



# European PhD Network "Insect Science" XVII Annual Meeting

Firenze, 18-20 November 2026

## PROGRAMME & BOOK OF ABSTRACTS

CREA Centro di Ricerca per la Difesa e la Certificazione  
Via Lanciola 12/a - Cascine del Riccio (Firenze)

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# PROGRAMME

### SESSIONS ON:

- **INSECT BIOLOGY**  
**18 November**, 15:00-16:05; **19 November**, 14:45-15:45; **20 November**, 10:30-11:45
- **INSECT PEST CONTROL**  
**18 November**, 16:30-17:40; **19 November**, 11:20-12:45 & 16:05-17:30
- **INSECT ECOLOGY AND CONSERVATION**  
**19 November**, 10:00-11:00; **20 November**, 09:15-10:20

### Wednesday 18 November 2026

- 14:00**      **Registration**
- 14:25**      **Welcome address**
- 14:30 - 15:00**    **Senior scientist lecture:** Daniele Bruno – University of Insubria  
**Unlocking the potential of *Hermetia illucens* bioconversion through midgut physiology**
- 15:00 - 16:05**    **SESSION ON INSECT BIOLOGY**  
Oral Presentations (regular & short talks)  
Chair: TBD onsite
- 15:00 - 15:15**    **R** Ilaria Armenia – University of Insubria  
**Chitosan-based nanocarriers for CRISPR/Cas9 delivery in *Hermetia illucens*: towards enhanced plastic biodegradation**
- 15:15 - 15:30**    **R** Bruno Emanuel Rosso – University of Torino  
**Host choice and diet shape gut bacterial communities and survival of the southern green stinkbug (*Nezara viridula*) of pampeana region in Argentina**
- 15:30 - 15:45**    **R** Christina Adamaki-Sotiraki – University of Thessaly  
**The effect of adults' sex ratio on the reproductive output of *Tenebrio molitor***
- 15:45 - 16:00**    **R** Federica Daga – Sant'Anna School of Advanced Studies  
**Ant-inspired and scorpion-inspired foot-ground interfaces for hexapod locomotion on granular terrains**
- 16:00 - 16:05**    **S** Gabriele Brenna – University of Milano  
**Linking substrate fibre composition to chitin content in *Hermetia illucens* larvae reared on agri-food by-products**
- 16:05 – 16:30**    **Coffee break**
- 16:30 - 17:40**    **SESSION ON INSECT PEST CONTROL**  
Oral Presentations (regular & short talks)

**R** Regular Presentation (15 min, discussion included) **S** Short Presentation (5 min, discussion included)

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Chair: TBD onsite

- 16:30 - 16:45 **R** Denise Busa – University of Padova  
**Wind & beetle: the compound effects of disturbances on regenerating mountain forests**
- 16:45 - 16:50 **S** Alessia De Luigi – University of Torino  
**Adaptation of native natural enemies to emerging alien phloem-feeding planthoppers**
- 16:50 - 16:55 **S** Pedro Rodrigues Junior – University of Torino  
**Optimizing digital radiography for the detection of hidden insect damage in bamboo**
- 16:55 - 17:00 **S** Giulia Lucetti – University of Madrid  
**Impact of vibrational signals on leafhopper feeding behaviour and phytoplasma transmission**
- 17:00 - 17:15 **R** Jeanpierre Michael Apuzzo – University of Napoli Federico II  
**Effect of *Hermetia illucens* frass extract and *Trichoderma afroharzianum* T22 on the development and immune response of the tomato pest *Spodoptera littoralis***
- 17:15 - 17:30 **R** Diletta Missere – University of Bologna  
**Experimental releases of pupal parasitoids to control *Piophilidae* (L.) (Diptera: Piophilidae) in ham production**
- 17:30 - 17:35 **S** Domenico Elia – University of Torino  
**Seasonal abundance and spatial distribution of *Tetranychus urticae* in processing tomato fields**
- 17:35 - 17:40 **S** Eleonora Fabris – Free University of Bolzano  
**Investigation on the herbivore induced plant volatiles (HIPVs) of apple plants by *Eriosoma lanigerum*, the woolly apple aphid**

### Thursday 19 November 2026

- 09:30 - 10:00 **Senior scientist lecture:** Rachele Nieri - University of Trento  
**New approaches to insect pest management in cultural heritage**
- 10:00 - 11:00 **SESSION ON INSECT ECOLOGY AND CONSERVATION**  
Oral Presentations (regular & short talks)  
Chair: TBD onsite
- 10:00 - 10:15 **R** Mónica Cepeda – Catholic University of Temuco  
**Colony-level dietary exposure to a *Bacillus thuringiensis*-based product and flupyradifurone during *Apis mellifera* queen rearing: larval acceptance, cell capping, and emergence**
- 10:15 - 10:30 **R** Maria Liliana Di Pasquale – University of Palermo  
**Arthropod vectors in a changing environment: why surveillance matters for human and animal health**
- 10:30 - 10:45 **R** Milo Zanardi – University of Padova  
**Intraspecific crop diversification promotes pollinator coexistence**

