does EPF colonisation of host plant tissues cause indirect effects in *Philaenus spumarius*?

Identifying strains that exhibit both direct pathogenicity and indirect effects on the target insect could represent a significant advancement in vector management



Direct and indirect effects of two endophytic entomopathogenic fungi on survival and feeding behaviour of meadow spittlebug *Philaenus spumarius*

Meelad Yousef-Yousef^{a,1}, Marina Morente^{b,1}, Natalia González-Mas^a, Alberto Ferreres^b, Enrique Quesada-Moraga^a, Aranzazu Moreno^{b,2}

^a Departamento de Agronomía (DAUCC) María de Maza Unit of Excellence 2021-2023), Campus de Rabanales, Universidad de Córdoba, Rdif. CA, 14071 Córdoba, Spain

^b Instituto de Ciencias Agrarias. Consejo Superior de Investigaciones Científicas (ICIA-CSIC), C/ Sierra, 115 dpto., 28006, Madrid, Spain



Journal of Pest Science (2026) 99:54
https://doi.org/10.1007/s10340-026-02015-3

RESEARCH

Endophytic colonization and epiphytic presence of *Metarhizium brunneum* alter the feeding behavior of the *Xylella fastidiosa* vector *Philaenus spumarius*

Clara Lago^{1,2} · Meelad Yousef Yousef³ · Alberto Ferreres¹ · Enrique Quesada-Moraga³ · Aranzazu Moreno¹ · Natalia González-Mas²

Received: 7 October 2025 / Revised: 21 December 2025 / Accepted: 9 January 2026
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Endophytization trials



3 dd ➡➡ 7 dd

➡➡
14 dd
➡➡



Journal of Pest Science (2019) 92:1271–1281
<https://doi.org/10.1007/s10340-019-01098-5>

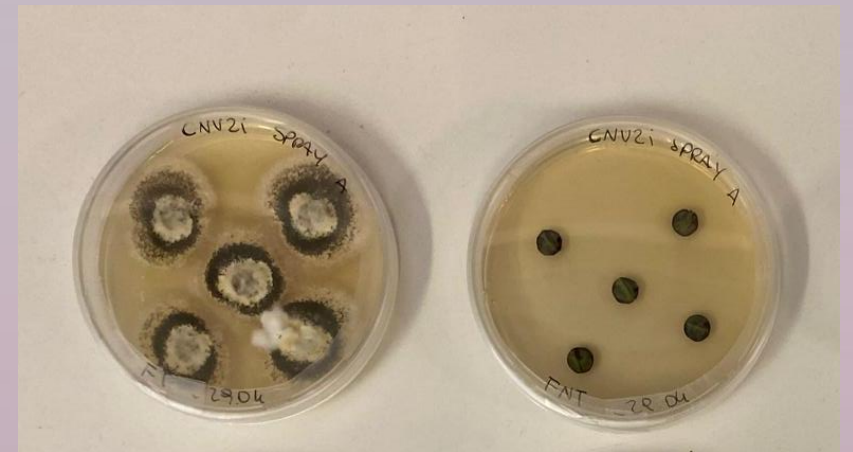
ORIGINAL PAPER



Bottom-up effects of endophytic *Beauveria bassiana* on multitrophic interactions between the cotton aphid, *Aphis gossypii*, and its natural enemies in melon

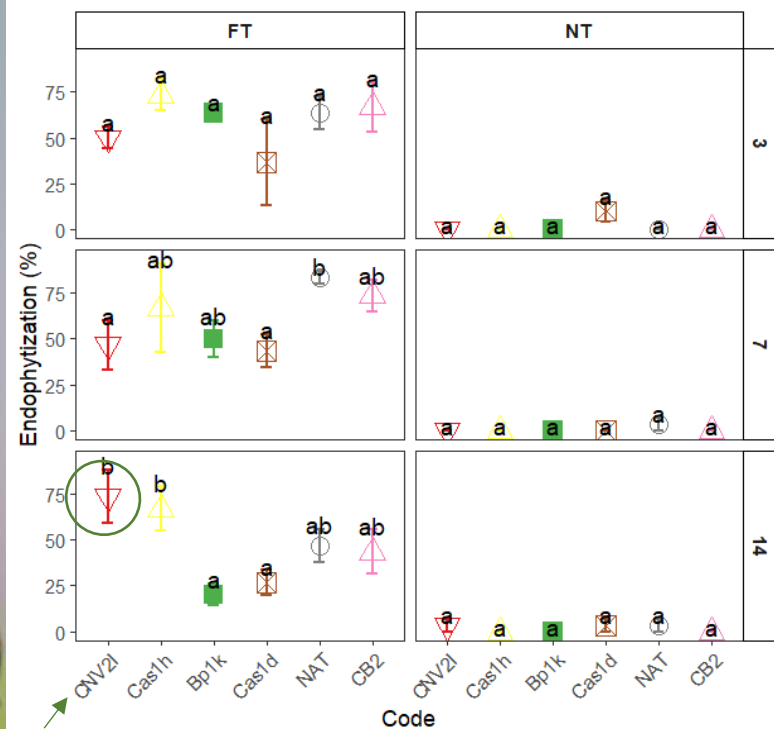
N. González-Mas¹ · M. Cuenca-Medina¹ · F. Gutiérrez-Sánchez¹ · E. Quesada-Moraga¹

Received: 2 December 2018 / Accepted: 18 February 2019 / Published online: 25 February 2019
© The Author(s) 2019

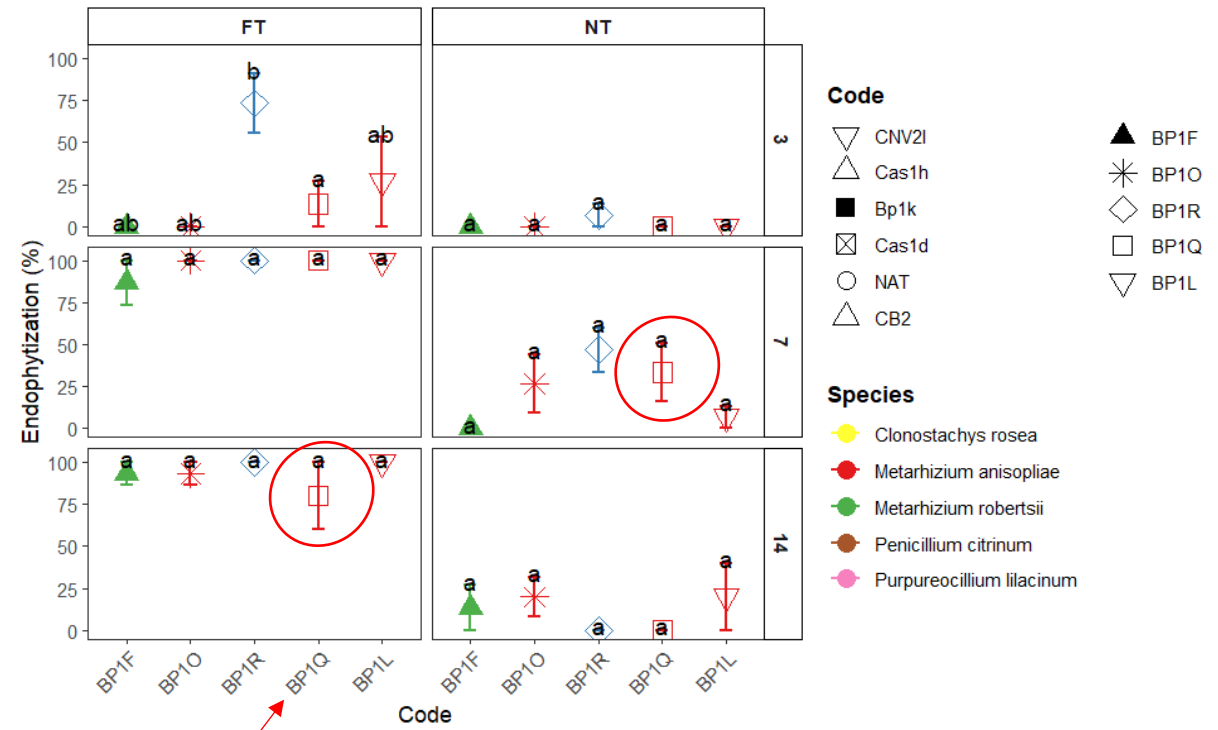


Endophytization trials

TRIAL 1



TRIAL 2

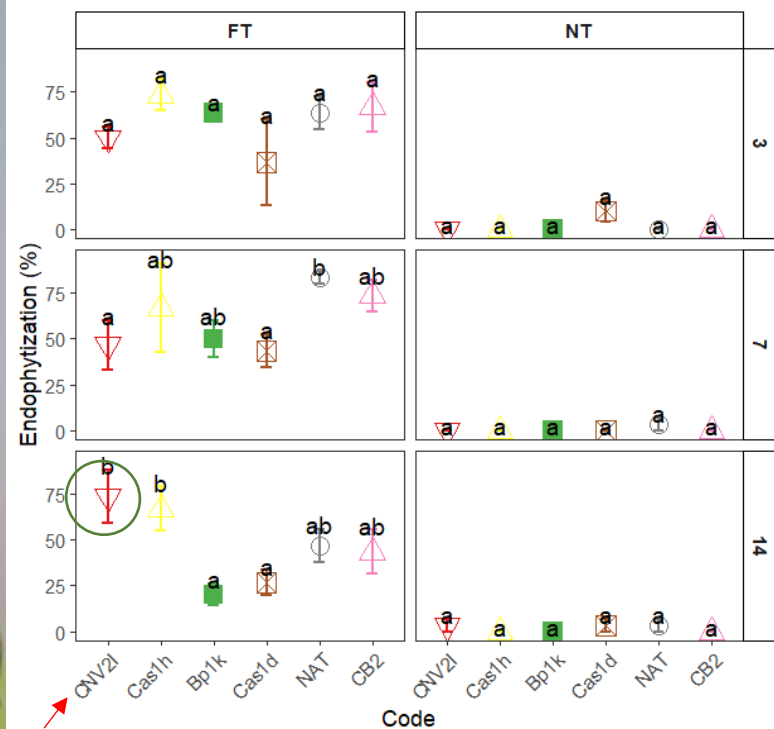


Good activity of *M. anisopliae* CNV2l and *M. anisopliae* Bp1q

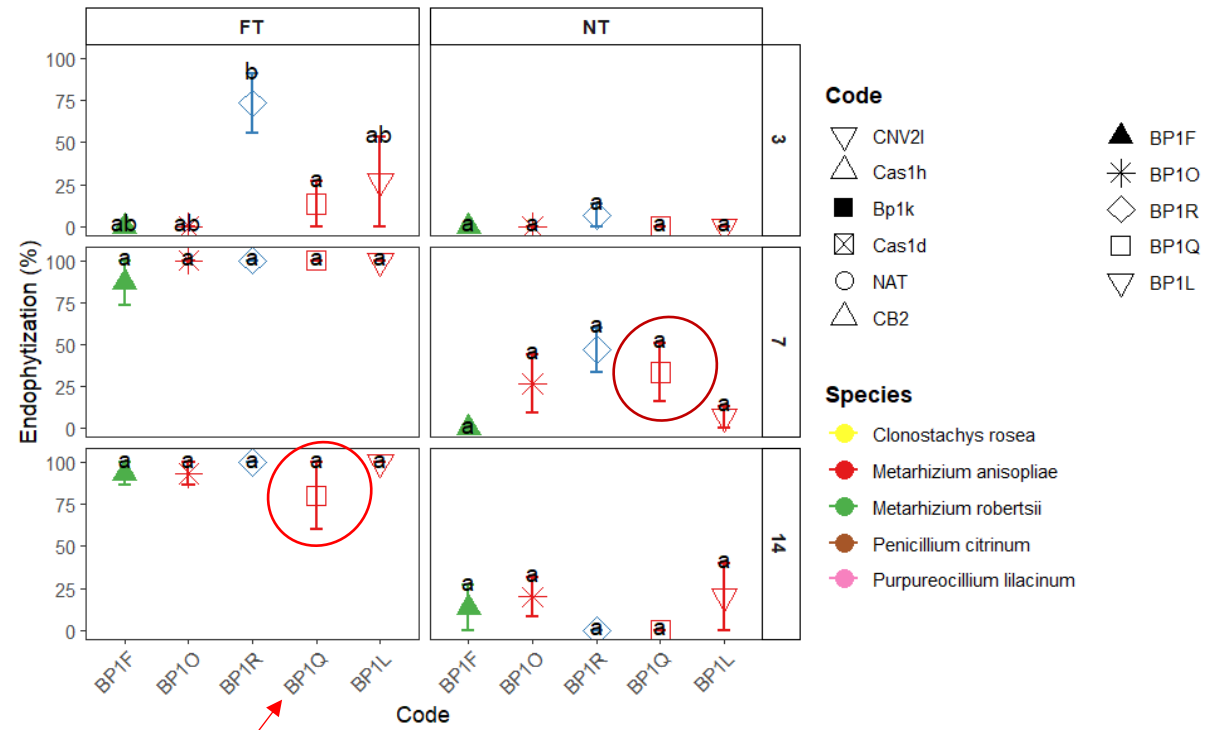
- CNV2l and BP1q showed an high presence in treated leaves at 14 days
- BP1q showed an high presence in treated and untreated leaves at 7 days