**R** Regular Presentation (15 min, discussion included) **S** Short Presentation (5 min, discussion included)

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- 10:45 - 11:00 **R** Alberto Fassio – University of Torino  
**Overwintering dynamics of *Eriosoma lanigerum* and its parasitoid *Aphelinus mali* in apple orchards**
- 11:00 - 11:20 **Coffee Break**
- 11:20 - 12:45 **SESSION ON INSECT PEST CONTROL**  
Oral Presentations (regular & short talks)  
Chair: TBD onsite
- 11:20 - 11:25 **S** Flavia Isoli – University of Tuscia  
**Preliminary pathogenicity assay of the entomopathogenic fungus *Akanthomyces muscarius* on *Lymantria dispar* larvae**
- 11:25 - 11:30 **S** Miriam Pernter – Free University of Bolzano  
**Harnessing *Wolbachia* for sustainable control of psyllid-transmitted phytoplasmas**
- 11:30 - 11:45 **R** Giacomo Bulgarini – Free University of Bolzano  
**Field evaluation of female removal as a control strategy for *Cydia pomonella* in an Alpine apple-growing region**
- 11:45 - 12:00 **R** Alessandro Borsotti – Free University of Bolzano  
**Uncovering hidden host-parasitoid interactions in unhatched stink bug eggs through sensitive molecular detection**
- 12:00 - 12:15 **R** Valeria Papili – University of Molise  
**Evaluation of an attract-and-kill device against *Ceratitis capitata* Wiedemann under semi-field conditions**
- 12:15 - 12:30 **R** Veronica Carnio – Free University of Bolzano  
**The automated detection of *Drosophila suzukii* using wingbeat signals and machine learning**
- 12:30 - 12:45 **R** Carlo Le Boffe – University of Napoli Federico II  
***Hermetia illucens* frass extract and *Trichoderma afroharzianum* T22 increase the susceptibility of *Spodoptera littoralis* to entomopathogens**
- 12:45 - 14:15 **Lunch**
- 14:15 - 14:45 **Senior scientist lecture:** David Baracchi – University of Firenze  
**A multidimensional approach to understanding emotions in insects**
- 14:45 - 15:45 **SESSION ON INSECT BIOLOGY**  
Oral Presentations (regular & short talks)  
Chair: TBD onsite
- 14:45 - 15:00 **R** Martina Marzari – University of Insubria  
**Development of transgenic black soldier fly larvae for polyethylene terephthalate (PET) degradation**

**R** Regular Presentation (15 min, discussion included) **S** Short Presentation (5 min, discussion included)

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- 15:00 - 15:15 **R** Paola Costagliola – University of Napoli Federico II  
**DIGEST: origin and function of plant cell wall-degrading enzymes underlying dietary specialization in leaf beetles (Coleoptera, Chrysomelidae)**
- 15:15 - 15:30 **R** Mohamad Baker Ala Eddine – University of Trento  
**Valorisation of agro-industrial by-products using black soldier fly: effects on larval performance and nutrient composition at different rearing scales**
- 15:30 - 15:45 **R** Gaetano Ferraro – Sant'Anna School of Advanced Studies  
**Wing oscillations in insects with indirect asynchronous flight: a mathematical study**
- 15:45 - 16:05 **Coffee Break**
- 16:05 - 17:30 **SESSION ON INSECT PEST CONTROL**  
Oral Presentations (regular & short talks)  
Chair: TBD onsite
- 16:05 - 16:10 **S** Francesco Turillazzi – University of Napoli Federico II  
**Two *Akanthomyces* species associated with *Toumeyella parvicornis*: isolation and preliminary assessment of their entomopathogenic activity**
- 16:10 - 16:15 **S** Pierluigi Perfetto – University of Bari  
**Understanding variation in entomopathogenic nematodes' virulence against spittlebugs**
- 16:15 - 16:30 **R** Edoardo Sala – University of Padova  
**New lure combinations to monitor the ash bark beetle, *Hylesinus varius***
- 16:30 - 16:45 **R** Maria Rosaria Chianese – University of Naples Federico II  
**Black soldier fly frass and RNAi silencing of *Slepat1* and *Sl102* increase susceptibility of *Spodoptera littoralis* to *Bacillus thuringiensis***
- 16:45 - 17:00 **R** Abderrahmane Boucherf – University of Bari  
**Developing a behavioral manipulation strategy to disrupt vector-plant interaction: a case study with the sharpshooter *Draeculacephala robinsoni***
- 17:00 - 17:15 **R** Laura Zavatta – University of Bologna  
**Differential compatibility of essential oil nanoemulsions with aphid predators: high selectivity towards Diptera Syrphidae**
- 17:15 - 17:30 **R** Serena Gallizia – University of Torino  
**Biological traits and biocontrol potential of *Eriborus* sp., a newly recorded Asian parasitoid of the invasive box tree moth**

### Friday 20 November 2026

- 09:15 - 10:20 **SESSION ON INSECT ECOLOGY AND CONSERVATION**  
Oral Presentations (regular & short talks)  
Chair: TBD onsite
- 09:15 - 09:30 **R** Alma De Angelis – University of Padova  
**Predator-prey interaction between the great tit (*Parus major*) and the pine processionary moth (*Thaumetopoea pityocampa*) in montane pine forests**

**R** Regular Presentation (15 min, discussion included) **S** Short Presentation (5 min, discussion included)

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- 09:30 - 09:45 **R** Andrea Ferrari – Free University of Bolzano  
**Eco-evolutionary insights into the colouration of bumblebees**
- 09:45 - 10:00 **R** Tommaso Fusco – University of Roma Tre  
**Hide, Seek and Sift: efficiency of active and passive methods in sampling litter spiders**
- 10:00 - 10:05 **S** Edoardo Lincetto – University of Padova  
**Effects of insect pollination on soybean yield**
- 10:05 - 10:20 **R** Matilde Case – University of Padova  
**Combined effects of forest disturbances on arthropod communities**
- 10:20 - 10:30 **Break**
- 10:30 - 11:45 **SESSION ON INSECT BIOLOGY**  
Oral Presentations (regular & short talks)  
Chair: TBD onsite
- 10:30 - 10:45 **R** Conor Scott – University of Milano  
**Mining the plastic-degrading midgut community of *Hermetia illucens***
- 10:45 - 11:00 **R** Lucrezia Spadoni – Sant’Anna School of Advanced Studies  
**Unravelling the structural principles of desert locust hindwings through bioinspired modelling**
- 11:00 - 11:15 **R** Andrea De Benedictis – University of Insubria  
**Effects of heavy metal contamination on black soldier fly larvae**
- 11:15 - 11:30 **R** Pierre Royer – University of Torino  
**Uncovering viral partners: how the virome shapes fitness in *Phlaenus spumarius***
- 11:30 - 11:45 **R** Elia Scabbio – University of Padova  
**Chemical ecology of ambrosia beetle communities: response patterns to ethanol and other host volatiles**
- 11:45 - 12:15 **Senior scientist lecture:** Francesco Pennacchio – University of Napoli Federico II  
**Insect multitrophic interactions for sustainable plant protection**
- 12:15 - 12:30 **Discussion on PhD education and future careers and meeting closure**
- 12:30 - 13:30 **Brunch**

We kindly request that all speakers respect the designated time limits assigned in the program to ensure smooth proceedings. Thank you for your cooperation.

More information is also available at <https://www.accademiaentomologia.it/scuole/>

The organizers

*Gianfranco Anfora, Morena Casartelli, Francesca Romana Dani, Giuseppino Sabbatini Peverieri.*

**R** Regular Presentation (15 min, discussion included) **S** Short Presentation (5 min, discussion included)

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Organizing Secretariat Event Planet Srl Contact: Marina Morra - [marina.morra@eventplanetgroup.com](mailto:marina.morra@eventplanetgroup.com)

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# REGULAR & SHORT PRESENTATIONS



# ABSTRACTS

(in alphabetical order by last name of the 1<sup>st</sup> author)

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## European PhD Network "Insect Science" - XVII Annual Meeting

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### The effect of adults' sex ratio on the reproductive output of *Tenebrio molitor*

C. Adamaki-Sotiraki<sup>1</sup>, S. Zafeiriadis<sup>1</sup>, M. Krzyżaniak<sup>2</sup>, D. Deruytter<sup>3</sup>, C. I. Rumbos<sup>4</sup>,  
C. G. Athanassiou<sup>1</sup>

<sup>1</sup> University of Thessaly – Department of Agriculture, Crop Production and Rural Environment, Laboratory of Entomology and Agricultural Zoology, Greece; <sup>2</sup> University of Warmia and Mazury in Olsztyn – Department of Genetics, Plant Breeding and Bioresource Engineering, Poland; <sup>3</sup> Inagro – Insect Research Centre, Belgium; <sup>4</sup> International Hellenic University – Department of Agriculture, Laboratory of Entomology, Greece

Manipulating sex ratio has been studied thoroughly as a means of more efficient mass rearing of insects. Recently, the approach of mass production is also applied in the insects as food and feed. Although much research is currently directed to the optimization of larval growth parameters, a factor that has not been thoroughly investigated yet is the effect of sex ratio on the fecundity of farmed insects. Findings so far concerning other insect species have shown that the optimum sex ratio is species-dependent. Based on that, in the present study the effects of different percentages of female:male ratios (50:50, 60:40, 40:60, 80:20 and 20:80) and adult densities (10, 20 and 30 adults/vial) on the reproductive output of the yellow mealworm, *Tenebrio molitor*, were evaluated. Adults were left undisturbed to mate and oviposit for 7 days. After this interval, adult mortality was recorded for both males and females, while laid eggs were collected and counted. After an additional interval of 14 days, the number of the newly emerged larvae was recorded. The same procedure was repeated five times for a time period of 35 days in total. The results showed that both factors affected offspring production. Interestingly, for density 20, 20% females produced more offspring per female. These results tend to reveal the optimum potential of the population, promoting the mass production of *T. molitor*.

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### **Valorisation of agro-industrial by-products using black soldier fly: effects on larval performance and nutrient composition at different rearing scales**

M. B. Ala Eddine<sup>1,2</sup>, A. Resconi<sup>1,2</sup>, G. Benassi<sup>2</sup>, S. Dabbou<sup>1</sup>

<sup>1</sup> University of Trento – C3A Center Agriculture Food Environment, Italy; <sup>2</sup> Kinsect S.r.l. SB, Italy

The black soldier fly is a key species in a circular economy because its larvae can convert agro-industrial by-products into protein- and lipid-rich biomass for animal feed. This study evaluated agro-industrial by-products from Trentino–Alto Adige using apple pomace as a base substrate, combined with fish-processing by-products (AF), brewer's spent grain (AB), or both (AFB). A Gainesville diet (GA) served as the control. Rearing trials were conducted at industrial and laboratory scales to assess survival, growth rate, and bioconversion efficiency corrected for residue. Larval proximate composition (crude protein and crude fat) was evaluated at the industrial scale. The measured parameters were analysed using ANOVA. Survival exceeded 80% across all substrates and at both scales. Growth rate was significantly affected by substrate and scale, with GA showing the highest values, followed by AF, AFB, and AB. Growth rates on the apple-based formulations were higher at the industrial scale than at the laboratory scale, whereas GA showed no differences between scales. At the industrial scale, GA, AF, and AFB had significantly higher bioconversion efficiency than AB, with no significant differences among substrates. At the laboratory scale, GA had the highest efficiency, followed by AFB and AF, while AB had the lowest. Bioconversion efficiency was higher at the industrial scale for all substrates. Larval proximate composition did not differ significantly among diets. These findings support the use of local agro-industrial by products to produce larvae for animal feed and highlight the importance of industrial-scale rearing in converting complex by-product mixtures within a circular bioeconomy.