Endophytization trials

TRIAL 1



TRIAL 2



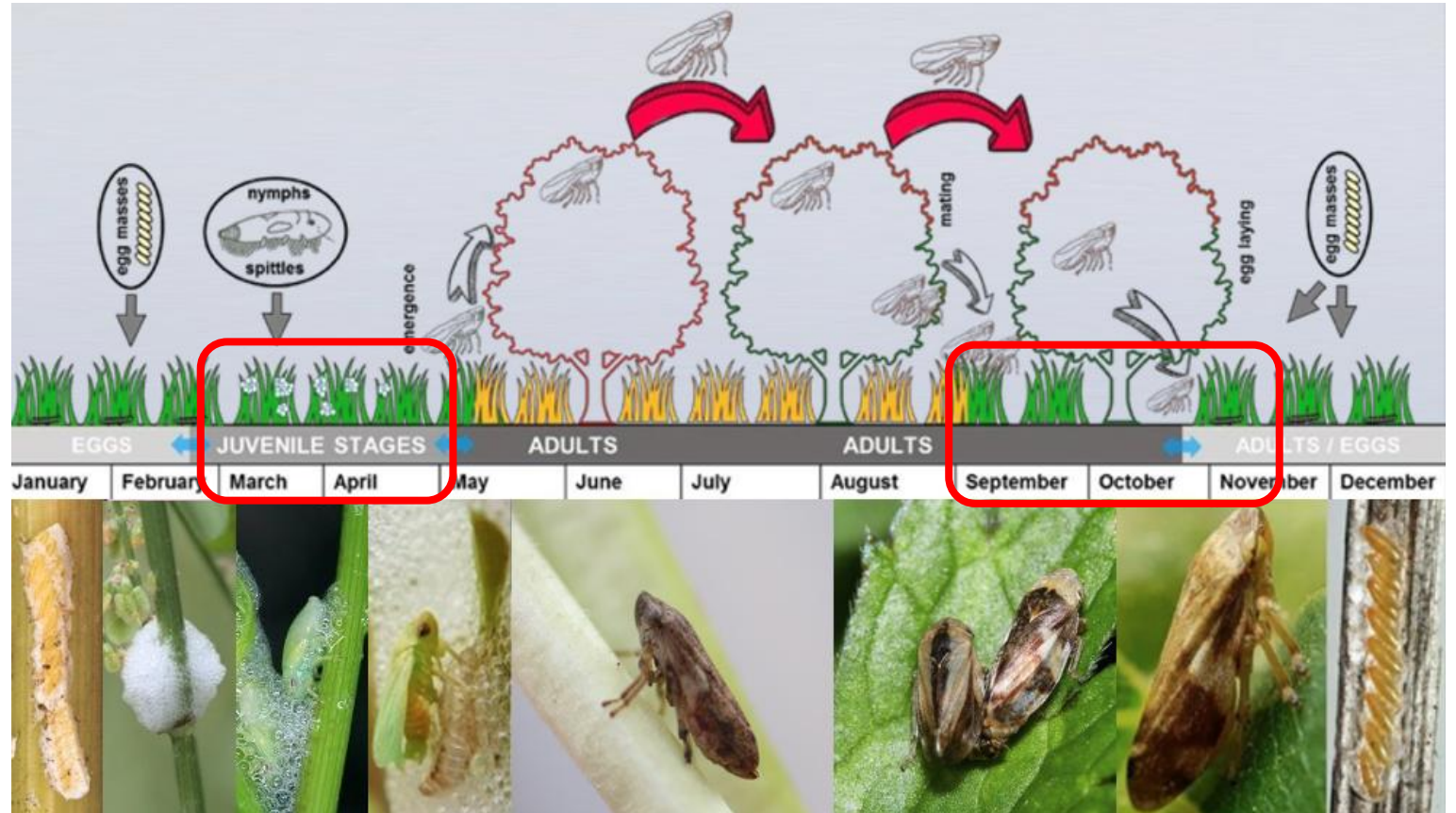
These two *M. anisopliae* strains are good candidate for a **dual action approach**
(**DIRECT EFFECTS** and **INDIRECT EFFECTS**)

The capability to colonize plant tissues could improve the persistence of EPF treatments

Future outlook

Two key time windows for vector control:

- **SPRING**
- **AUTUMN**



Future outlook

Two key time windows for vector control:

- **SPRING**, targeting nymphs



FIELD DATA AVAILABLE



Future outlook

Two key time windows for vector control:

- AUTUMN

- Multi-target treatment
- Adults with low fitness and mobility
- Targeting adults before oviposition may reduce offspring (Weaver and King, 1954)



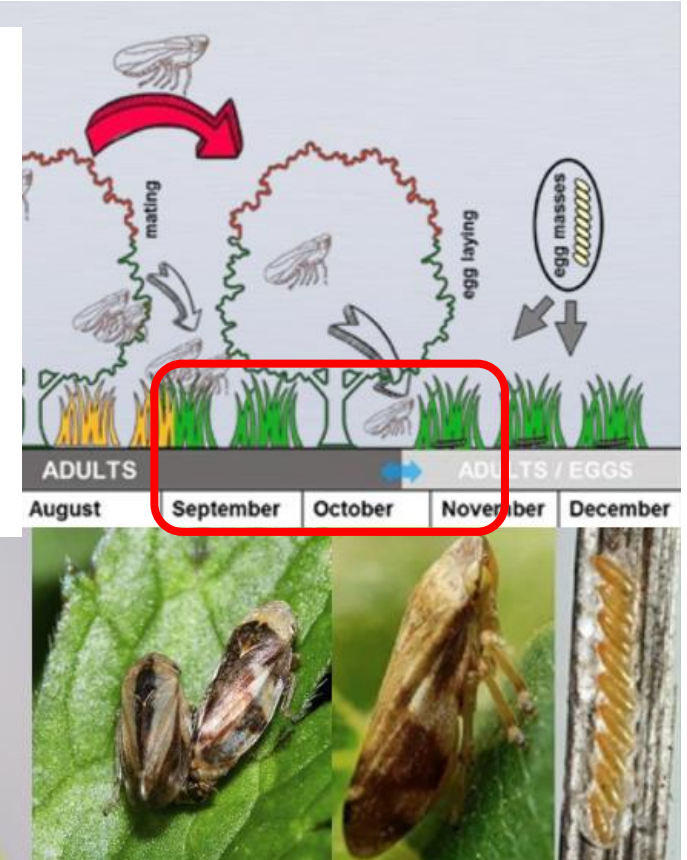
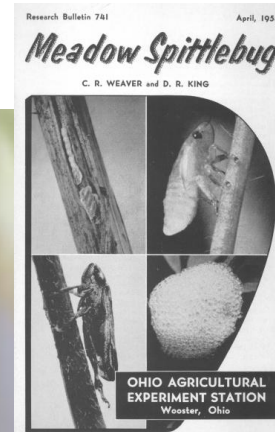
FURTHER STUDIES
REQUIRED

Fall Migration

Movements of the adults apparently do not proceed at the same rate throughout the season. The influence of temperature would naturally be expected to produce differences in the amount of movement. Adult spittlebugs kept in temperature controlled rooms exhibited a much greater tendency to move about at 70° than at 50° F. As the season progresses, the lower temperatures of September and October would be expected to have a retarding influence on the tendency for migration.

DeGeer (1773) says, "Comme c'est vers l'automne que les femelles ont le ventre si rempli d'oeufs, qu'a pleine peuvent elles sauter ni voler, tant elles sont grosses et pesantes. . . ." The presence of eggs in the female undoubtedly prevents the female from being as active as she would be during the summer.

56



Future outlook

- **SPRING**, targeting nymphs



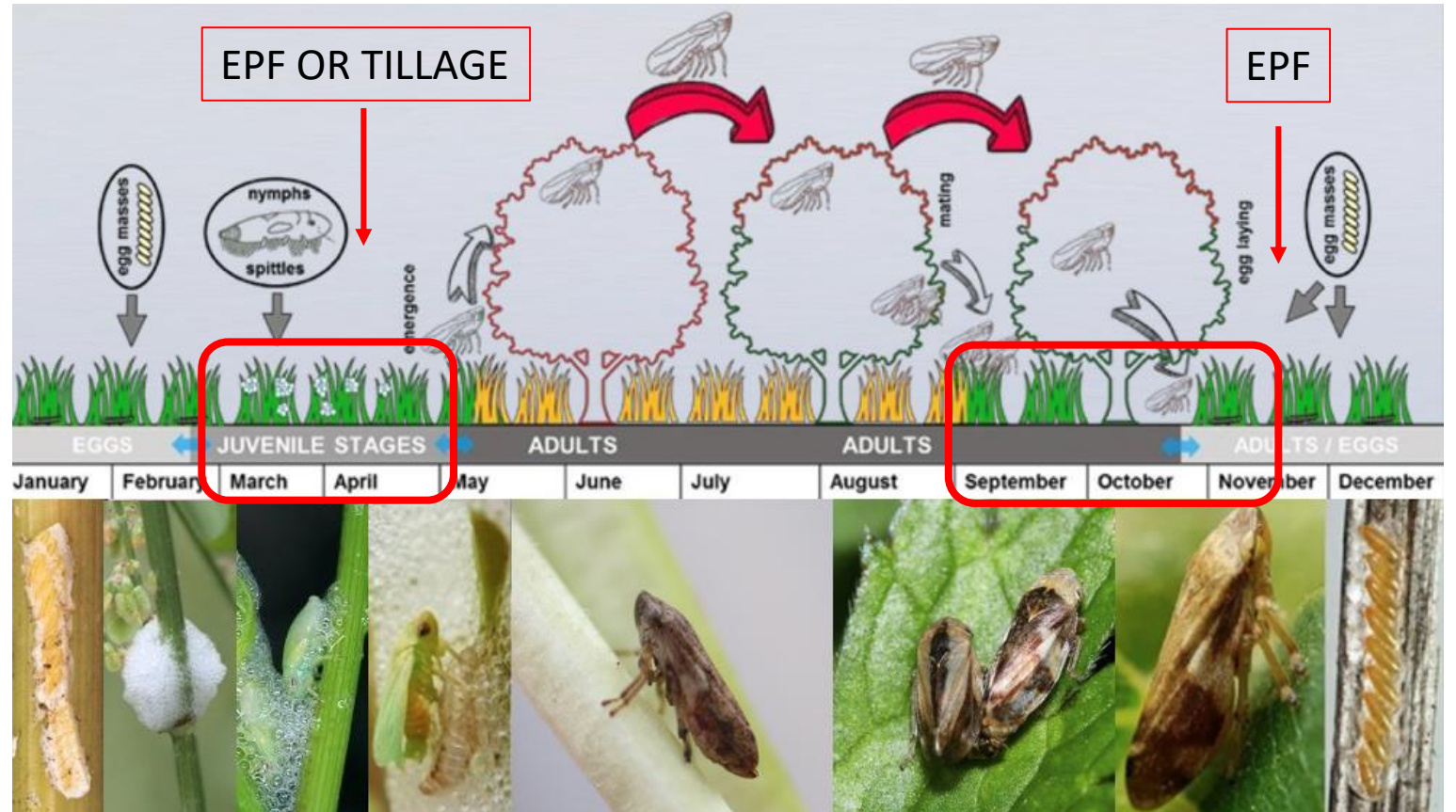
INDIRECT
EFFECTS?

- **AUTUMN**



INDIRECT
EFFECTS?

FURTHER STUDIES
REQUIRED



ACTING IN BOTH TIMES COULD REDUCE SIGNIFICANTLY THE VECTOR ABUNDANCE DURING THE YEARS

THANK YOU

francesco.volpe@unito.it

Special thanks to all the CRSFA members
involved in the field trial

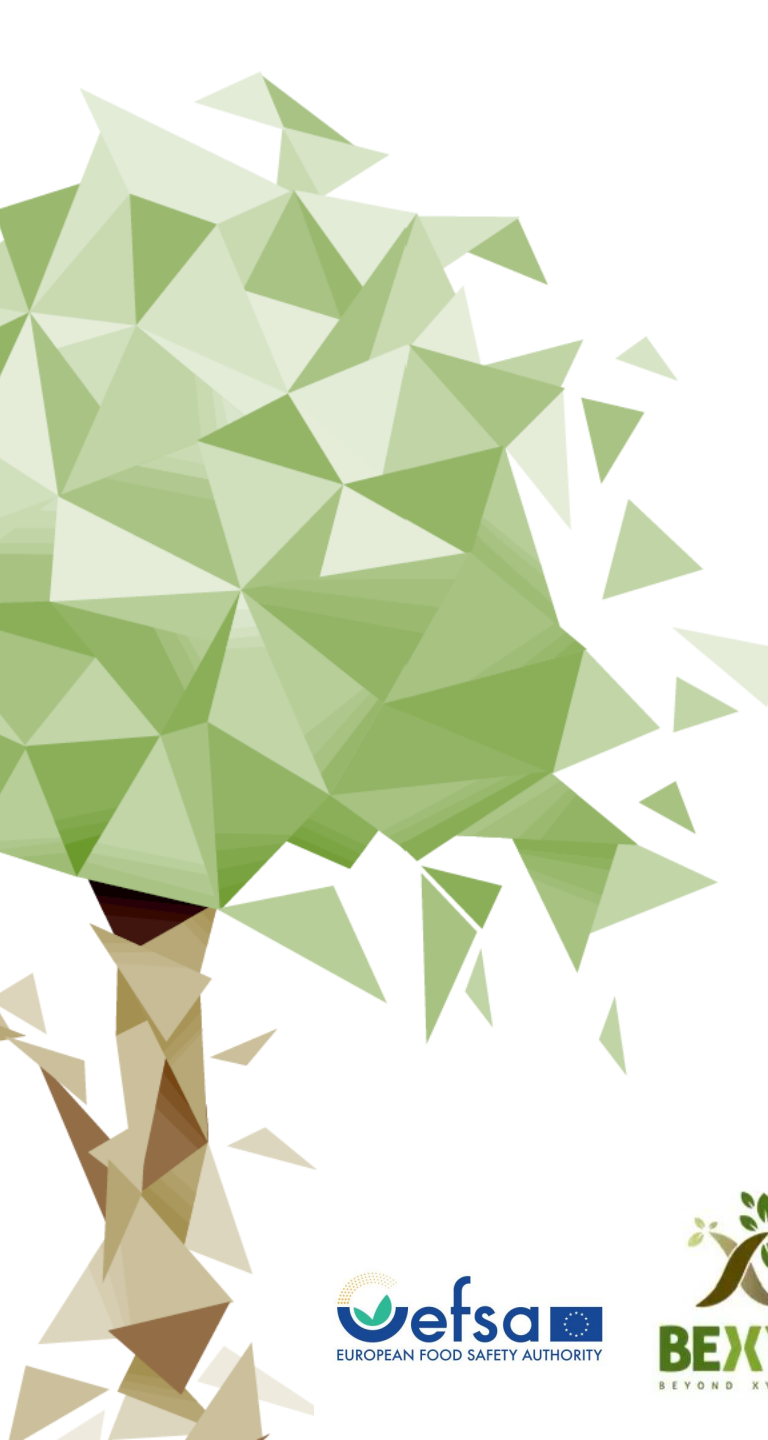
Michele Di Carolo
Michele Casetta
Martino Tagliente

Mauro Carrieri
Roberto Argentieri



Centro di Ricerca
Sperimentazione e Formazione
in Agricoltura "Basile Caramia"





DRAECULACEPHALA ROBINSONI, A POTENTIAL VECTOR OF XYLELLA FASTIDIOSA IN EUROPE: DISTRIBUTION AND POPULATION DYNAMICS ACROSS THE IBERIAN PENINSULA

LÓPEZ-GÓMEZ, R.^(1,2), SABATE, J.⁽³⁾, PLAZA, M. ⁽¹⁾, MORENO, A. ⁽¹⁾, FERERES, A. ⁽¹⁾

- (1) Instituto de Ciencias Agrarias, Consejo Superior de Investigaciones Científicas (ICA-CSIC)
- (2) Escuela Técnica Superior de Ingeniería Agronómica, Alimentaria y de Biosistemas (ETSIAAB), Universidad Politécnica de Madrid (UPM)
- (3) Instituto de Investigación y Tecnología Agroalimentaria (IRTA)

INTRODUCTION

Draeculacephala robinsoni Hamilton (1967), sharpshooter native to the eastern United States.

- First detected in 2021 in southern France and northeastern Spain. Since then, its distribution has expanded rapidly in both countries.
- Species of the genus *Draeculacephala* are known vectors of Xf in North America.
- Ecology and population dynamics under European conditions remain largely unknown.

Objective: To assess the current distribution and seasonal population dynamics of *D. robinsoni* in Spain



Data density map of the genus *Draeculacephala* Ball 1901 based on GBIF records (2020-2025)(*Draeculacephala* Ball, 1901 in GBIF Secretariat (2023). GBIF Backbone Taxonomy. Checklistdataset <https://doi.org/10.15468/39omei> accessed via GBIF.org on 2026-06-15). © GBIF

METHODOLOGY



- Monthly sampling (6 sites) → Known presence of *D. robinsoni*.
- Sampling every 3 months (10 sites) → No previous detections.

Habitats surveyed:

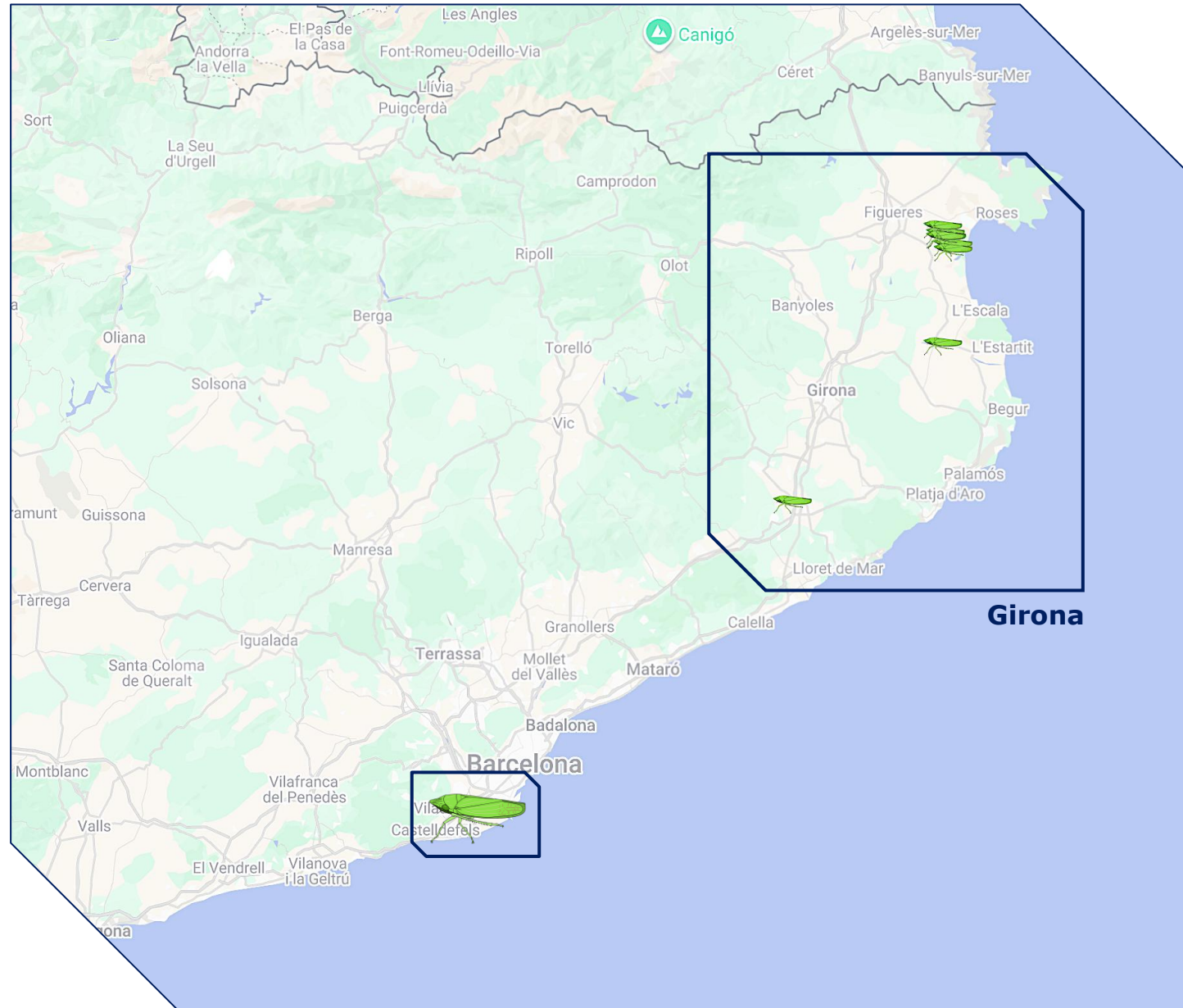
- Permanent pastures.
- Cereal and alfalfa fields.
- Canopy and ground cover vegetation of vineyards, apple orchards and olive groves.

RESULTS

D. robinsoni was **not detected outside Catalonia.**

The **southernmost records** corresponded in **Barcelona** province.

Largest populations found in **Girona**.



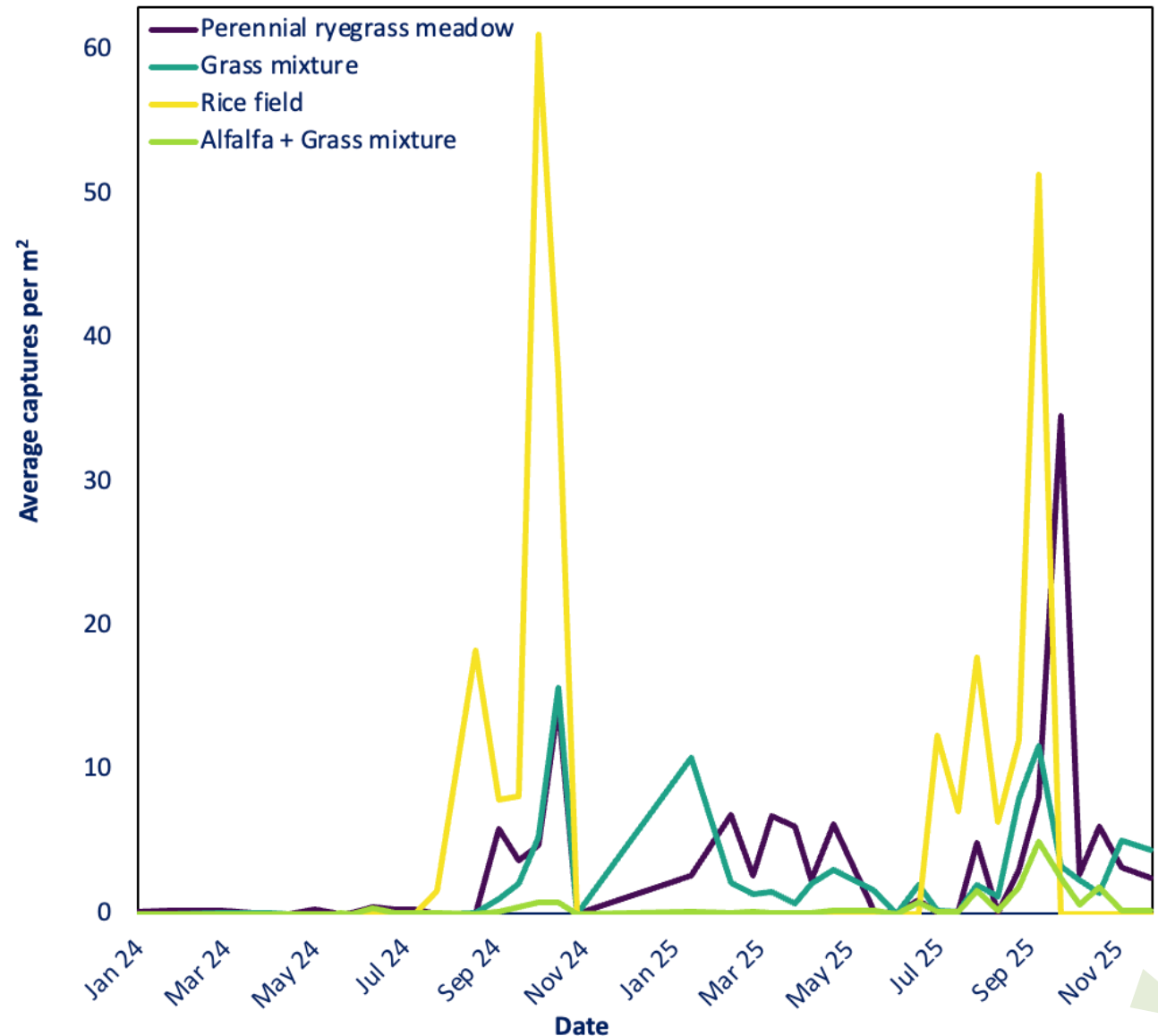
RESULTS

Highest population densities were recorded in **rice and perennial ryegrass fields**.

- Rice populations peaked likely linked to delayed sowing.
- Perennial ryegrass supported high densities, specially after rice harvest.
- **Four major population peaks** were observed **annually**.
- Additional smaller peaks occurred during winter, specially in 2025.

These results confirm that **populations are well established in Spain, maintaining stable and abundant populations year-round**.