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### **Effect of *Hermetia illucens* frass extract and *Trichoderma afroharzianum* T22 on the development and immune response of the tomato pest *Spodoptera littoralis***

J. Apuzzo, I. Di Lelio, M. Gebiola

University of Naples Federico II – Department of Agricultural Sciences, Italy

Combining multiple biocontrol tools is a promising route to more robust and sustainable pest management. We tested whether an aqueous extract of black soldier fly (*Hermetia illucens*) frass, applied to the growing substrate, enhances the effects of the fungal biocontrol agent *Trichoderma afroharzianum* strain T22 applied as seed coating on the tomato pest *Spodoptera littoralis*. Tomato plants were assigned to four treatments (untreated control, frass extract, T22, and T22 combined with frass extract), and larvae were fed on their leaves. Larval survival, growth and development, adult longevity and cellular immunity (phagocytosis, nodulation and encapsulation) were assessed. Final larval survival was 90.6% in the control, 65.6% with frass, 15.6% with T22 and 12.5% with T22 +frass; the two treatments that included T22 did not differ significantly, although the combination reached critically low survival about two days earlier. Frass alone was the least harmful treatment during the larval stage, but it reduced pupal weight and shortened adult longevity by about 72%, indicating delayed costs. All immune assays showed the same ranking of effects (T22 + frass > T22 > frass > control), with the combination reducing encapsulation, nodulation and phagocytosis by 69%, 57% and 55% relative to the control. In plants, frass alone reduced root length and photosynthesis, whereas the combination prevented the reduction in root growth. These results suggest that frass extract and T22 jointly weaken larval immunocompetence, which may increase susceptibility to entomopathogens.

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### **Chitosan-based nanocarriers for CRISPR/Cas9 delivery in *Hermetia illucens*: towards enhanced plastic biodegradation**

I. Armenia<sup>1</sup>, N. Esteban-Pérez<sup>2,3</sup>, M. Orduña Polo<sup>2</sup>, E. Catelan-Carphio<sup>4</sup>, A. Grapputo<sup>4</sup>,  
F. Sandrelli<sup>4</sup>, V. Grazú<sup>2,3</sup>, J. M. de la Fuente<sup>2,3</sup>, G. Tettamanti<sup>1,5</sup>

<sup>1</sup> University of Insubria – Department of Biotechnology and Life Sciences, Italy; <sup>2</sup> Aragon Nanoscience and Materials Institute (INMA-CSIC-UNIZAR), Spain; <sup>3</sup> Biomedical Research Networking Center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN), Spain; <sup>4</sup> University of Padua – Department of Biology, Italy; <sup>5</sup> Interuniversity Center for Studies on Bioinspired Agro-environmental Technology (BAT Center), Italy

The black soldier fly, *Hermetia illucens*, represents a promising biological resource for organic waste valorization and sustainable biotechnological applications. The introduction of new metabolic functions through genetic engineering could broaden its applications, particularly in the degradation of persistent environmental contaminants, including synthetic plastics.

This study explores the potential of biodegradable chitosan-based nanocarriers as delivery systems for genome-editing components in *H. illucens*. The ultimate goal is to enable the expression of polyethylene terephthalate (PET)-degrading enzymes in insect gut using CRISPR/Cas9-based approaches. Nanocarriers were formulated through oil-in-water emulsification and characterized according to their size distribution, morphology, colloidal stability, and release properties.

Assessing biocompatibility is a crucial step towards the practical application of these delivery systems. *In vitro* toxicity tests are currently underway using *Drosophila melanogaster* cell lines to establish concentration ranges that preserve cellular viability and identify potential toxic effects. Preliminary *in vivo* experiments in *H. illucens* larvae and eggs have been undertaken to investigate the applicability and biological compatibility of chitosan-based nanocarriers. Fluorescence analyses were performed on treated eggs to assess nanoparticle distribution, while egg viability was evaluated to investigate potential effects of the treatment on embryonic survival.

Further studies will focus on optimizing delivery strategies and assessing their efficiency through fluorescence-based approaches and molecular analyses. These investigations will help clarify the suitability of chitosan-based nanocarriers for genetic engineering in *H. illucens* and their potential for enabling the expression of heterologous enzymes.

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### SENIOR LECTURE

#### **A multidimensional approach to understanding emotions in insects**

D. Baracchi

*University of Florence – Department of Biology, Italy*

For a long time, social insects were considered simple reflexive automata, but they are now recognised as cognitively sophisticated organisms. Although cognitive sophistication does not automatically imply emotional experience, the recognition of social insect intelligence and behavioural flexibility raises a compelling question: might insects also experience basic emotions? Studying emotions in non-human animals is challenging because subjective experience is inaccessible. A functional, multicomponent framework—inferring emotions from coordinated changes across behaviour, cognition, and physiology—is therefore essential to advance the field without relying on subjective reports. While this framework makes it possible to rigorously evaluate internal affective states in animals incapable of verbal report, their systematic characterisation in insects remains in its infancy. I will present our recent work applying this approach to honeybees, integrating behavioural, cognitive, physiological, and neurochemical evidence to characterise affective states. Inspired by mammalian paradigms, such as fear conditioning, we investigated whether bees exhibit fear-like responses to immediate or anticipated aversive stimuli. Because no single measure can distinguish reflexive reactions from genuine emotional responses, we maintain that only the convergence of multi-level evidence reveals sustained, internally coordinated states. Our findings indicate that honeybees share core emotion primitives with vertebrates - namely valence, persistence, scalability, generalization, and global coordination- offering pivotal insights into the evolution of emotions, invertebrate cognition, and welfare considerations.