Seasonal abundance *D. robinsoni* individuals (including nymphs and adults) on **herbaceous hosts** (Castelló d'Empúries, **Girona**, Spain) (D-VAC aspiration)



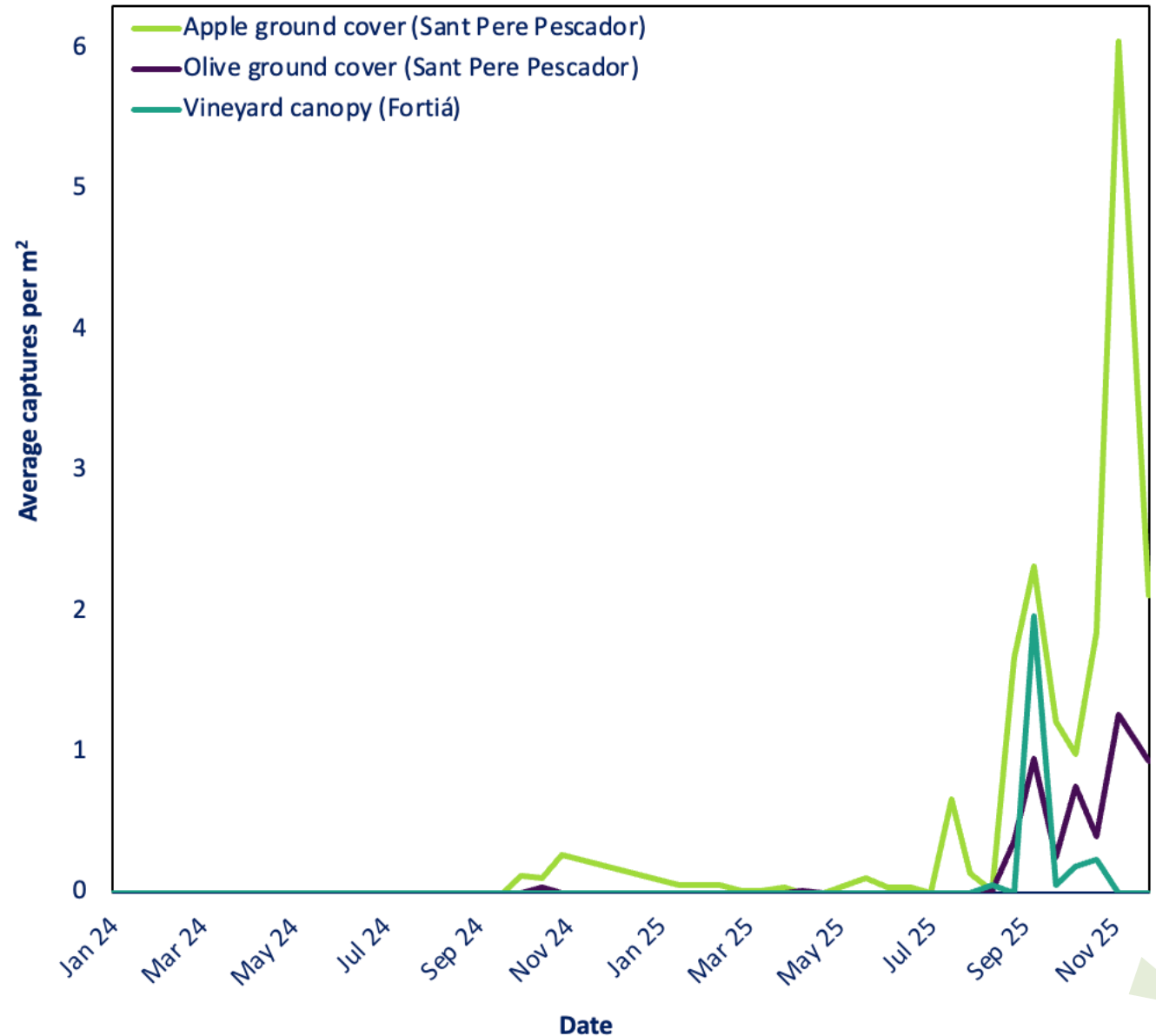
RESULTS

D. robinsoni was detected in olive groves, apple orchards, and vineyards.

- Higher densities were recorded in 2025, specially in apple orchards.
- Vineyards also harboured abundant populations.
- **Three population peaks** were observed across woody hosts.

These results indicate that *D. robinsoni* is not restricted to herbaceous habitats.

Seasonal abundance *D. robinsoni* individuals (including nymphs and adults) on **woody hosts** (Girona, Spain) (D-VAC aspiration)



CONCLUSIONS

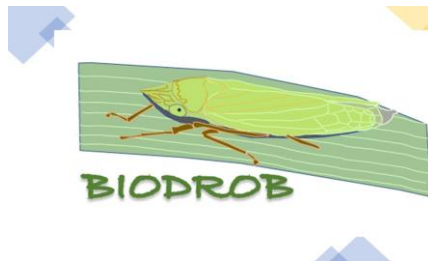
- *D. robinsoni* is currently established in northeastern Spain and continues to expand locally.
- *D. robinsoni* is established in both herbaceous and woody agroecosystems, with three and four annual population peaks in woody and herbaceous habitats respectively.



Although the species has not yet been detected outside Catalonia, continued monitoring and further studies on its ecology and potential role as a vector of Xf will be essential to properly assess its phytosanitary risk and support future management strategies.

**THANK YOU
FOR YOUR
ATTENTION**

POSTER 86



IRTA



Metarhizium brunneum direct
exposure reduces survival and
disrupts feeding behaviour in
Philaenus spumarius

HERNÁNDEZ-LAO, T.¹; GONZALEZ-MAS, N.²; QUESADA-MORAGA, E.²; FERERES, A.¹; MORENO, A.¹

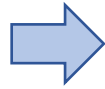
¹ INSTITUTO DE CIENCIAS AGRARIAS. CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS (ICA-CSIC), C/ SERRANO, 115 DPDO., 28006, MADRID, ESPAÑA

² DEPARTAMENTO DE AGRONOMÍA, ETSIAM, UNIVERSIDAD DE CÓRDOBA, CAMPUS DE RABANALES, EDIF C4, 14071 CÓRDOBA, ESPAÑA

Introduction

Philaenus spumarius is the main vector of *Xylella fastidiosa* in Europe

Bactericidal treatments
have shown limited
effectiveness against this
pathogen



Control insects vector:

- Chemical Control
- Physical Control
- Biological Control



Indirect application has shown
promising results against *P.*
spumarius



Metarhizium brunneum

Philaenus spumarius



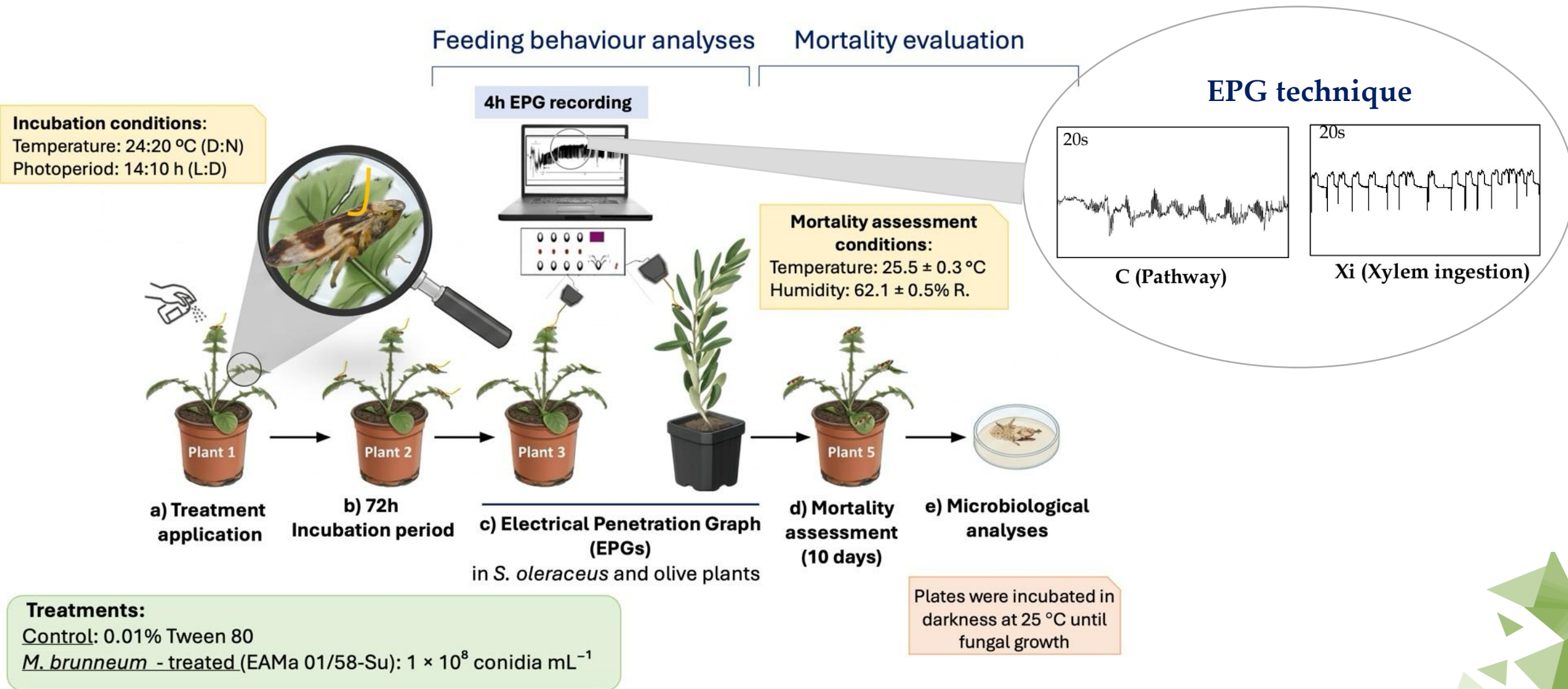
It's direct effects on the
insect's feeding behaviour
and survival are still not
fully understood.

Objectives:

To assess the **feeding behaviour** of *Philaenus spumarius* on *Sonchus oleraceus* and *Olea europaea*
when sprayed with *Metarhizium brunneum*

To assess the **mortality** of *Philaenus spumarius* when sprayed with *Metarrhizium brunneum*

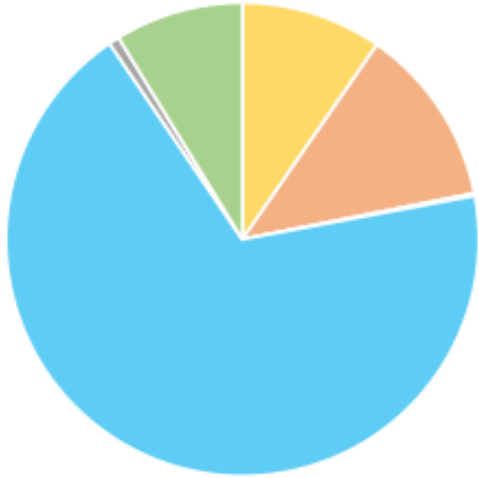
Methodology



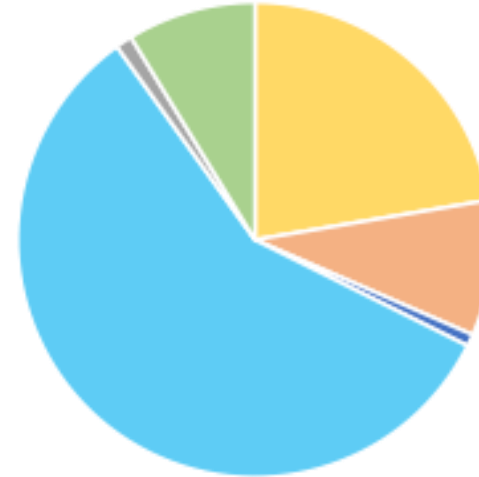
Results

Proportion of Each Waveform Duration Relative to the Total Recording Duration

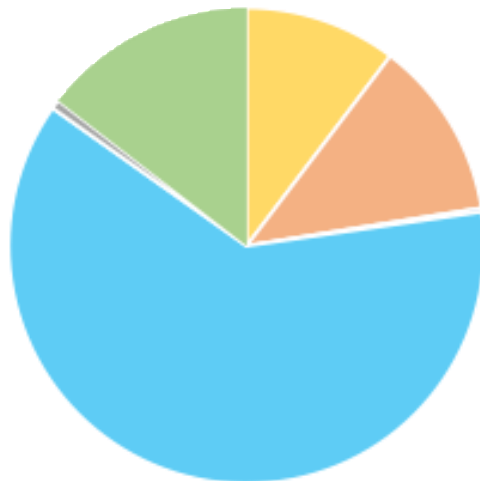
Control - *Sonchus oleraceus*



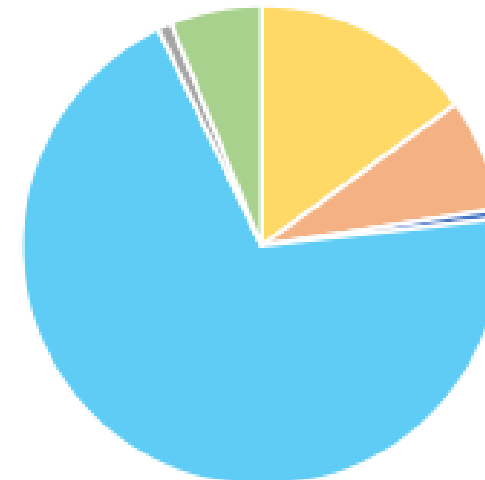
Control - *Olea europaea*



M. brunneum - Treated - *Sonchus oleraceus*



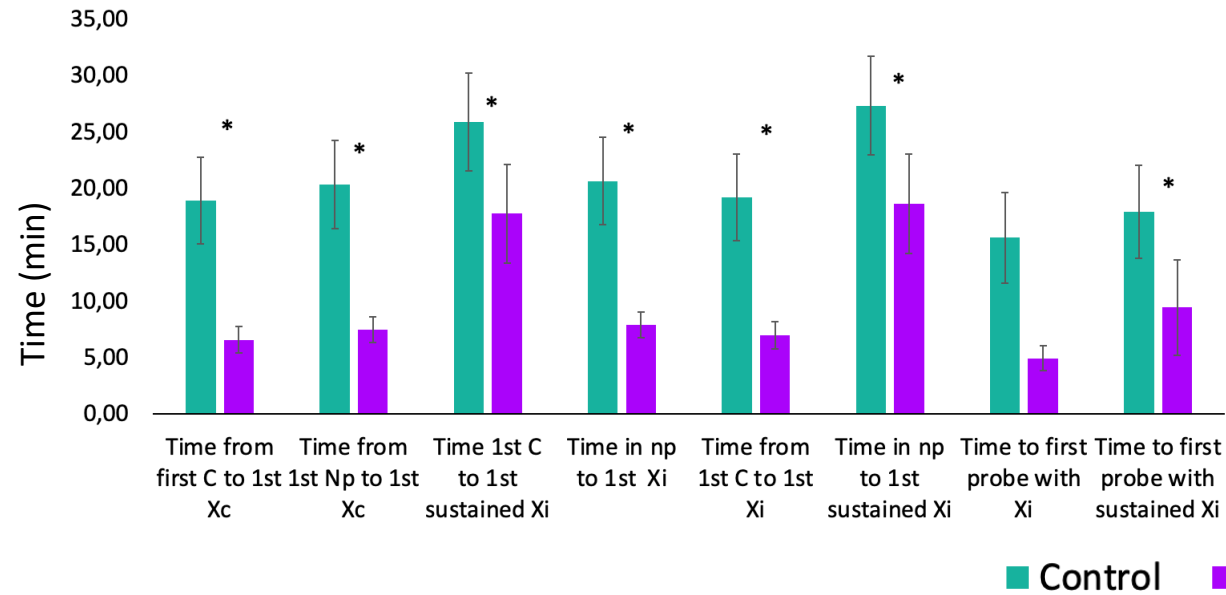
M. brunneum - Treated - *Olea europaea*



- % Time in np
- % Time in C
- % Time in Xc
- % Time in Xi
- % Time in N
- % Time in R

Results

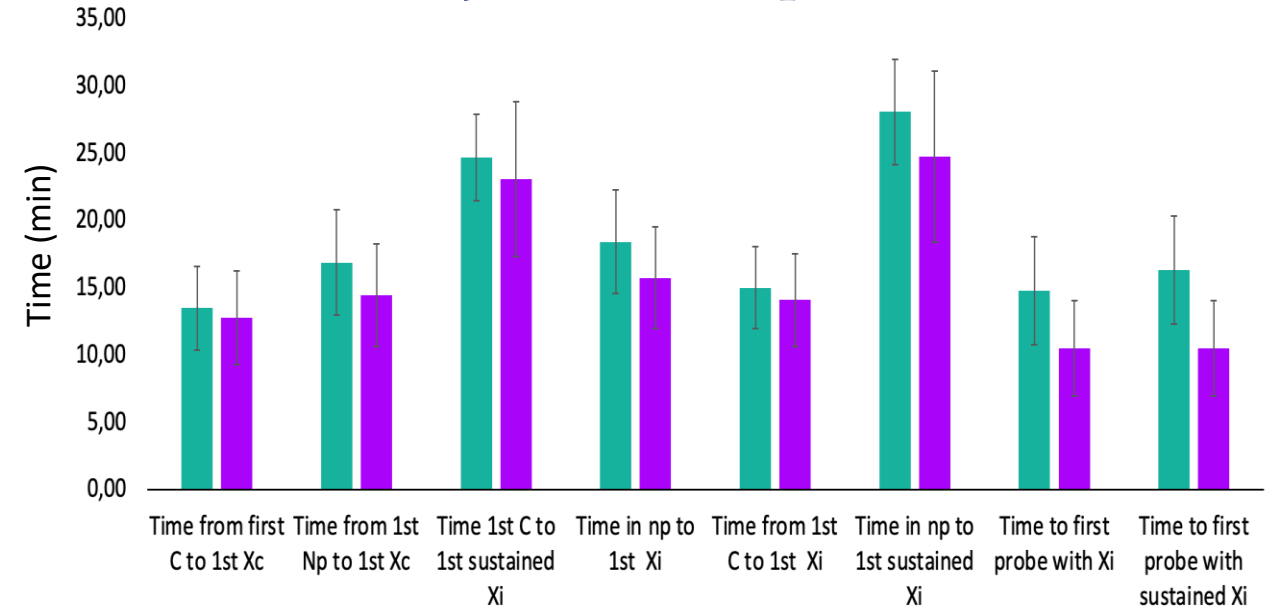
Sonchus oleraceus EPG sequential variables



$N_{\text{Control}} = 27$; $N_{\text{Treated}} = 30$

Student's *t*-test or Mann-Whitney *U* test analyses

Olea europaea EPG sequential variables

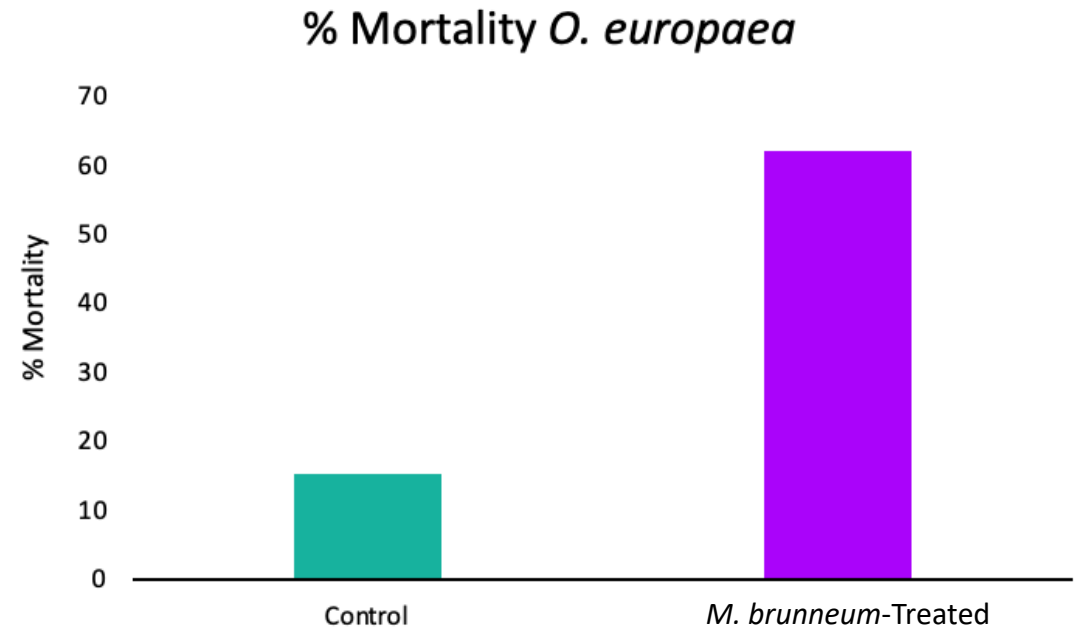
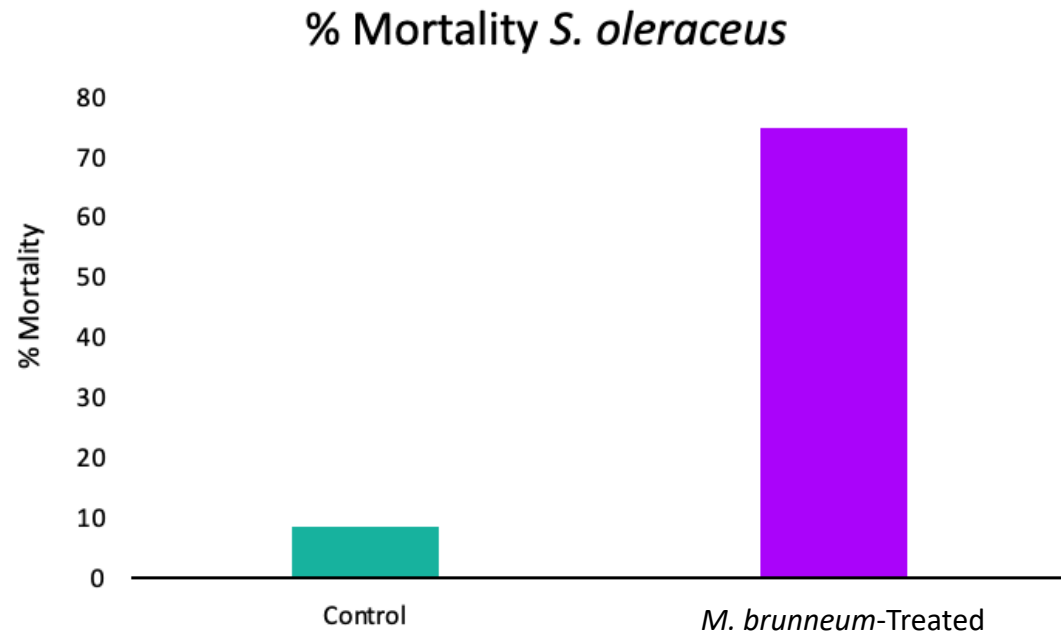


$N_{\text{Control}} = 19$; $N_{\text{Treated}} = 17$

Treated insects reached the xylem and initiated xylem ingestion earlier than controls



Results



M. brunneum significantly increased the mortality of *P. spumarius*





Conclusions

- Direct application of *M. brunneum* altered the feeding behaviour of *P. spumarius*, promoting earlier access to xylem ingestion, particularly on *S. oleraceus*.
- A similar trend was observed in olive, where treated insects also showed longer xylem ingestion events.
- This consistent pattern across host plants may indicate a compensatory response to fungal colonisation.
- In addition, *M. brunneum* significantly increased insect mortality, supporting its potential use in integrated pest management strategies against *P. spumarius*.