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### Uncovering hidden host-parasitoid interactions in unhatched stink bug eggs through sensitive molecular detection

A. Borsotti<sup>1,2</sup>, S. Bortolini<sup>1,3</sup>, B. Delaiti<sup>2</sup>, S. Zanini<sup>2</sup>, M. Wolf<sup>2</sup>, M. Falagiarda<sup>2</sup>,  
H. Schuler<sup>1,3</sup>

<sup>1</sup> Free University of Bozen-Bolzano – Faculty of Agricultural, Environmental and Food Sciences, Italy; <sup>2</sup> Research Centre Laimburg – Institute for Plant Protection, Italy; <sup>3</sup> Free University of Bozen-Bolzano – Competence Centre for Plant Health, Italy

The brown marmorated stink bug, *Halyomorpha halys* (Hemiptera: Pentatomidae), is an invasive pest causing substantial agricultural damage worldwide. To control this pest, several countries have adopted biological control strategies involving the release of its primary egg parasitoid, the samurai wasp, *Trissolcus japonicus* (Hymenoptera: Scelionidae). However, the introduction of this parasitoid into new environments highlights the need for long-term monitoring to assess potential non-target effects on native stink bugs and interactions with native parasitoids. In particular, interactions between native and non-native species may give rise to novel host-parasitoid interactions, potentially resulting in phenomena known as “egg abortion” or “evolutionary trap”. These occur when parasitoids attempt to parasitize novel hosts with which they lack a shared co-evolutionary history but fail to complete their development, causing host egg mortality without visible signs of parasitization. Such hidden trophic interactions may affect both released *T. japonicus* populations and native stink bug communities. Because these events may go undetected by egg dissection or conventional molecular methods, more sensitive approaches are needed. Here, we describe the development and optimization of a highly sensitive digital droplet PCR (ddPCR) assay panel targeting eight native and non-native parasitoid species in eggs of three stink bug species. The panel is ready for application to field-collected eggs from a biological control area, enabling comparisons across successive years in a region where ecological equilibria are still evolving. The resulting data are expected to uncover previously unrecognized trophic interactions and provide a high-resolution tool for monitoring potential non-target effects within biological control programmes.

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### **Developing a behavioral manipulation strategy to disrupt vector-plant interaction: a case study with the sharpshooter *Draeculacephala robinsoni***

A. Boucherf<sup>1</sup>, V. Mazzoni<sup>2</sup>, M. V. Rossi Stacconi<sup>2</sup>, A. Rashed<sup>3</sup>, D. Cornara<sup>1</sup>

<sup>1</sup> University of Bari – Department of Soil, Plant and Food Sciences (DiSSPA), Italy; <sup>2</sup> Edmund Mach Foundation – Research and Innovation Center, Italy; <sup>3</sup> Virginia Tech – Department of Entomology, Southern Piedmont Agricultural Research and Extension Center, USA

The North American sharpshooter *Draeculacephala robinsoni* was first reported in Europe in 2022. As a xylem-feeder, the species is theoretically competent for the transmission of *Xylella fastidiosa* (Xf). This project aims to (i) characterize bacterium transmission efficiency between herbaceous and woody hosts, using alfalfa and grapevine as source and recipient plants, and (ii) describe intra-specific vibrational communication to develop behavioral manipulation strategies for mitigating transmission risk. Transmission assays using single and grouped insects revealed that *D. robinsoni* is a competent though poor vector of Xf for the tested hosts. With single insects, neither acquisition nor inoculation occurred under any tested combination. Artificial diet assays indicated differential acquisition between Xf genotypes, with 40% acquisition rate for Xf subsp. *fastidiosa* ST1, and 19% for Xf subsp. *multiplex* ST43. Low transmission efficiency suggests that reducing vector activity through sustainable approaches, such as vibration-based behavioral interference, could further decrease the probability of transmission, potentially to zero. Vibrational communication is characterized by four distinct, context-specific substrate-borne signals primarily associated with mating. Two of them were emitted by males, who can emit signal spontaneously. Female signaling was activated only in response to male calls, and subsequent mating behavior involved duet establishment, partner localization, and short copulation. A female vibrational signal potentially involved in deterring males was also identified and will be tested as a candidate disruptive signal. Trials using vibrational signals to disrupt insect-plant interactions and reduce transmission risk are ongoing. These findings provide insights into the potential role of *D. robinsoni* in Xf epidemiology in Europe and provide the basis for vibration-based control strategies.

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### Linking substrate fibre composition to chitin content in *Hermetia illucens* larvae reared on agri-food by-products

G. Brenna<sup>1</sup>, M. Esposito<sup>2</sup>, B. Scaglia<sup>2</sup>, C. Jucker<sup>1</sup>

<sup>1</sup> University of Milan – Department of Food, Environmental and Nutritional Sciences, Italy; <sup>2</sup> University of Milan – Department of Agricultural and Environmental Sciences – Production, Landscape and Agroenergy, Italy

*Hermetia illucens* (Diptera: Stratiomyidae) larvae are usually reared as animal feed for their protein and lipid content, while chitin, a valuable biopolymer, is rarely the main target. Whether the fibre composition of the rearing substrate influences larval chitin content remains largely unexplored. To that end, six agrifood byproducts (potato waste, soybean okara, brewer's spent grain, brewer's trub, exhausted grape marc, tomato pomace) were used to formulate six approximately isoproteic diets (19–24% crude protein) ranging from 6 to 44% neutral detergent fibre (NDF) and from 1.3 to 19.1% acid detergent lignin (ADL) (formulated values). Each diet was tested in three replicates each with 300 four-day-old larvae. Larvae were reared until 5% prepupae appeared, which corresponded to approximately 22 days in all replicates. Survival ranged from 88 to 100%, mean final larval weight from 0.073 to 0.092 g, and feed conversion ratio (FCR) (fresh matter basis) from 4.9 to 6.3; lowest weight and highest FCR were observed on the diet richest in grape marc. Chitin determination is currently ongoing on larvae at L4-L6 instar and pupal stage, identified by head capsule width. Larvae are starved for 24 h, frozen and dried; 1 g dry matter per replicate undergoes demineralisation and deproteinisation, and crude chitin is quantified gravimetrically (% dry matter). We expect higher substrate fibre to be associated with higher chitin content; NDF and the ADL/NDF ratio will be tested as predictors, with protein and lipid contents as covariates. Preliminary results will be presented.