Thank you for your attention



Xylella fastidiosa

5th European conference

Bari, Italy | 22-26 June 2026





UNCOVERING VIRAL PARTNERS: HOW THE VIROME SHAPES FITNESS IN *PHILAEENUS SPUMARIUS*

Pierre Royer^{1,2}, *Bruno Rosso*^{1,2}, *Simona Abbà*², *Nicola Bodino*¹, *Cristina Marzachi*², *Domenico Bosco*^{1,2}

1. Università degli Studi di Torino, DISAFA – Entomologia, Grugliasco (TO), Italy; 2. CNR - Istituto per la Protezione Sostenibile delle Piante, Torino, Italy;

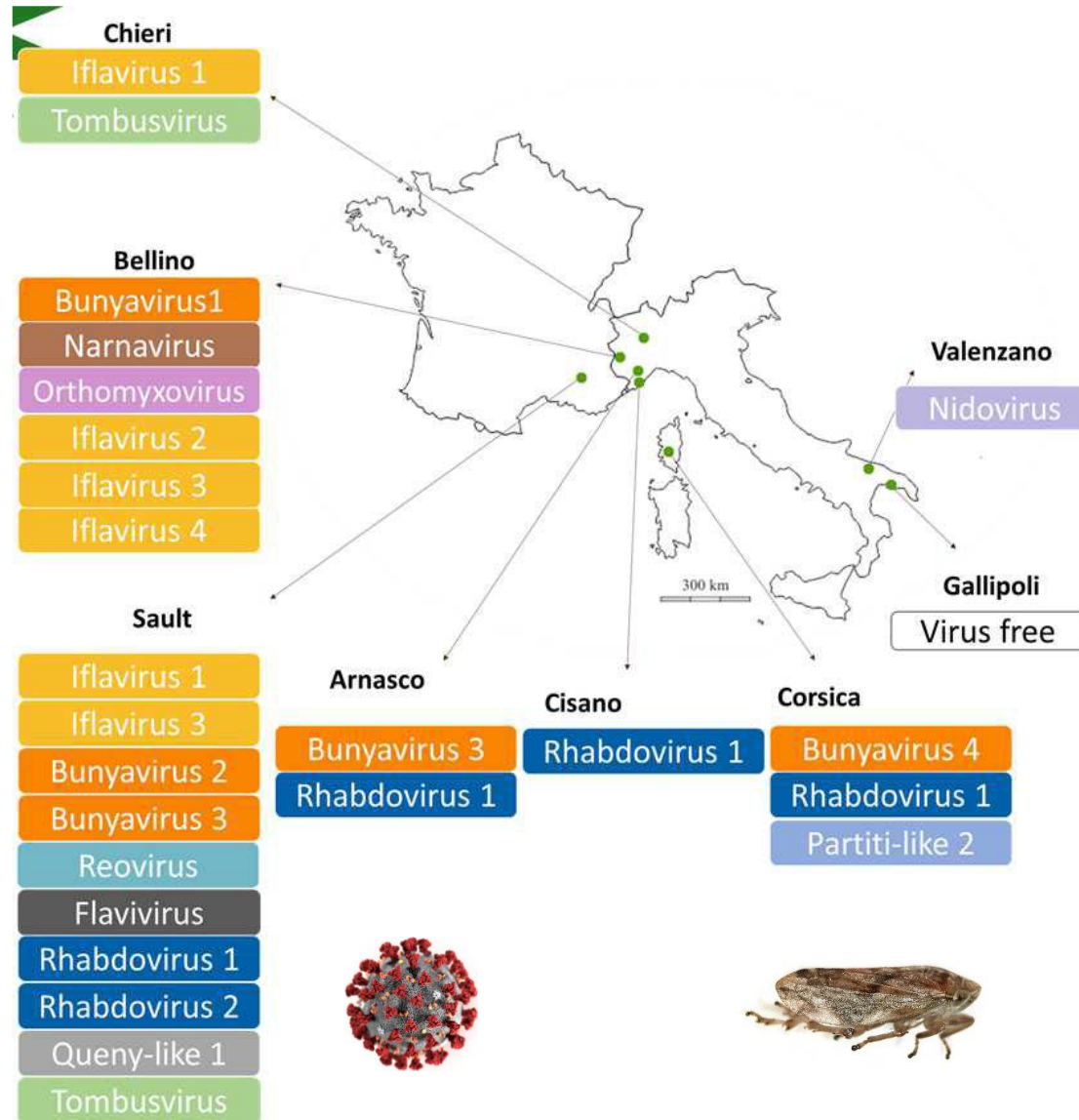
A presentation by

Pierre Royer

Ph.D. student of the University of Turin



Background



Article | [Open access](#) | Published: 24 December 2025

Diversity and persistence of the RNA virome of *Philaenus spumarius*, the European vector of *Xylella fastidiosa*

[Sara Ottati](#), [Luciana Galetto](#), [Francesco Volpe](#), [Nicola Bodino](#), [Cristina Marzachi](#), [Domenico Bosco](#) & [Simona Abbà](#)

[Scientific Reports](#) **16**, Article number: 2800 (2026) | [Cite this article](#)

- Previous studies established a first snapshot of *Philaenus spumarius* virome
- Many viral species are yet to be discovered.
- What are the host–virus interactions?

Figure 1. Viral species diversity in *Philaenus spumarius* in 2024

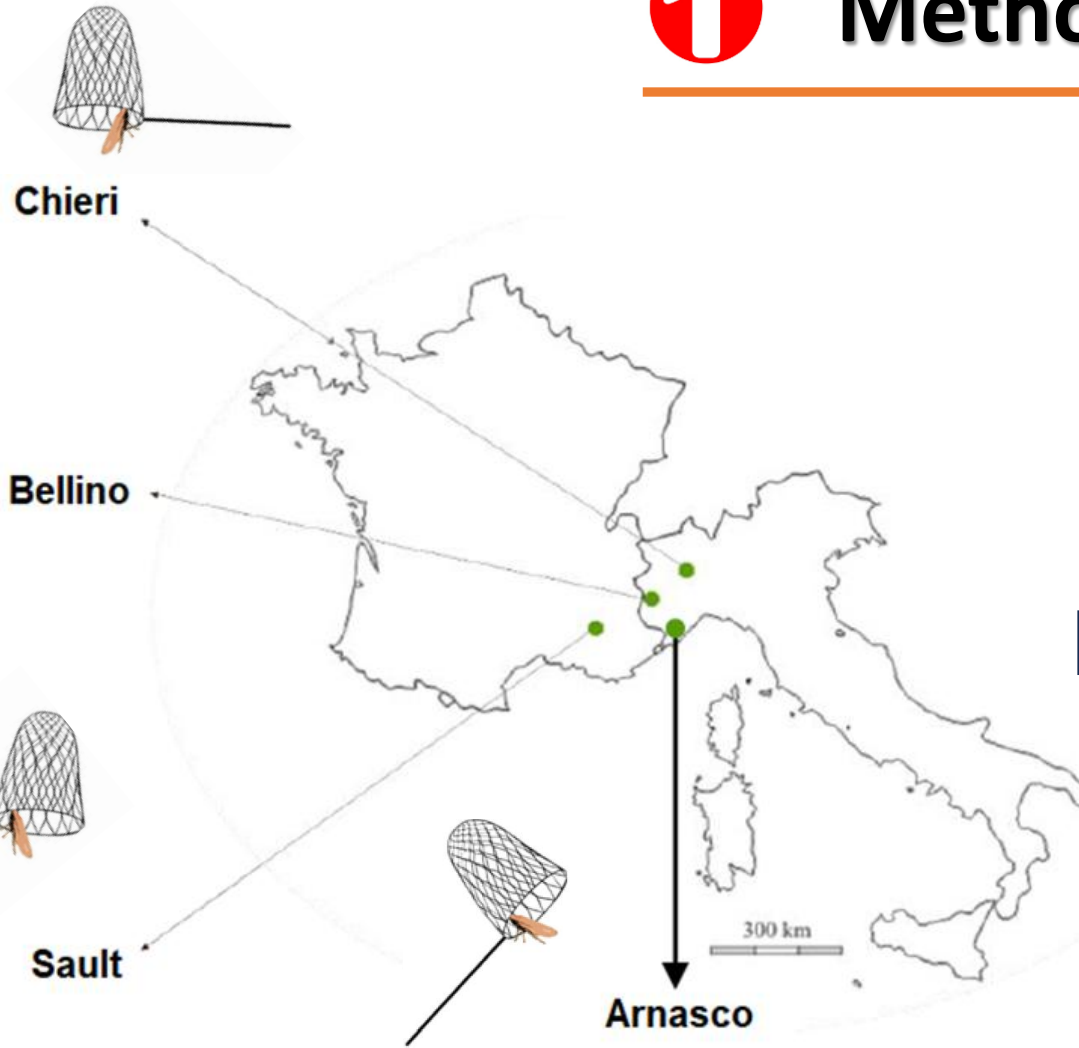


Aims

- 1 ... to continue the **characterization of the virome of *P. spumarius***
 - 2 and to evaluate the **effects of the virome on host fitness**
- 

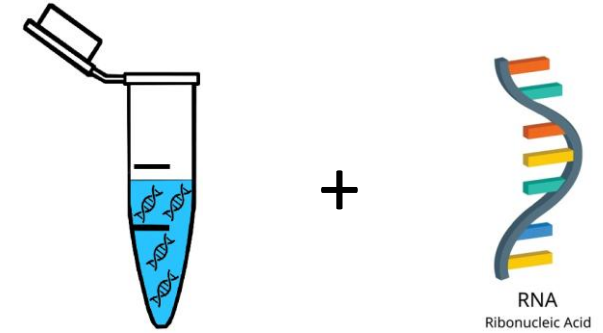
1

Methodology



P. spumarius sampling

RNA extraction and sequencing



Nucleotide sequence analysis and virus identification

AGACAACTTATG
CCAATCATAATG
CTTAGCAAACGT

+



=



2

Methodology



1. Micro-injection of **virus macerate** in Arnasco (virus-free population)
2. Evaluation of **four fitness parameters** of five population :
 - Arnasco (virus free)
 - Arnasco infected (injected with virus)
 - Chieri
 - Sault
 - Bellino
3. **15 couples from each population** were maintained on a chicory plant (*Cichorium intybus*)



Results

Chieri	Sault	
Elliovirales 1	Elliovirales 1	
Iflavirus 1	Iflavirus 3	
Iflavirus 4	Orthovirus 3	←
Narnavirus 1	Phasmavirus 2	
Phenuivirus 1	Phasmavirus 3	←
⇒ Solemo-like virus 1	Rhabdovirus 1	3 new viral species identified !
Tombusvirus 1	Tombusvirus 1	



- **Viruses found in Chieri and Sault populations.** Note that this table only includes viruses whose presence was confirmed following the use of primers designed for this study.
- **Arnasco is a virus-free population.** ✓
- The Bellino population is not represented as the total RNA was insufficient to validate the results.

Results

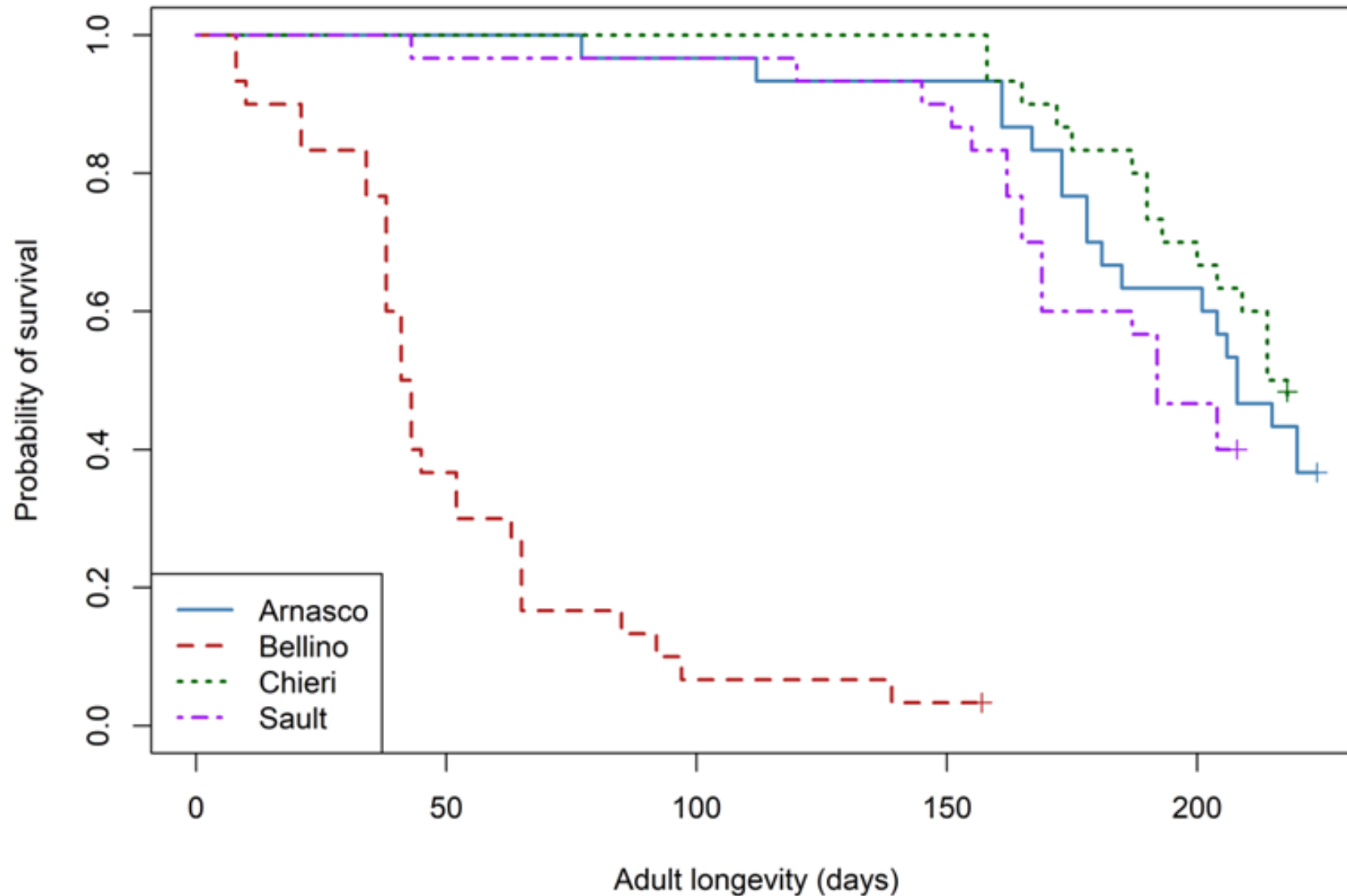


Figure 1. Survival curves for the four populations studied: Arnasco, Bellino, Chieri and Sault populations (F0).

Results

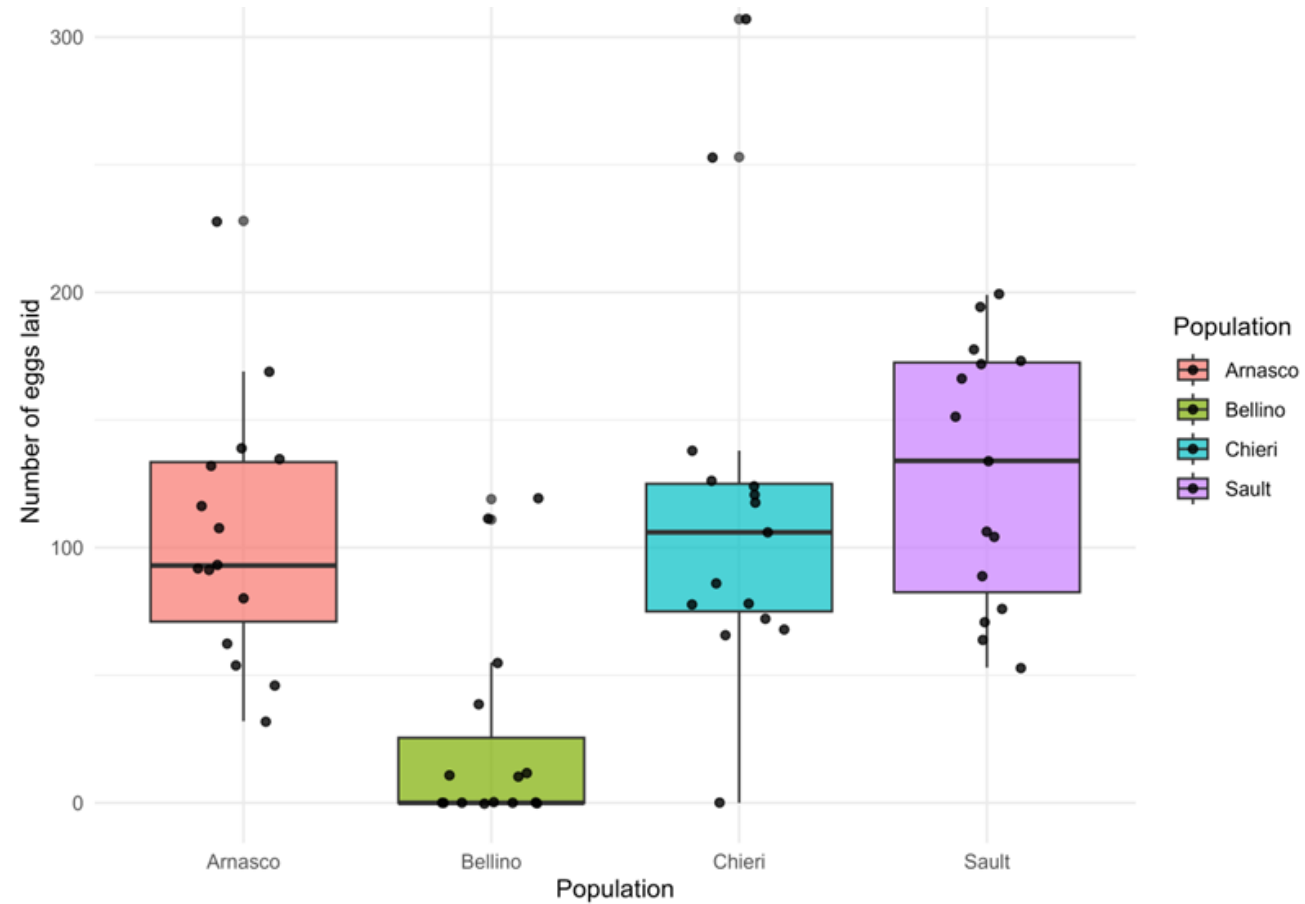


Figure 2. Number of eggs laid per female and population (F0).

Results

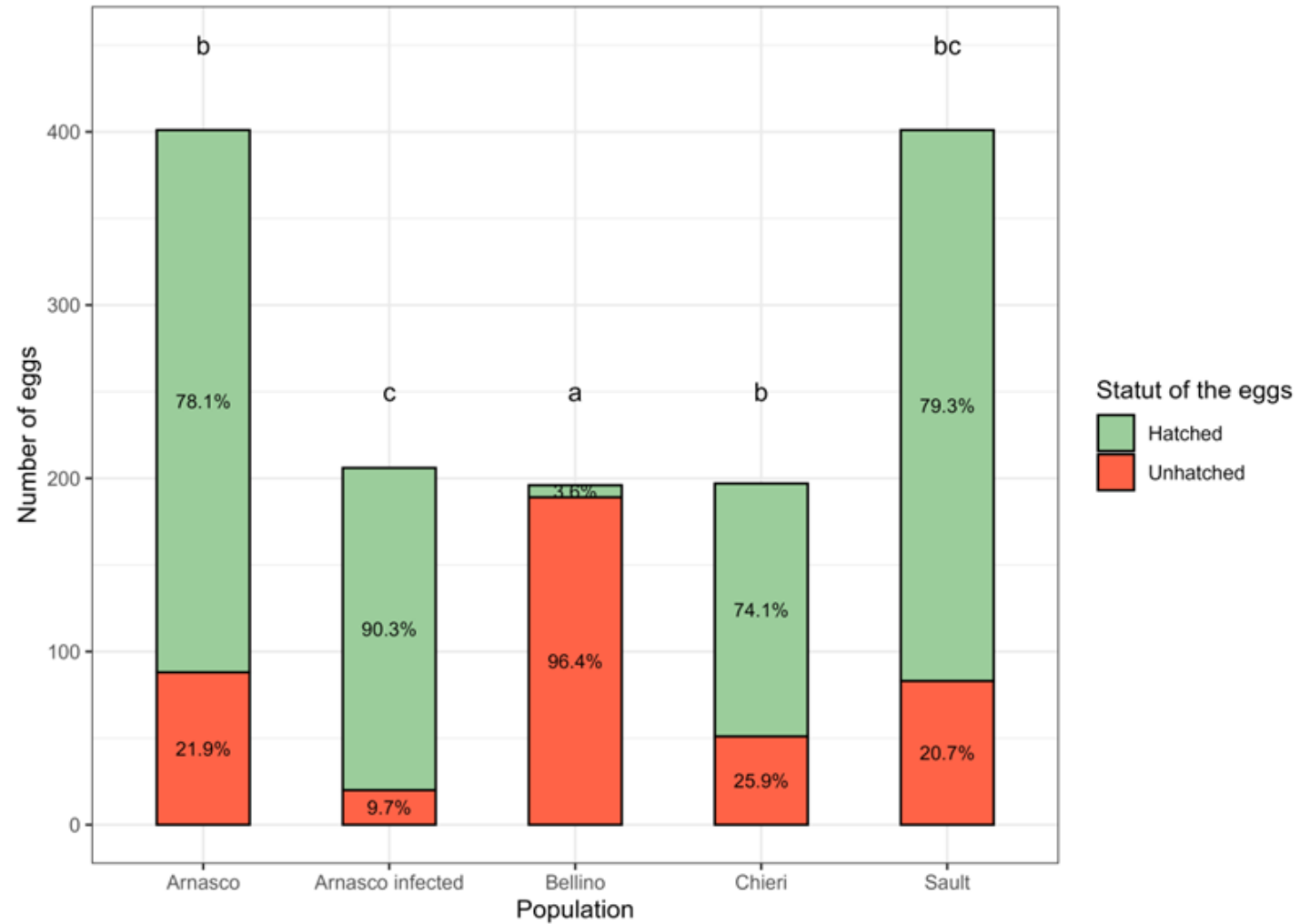


Figure 3. Total number of eggs hatched in cylinders for each population (F1).

Results

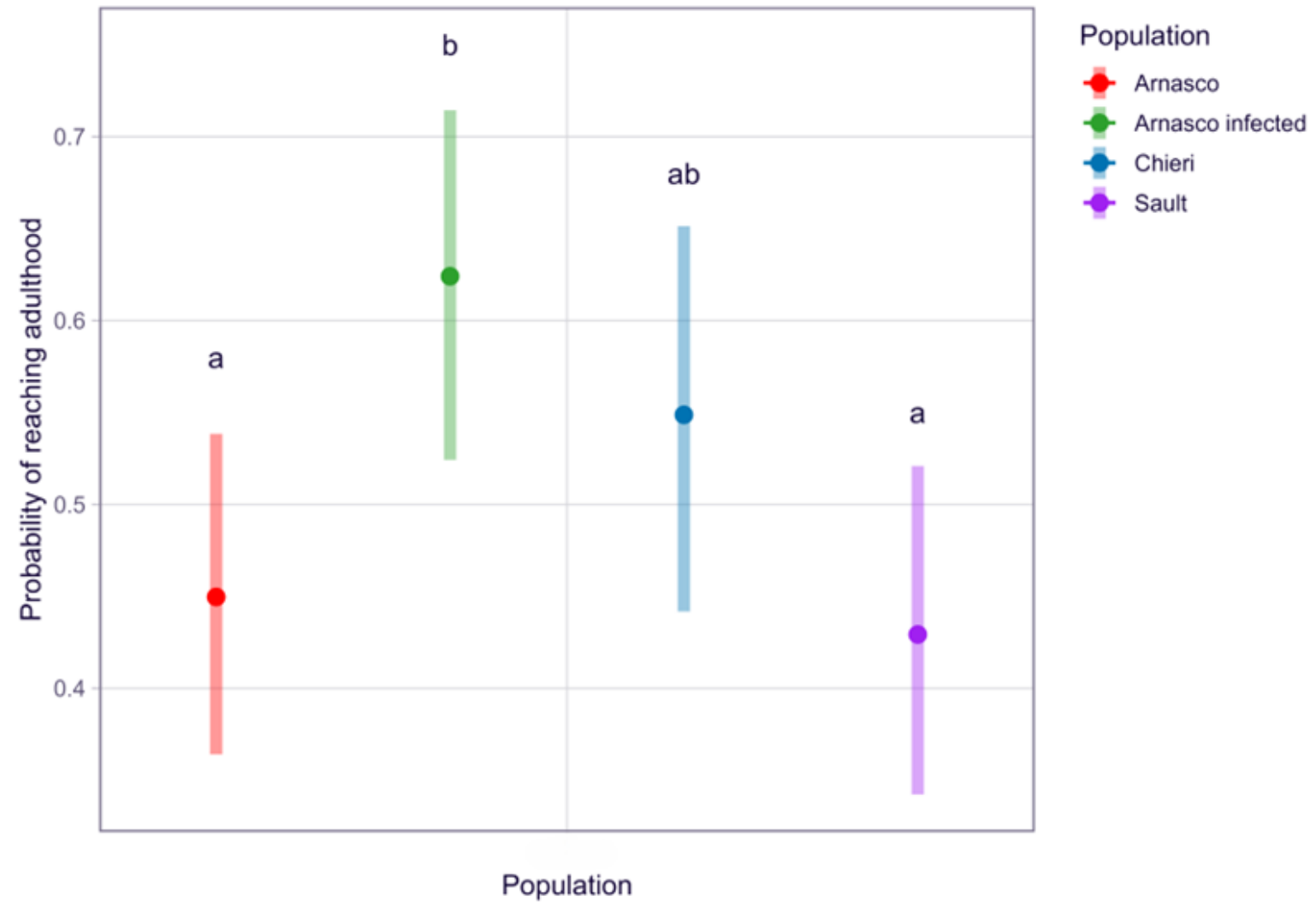
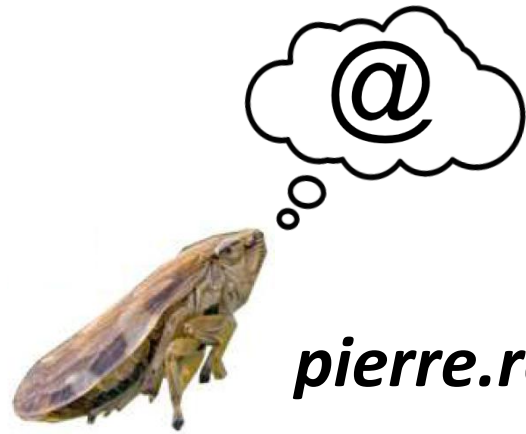


Figure 4. Estimated probability of larval survival to adulthood (F1).

Conclusion



Thanks !