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### SENIOR LECTURE

## Unlocking the potential of *Hermetia illucens* bioconversion through midgut physiology

D. Bruno

*University of Insubria – Department of Biotechnology and Life Sciences, Italy*

*Hermetia illucens* larvae are important bioconverters of organic waste streams and by-products into valuable insect biomass with a range of potential applications. Their remarkable bioconversion ability is largely attributable to the unique structural and functional characteristics of their midgut which, in combination with the associated microbiota, enable larvae to digest a broad variety of organic substrates. This extraordinary flexibility is provided by the capability of the midgut to undergo physiological and morphological adaptations in response to the substrate being processed, making *H. illucens* a promising biological tool for the mitigation of environmental and economic challenges associated with waste management.

Understanding how the morphofunctional characteristics of the midgut underpin the remarkable bioconversion capacity of these larvae is important not only from an environmental and economic perspective, but also for expanding the range of applications of the larvae and their derivatives. On the one hand, larval biomass can be processed to recover valuable compounds, such as proteins, obtained through midgut-mediated bioconversion and exploited in advanced applications, including bioplastic production. On the other hand, the physiological properties of the midgut contribute to the larvae's potential as bioremediation agents for waste streams contaminated with recalcitrant biological and chemical contaminants, including foodborne pathogens and micro- and nanoplastics, thus mitigating the environmental burden associated with certain contaminants.

Overall, understanding the morphofunctional properties of *H. illucens* larval midgut is essential to “unlock” the full potential of these larvae as a valuable biological tool for advancing circular economy processes and addressing environmental challenges.

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### Field evaluation of female removal as a control strategy for *Cydia pomonella* in an Alpine apple-growing region

G. Bulgarini<sup>1</sup>, V. Carnio<sup>1,2</sup>, S. Schmidt<sup>3</sup>, S. Angeli<sup>1,2</sup>

<sup>1</sup> Free University of Bozen-Bolzano – Faculty of Agricultural, Environmental and Food Sciences, Italy; <sup>2</sup> Free University of Bozen-Bolzano – Competence Center for Plant Health, Italy; <sup>3</sup> Laimburg Research Centre – Institute for Plant Health, Italy

*Cydia pomonella* (Linnaeus, 1758) (Lepidoptera: Tortricidae) is a major pest of apple orchards, causing substantial economic losses. Conventional control methods based on synthetic insecticides are unsuitable for organic farming and may not provide effective, long-term pest suppression even when used within IPM programmes. Consequently, alternative sustainable strategies, including kairomone-based mass trapping, have gained increasing interest. “Female removal” is a mass-trapping strategy intended to reduce female populations in the orchards, in order to reduce pest potential and larval infestation. Over four growing seasons, we evaluated the effectiveness of this strategy in 28 field trials in commercial apple orchards in Trentino-Alto Adige, northern Italy. Each trial involved a one-hectare treated plot equipped with 60 non-saturating bucket traps baited with the four-component kairomone lure PHEROCON® MEGALURE® CM DUAL 4K (Trécé Inc., Adair, OK, USA), comprising pear ester, (E)-4,8-dimethyl-1,3,7-nonatriene, linalool oxide, and acetic acid, and an untreated one-hectare control plot. Fruit damage was assessed by visual inspection of approximately 2,500 apples per plot in each treatment. Female removal significantly reduced fruit damage, with mean efficacy ranging from 12.5% to 59.3% and reaching 87% in some trials. In some orchards, captures exceeded 1,000 *C. pomonella* individuals per hectare, including approximately 600 females. Overall, these results highlight the potential of kairomone-based female removal as a sustainable tool for reducing *C. pomonella* damage over multiple growing seasons, particularly in organic apple production systems. Female removal may also complement mating disruption.

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### Wind & beetle: the compound effects of disturbances on regenerating mountain forests

D. Busa

*University of Padua – Department of Agronomy Food Natural Resources Animals and Environment, Italy*

In October 2018, the Vaia storm felled 8.6 million m<sup>3</sup> of timber across 42,500 ha of forest in north-eastern Italy. Delayed salvage operations in remote areas left windthrown wood that favoured an outbreak of the European spruce bark beetle (*Ips typographus*), which spread to standing trees, causing diffuse mortality that is hard to monitor through field surveys alone. Using 20 cm aerial imagery, we assessed how windthrow size and salvage logging influence beetle infestation in the surrounding forest, including small windthrows usually undetected by satellite imagery. We combined a windthrow map of the upper Belluno province with a region-wide detection of individual dead trees. Windthrow polygons (minimum area 0.01 ha) were delineated on September 2021 AGEA orthophotos and compared with pre-event 2018 orthophotos to exclude forest removal before the storm. Each polygon was classified as logged (timber removed) or non-logged; 92.9% of the mapped polygons were non-logged. A deep learning model developed for dead-tree detection in California was adapted to the local context and applied across Veneto to identify individual dead trees likely attacked by bark beetles. Within the upper Belluno windthrow area, it produced 86,143 detections (about 279 ha of canopy). In this area, infested-tree density within 250 m of windthrow edges increased with windthrow size and was markedly higher around non-logged than logged windthrows. These findings suggest that prompt removal of uprooted trees may reduce the risk of infestation in adjacent stands.

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### The automated detection of *Drosophila suzukii* using wingbeat signals and machine learning

V. Carnio<sup>1,2</sup>, G. Bulgarini<sup>1</sup>, M. Bjeliac<sup>3</sup>, S. Angeli<sup>1,2</sup>, S. Schmidt<sup>3</sup>

<sup>1</sup> Free University of Bozen-Bolzano – Faculty of Agricultural, Environmental and Food Sciences, Italy; <sup>2</sup> Free University of Bozen-Bolzano – Competence Center for Plant Health, Italy; <sup>3</sup> Laimburg Research Centre – Institute for Plant Health, Italy

*Drosophila suzukii* (Matsumura, 1931) is a major invasive pest that damages high-value fruit crops, including strawberries, cherries, and raspberries. Automated monitoring can improve early detection and support effective pest management. However, conventional computer vision approaches can be challenging for small insects such as drosophilids. Wingbeat signals may offer a promising alternative for automated species identification. Here, we evaluated an infrared-based optical sensing system, the Lantern sensor (Irideon), combined with machine learning to classify *D. suzukii* and *D. melanogaster* under laboratory conditions using separate cohorts of different sexes and ages exposed to different temperatures. The sensor recorded 48,449 wingbeat signals from *D. suzukii* and *D. melanogaster*. Gradient boosting classifiers were trained using different combinations of wingbeat-derived features. Species-classification accuracy reached 87% using fundamental wingbeat frequency and signal power, and 93% using power spectral density (PSD) features. Sex-classification accuracy reached 83% with PSD features. These results indicate the potential of infrared-based wingbeat sensing for automated insect identification at both species and sex levels.

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### Combined effects of forest disturbances on arthropod communities

M. Case

*University of Padua – Department of Agronomy Food Natural Resources Animals and Environment, Italy*

In recent years, extreme climatic events, such as windstorms, pest outbreaks and droughts, have increased in frequency due to climate change. The effect on arthropod fauna of different types of forest natural disturbances and their interaction is still poorly understood. As bark beetles create new habitats within forests by opening the canopy due to needle loss, the proximity to already existing windthrown areas may exert a combined effect on diversity patterns. This study investigated whether landscape-scale windthrow influences arthropod communities in Norway spruce (*Picea abies*) forests subsequently affected by European spruce bark beetle (*Ips typographus*) outbreaks. We conducted a pair-designed study in the southeastern Italian Alps. Thirteen pairs of bark beetle-infested sites were selected according to their proximity to previous windthrow areas, distinguishing windstorm-affected contexts from isolated bark beetle infestations. Arthropods were sampled using pitfall and cross-vane traps in May-July 2025, targeting ground-dwelling predators and woodboring beetles. We assessed differences in community composition, beta diversity, and functional traits between disturbance contexts. Results indicated increased beta diversity in spiders (Araneae) and higher abundance of longhorn beetles (Cerambycidae) in sites associated with previous windthrow. Spiders also exhibited higher functional diversity, suggesting that disturbance context may influence the functional composition of arthropod communities in bark beetle-killed stands. Overall, these findings suggest that previous wind disturbance may shape arthropod community assembly in stands affected by bark beetle outbreaks, with effects varying among taxa and functional groups. Understanding these interactions can improve predictions of forest biodiversity dynamics under increasingly frequent and interacting disturbance events and inform biodiversity-oriented forest management.

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### Colony-level dietary exposure to a *Bacillus thuringiensis*-based product and flupyradifurone during *Apis mellifera* queen rearing: larval acceptance, cell capping, and emergence

M. Cepeda<sup>1</sup>, J. Sanhueza<sup>2</sup>, S. Erler<sup>3</sup>, J. Pistorius<sup>3</sup>, A. T. Alkassab<sup>3</sup>

<sup>1</sup> Catholic University of Temuco, Faculty of Natural Resources, Doctoral Program in Agricultural Sciences, La Araucanía, Chile; <sup>2</sup> Catholic University of Temuco, Faculty of Natural Resources, Department of Veterinary Sciences and Public Health, La Araucanía, Chile; <sup>3</sup> Julius Kühn Institute (JKI), Federal Research Centre for Cultivated Plants, Institute for Bee Protection, Braunschweig, Germany

Pesticide risk assessment for honey bees is mainly based on worker and brood survival endpoints, which may not fully capture responses in queens, the colony's reproductive females. Queen reproductive success is an important component of colony fitness. Here, we examined early queen-rearing outcomes following colony-level dietary exposure to plant protection products containing *Bacillus thuringiensis* (Bt, *B. thuringiensis* subsp. *aizawai*, strain ABTS-1857) or flupyradifurone. Fifteen queen-rearing colonies were randomly allocated to three groups: sugar syrup alone (control, n = 5), sugar syrup containing Sivanto® (flupyradifurone, n = 5), or sugar syrup containing XenTari® (Bt, n = 5). Larval acceptance, conditional queen-cell capping, and adult emergence were recorded. Following low queen production, the Bt dose was reduced tenfold. Data were analysed using binomial mixed models with colony as random effect; pairwise comparisons were adjusted using Tukey's method. Across all treatments, 992 larvae were grafted, 579 accepted, 376 cells capped, and 321 queens emerged. Acceptance was lower in the Bt group than in the control and flupyradifurone groups in rounds 1 and 2 ( $p < 0.001$ ). Conditional capping was lower in the Bt group than in the control in all rounds ( $p \leq 0.0004$ ). For emergence, the only significant within-round contrast was between the control and flupyradifurone group in round 2 ( $p = 0.0467$ ). These findings highlight that queen-specific developmental outcomes might be relevant endpoints for investigating potential toxicological effects and their implications for reproductive success and colony fitness in social bees.