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SCAN ME



Funding

CNR under the Project "Research actions for reducing the impact on agricultural and natural ecosystems of the harmful plant pathogen *Xylella fastidiosa*, REACH-XY"



Xylella fastidiosa

5th European conference

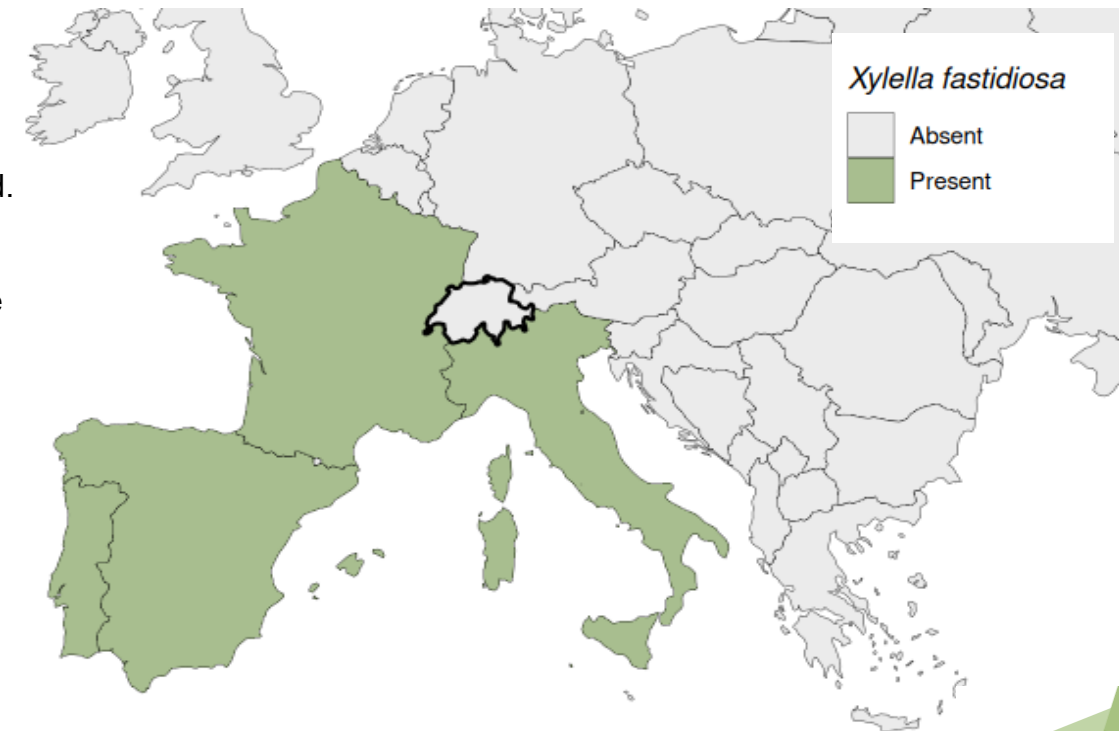
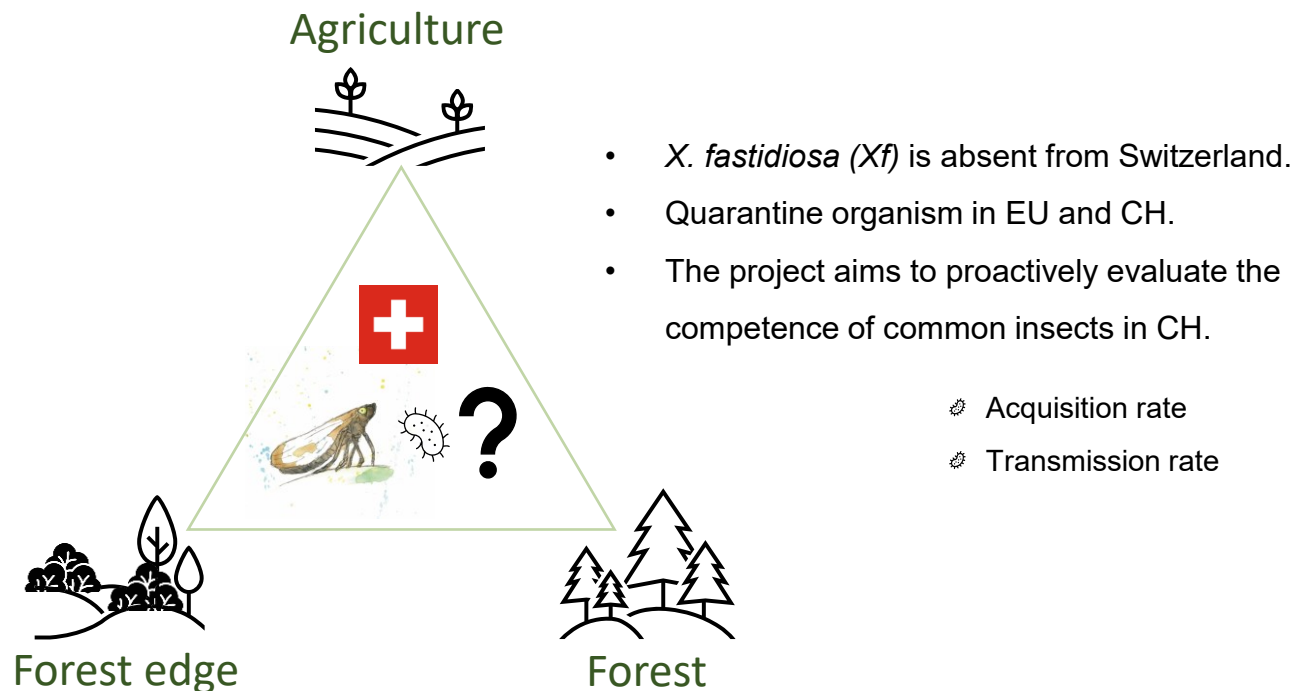
Bari, Italy | 22-26 June 2026



REGIONE PUGLIA

Assessment of insect vector competence for the acquisition and transmission of *Xylella fastidiosa* to agricultural and forest plant species in Switzerland

Júlia López-Mercadal, Francesca Dennert, Alice Pessina, Denise Altenbach, Laure Apothéloz-Perret-Gentil, Stéphane Hagmann, Attilio Rizzoli, Valentin Queloz, and Ramona Maggini

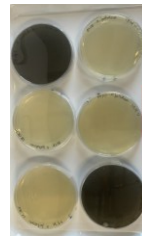


Objective: to assess the acquisition and transmission efficiency of different insect vectors present in Switzerland that could support the spread of *Xylella fastidiosa* from cultivated crop plants to forest plants (and vice versa).

Material and Methods

- Acquisition and transmission experiments were conducted in biosecurity level 3 facilities at WSL (Birmensdorf, Switzerland) between July and August 2025 (greenhouse temperature 20-26 °C).
- Plants were seedlings from local producers (30 – 100 cm height).

1 Field collected insects



Xf fastidiosa (CFBP7970) ST2
Xf multiplex (CFBP8418) ST6

2 Insect Xf acquisition

A) From infected plant:

- Plants inoculated twice (April and May 2025)
- Pin-prick method



96 hours AAP*



Agriculture:

- ♣ *Vitis vinifera*
- ♣ *Prunus armeniaca*

Forest edge:

- ♣ *Rubus fruticosus*
- ♣ *Corylus avellana*

Forest:

- ♣ *Fagus sylvatica*
- ♣ *Quercus robur*

B) From artificial diet:

- Holidic diet (Killiny et al. 2009)



6 hours AAP



3 Insect Xf transmission

96 hours IAP**



4 DNA extraction and qPCR

- CTAB DNA extraction (EPPO PM 7/24 (5) modified)
- TaqMan probe qPCR (EPPO diagnostic protocol PM7/24(5) Appendix 5 (Harper et al. 2010, erratum 2013))

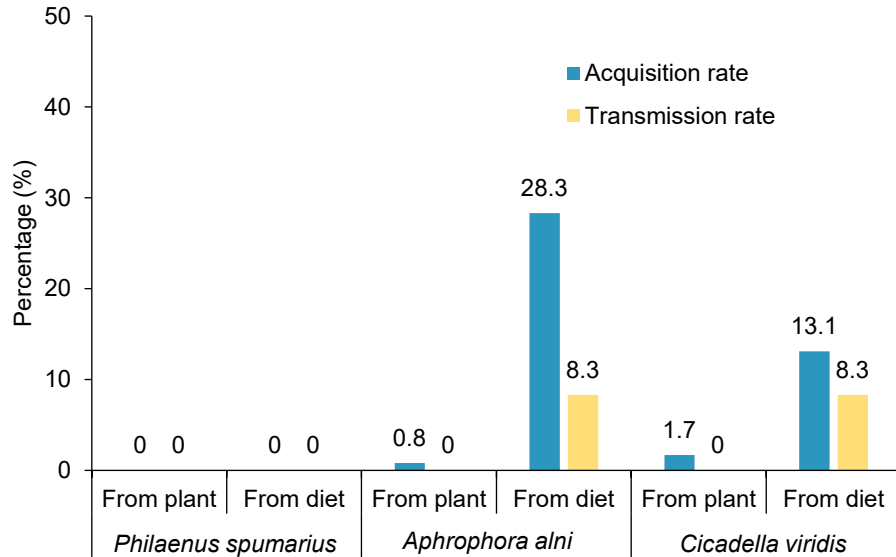


*AAP = Acquisition Access Period

**IAP = Inoculation Access Period

Results

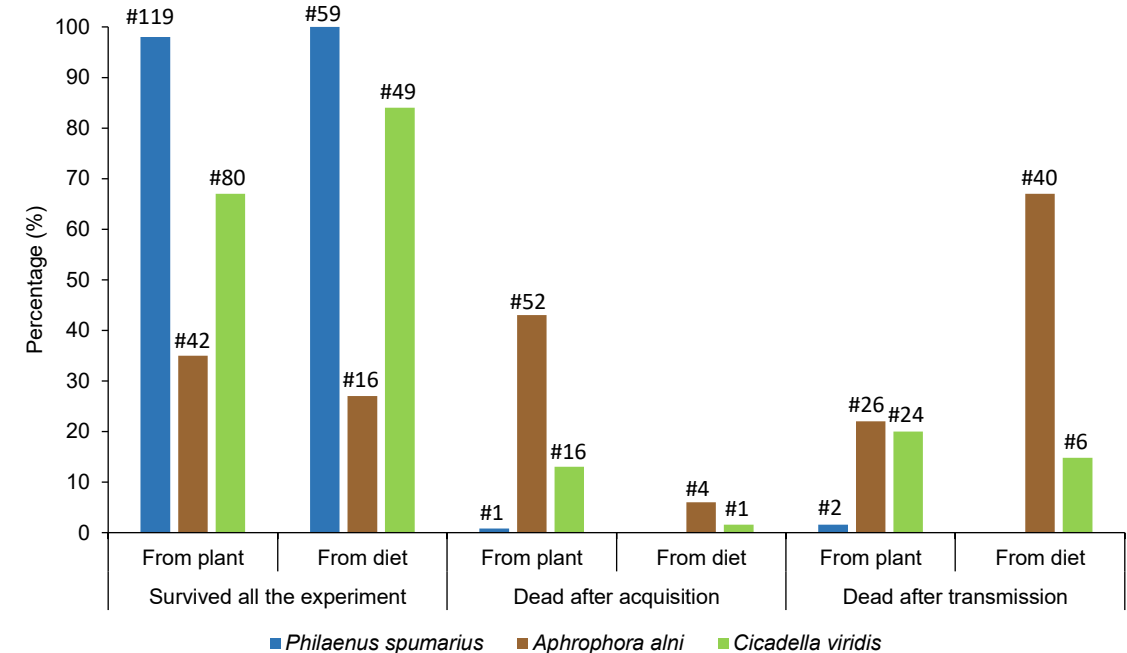
Percentage of insects and plants testing positive for *Xf* by qPCR after acquisition and transmission experiments



Acquisition rate (% positive insects / total insects)				
	Plant species	<i>Xf</i> subspecies	<i>A. alni</i>	<i>C. viridis</i>
From plant	<i>Q. robur</i>	<i>Xf fastidiosa</i>	0.84 %	-
			-	0.84 %
	<i>V. vinifera</i>	<i>Xf multiplex</i>	-	0.84 %
		<i>Xf fastidiosa</i>	16.67 %	11.48 %
From diet	-	<i>Xf fastidiosa</i>	11.67 %	1.64 %
		<i>Xf multiplex</i>		

Transmission rate (% positive plants / total plants)			
Vector species	<i>Xf</i> subspecies	<i>Q. robur</i>	<i>R. fruticosus</i>
<i>A. alni</i>	<i>Xf fastidiosa</i>	8.3 %	-
<i>C. viridis</i>	<i>Xf fastidiosa</i>	-	8.3 %

Insect survival during the acquisition and transmission experiments



Conclusions:

- Artificial diet enhanced acquisition, suggesting limited pathogen accessibility or insufficient bacterial loads in source plants.
- Vector efficiency varied between insect species, highlighting the role of *A. alni* and *C. viridis* in the acquisition and transmission of *Xf*.
- Insect survival differed among species, likely driven by differences in physiological tolerance and host feeding preferences.
- Forest and forest edge species remained infected until the end of the season, supporting the possible role as reservoir in the landscape (see results in Poster no. 87 López-Mercadal et al.).

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Waldschutz Schweiz
Protection de la forêt suisse
Protezione della foresta svizzera



Swiss Federal Institute for Forest,
Snow and Landscape Research WSL



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