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### **Black soldier fly frass and RNAi silencing of *Slrepat1* and *Sl102* increase susceptibility of *Spodoptera littoralis* to *Bacillus thuringiensis***

M. R. Chianese<sup>1</sup>, G. Volpe<sup>2</sup>, E. Barra<sup>1,3</sup>, A. Becchimanzi<sup>1,4</sup>, I. Di Lelio<sup>1,3</sup>, M. Gebiola<sup>1,4</sup>, F. Pennacchio<sup>1,4</sup>

<sup>1</sup> University of Naples Federico II – Department of Agricultural Sciences, Italy; <sup>2</sup> University of Naples Federico II – Department of Biology, Italy; <sup>3</sup> National Phytosanitary Service – Piedmont Region, Italy; <sup>4</sup> Interuniversity Center for Studies on Bioinspired Agro-Environmental Technology (BAT Center), Italy

*Bacillus thuringiensis* (Bt) is the most widely used microbial insecticide, yet its efficacy against *Spodoptera littoralis*, a polyphagous lepidopteran pest, remains limited. Larval survival following Bt exposure depends not only on toxin activity but also on the insect's capacity to tolerate infection and repair midgut damage. Here we investigated whether two mechanistically distinct approaches to Bt sensitization could be combined: plant-mediated immunomodulation by black soldier fly (*Hermetia illucens*) frass applied to the soil, and RNA interference (RNAi) targeting host defense genes. We first characterized *Slrepat1*, a member of the pathogen-responsive REPAT family. *Slrepat1* was expressed mainly in the midgut, and oral delivery of dsRNA reduced transcripts levels by about 90%. Silencing *Slrepat1* markedly increased larval susceptibility to a sublethal Bt dose. Yet, unlike silencing of the immune gene *Sl102*, *Slrepat1* knockdown did not impair cellular immune response. These findings suggest that *Slrepat1* contributes primarily to tolerance of Bt-induced midgut damage rather than to systemic cellular immunity.

Larvae feeding on frass-treated tomato plants displayed impaired cellular immune responses and increased Bt-induced mortality even in the absence of gene silencing. Notably, frass treatment also enhanced RNAi efficacy, resulting in stronger knockdown of both target genes. On control plants, survival following Bt exposure decreased to 67% after *Slrepat1* silencing, 47% after *Sl102* silencing, and 27% after simultaneous knockdown of both genes. Combining frass treatment, double-gene silencing, and Bt exposure further reduced larval survival to 17%.

Together, these results identify *Slrepat1* as a promising RNAi target that enhances Bt susceptibility through a mechanism distinct from cellular immune suppression. More broadly, plant-mediated immunomodulation and targeted gene silencing were compatible and produced complementary effects in terms of Bt susceptibility, highlighting the potential of BSF frass as a component of integrated, sustainable pest-management strategies.

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### **DIGEST: origin and function of plant cell wall-degrading enzymes underlying dietary specialization in leaf beetles (Coleoptera, Chrysomelidae)**

P. Costagliola

*University of Naples Federico II – Department of Agricultural Sciences, Italy*

Phytophagous insects must overcome structural and chemical barriers posed by plant cell walls (PCWs) to access nutrients within plant tissues. This process relies on plant cell wall-degrading enzymes (PCWDEs), including cellulases, hemicellulases and pectinases, which break down the main polysaccharide components of PCWs. These enzymes may be encoded in the insect genome or supplied by associated microorganisms, including the gut microbiota. In addition, the functional diversification of endogenous enzymes may contribute to maintaining digestive capabilities. However, the contributions of these different sources and their relationships with dietary specialization remain incompletely understood in many phytophagous insects. The DIGEST project aims to investigate the origin and function of PCWDEs in leaf beetles (Coleoptera, Chrysomelidae), focusing on the subfamily Cryptocephalinae, in which neither beetle-encoded nor primary symbiont-encoded pectinases have been identified yet. Enzymatic activities involved in PCWs degradation will be characterized using specific bioassays in at least 18 species with different ecologies and host-plant spectra. Subsequently, six selected species will be analysed through an integrated multi-omics approach combining host genomic and transcriptomic data with gut metagenomics and metatranscriptomics. By integrating molecular data with enzymatic profiles, the project will identify candidate genes and distinguish insect-derived from microbiota-associated contributions to PCWs degradation. Finally, selected candidate genes will be functionally validated through heterologous expression and enzymatic assays. By combining biochemical assays, multi-omics and functional validation, DIGEST will improve our understanding of digestive mechanisms in phytophagous insects and may contribute to sustainable pest management by identifying potential new molecular targets for innovative biocontrol approaches.

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### **Ant-inspired and scorpion-inspired foot-ground interfaces for hexapod locomotion on granular terrains**

F. Daga, G. Manduca, D. Romano

*Sant'Anna School of Advanced Studies – The BioRobotics Institute – Department of Excellence in Robotics and AI, Italy*

Arthropods exhibit a remarkable diversity of appendage morphologies that enable locomotion across substrates with different mechanical properties. Understanding how these morphological adaptations influence the interaction between the legs and granular environments can provide insights into locomotor function while informing the development of bioinspired locomotion systems. Movement on sand-like substrates presents challenging foot-ground interactions that can affect propulsion, stability and energy expenditure.

This study investigates the potential functionality of arthropods-inspired tarsal morphologies for locomotion on granular terrain. Foot-ground interfaces inspired by the tarsal structures of ants and scorpions were developed and integrated into an insect-inspired hexapod robot for performance assessments. The two configurations were tested on LHS-1, a lunar regolith simulant, and compared with a neutral reference configuration. Locomotor performance was assessed in terms of forward speed, steering capability and energy consumption.

Preliminary results indicate that both bioinspired configurations improve forward speed relative to the reference configuration. However, their effects on other performance measures differ: the ant-inspired interface shows an energetic advantage during steering, whereas the scorpion-inspired interface exhibits poorer steering performance. These findings suggest that distinct arthropod-inspired foot morphologies may influence locomotor performance in different ways, highlighting the importance of considering multiple functional outcomes when investigating appendage-substrate interactions. Further experiments are underway to strengthen these preliminary findings and assess how performance varies across granular substrates of terrestrial and extraterrestrial relevance. This approach may contribute to a better understanding of the functional implications of arthropod appendage morphology while supporting the development of locomotion systems for challenging environments.

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### **Predator-prey interaction between the great tit (*Parus major*) and the pine processionary moth (*Thaumetopoea pityocampa*) in montane pine forests**

A. De Angelis

*University of Padua – Department of Agronomy, Food, Natural Resources, Animals and Environment (DAFNAE), Italy*

The pine processionary moth (*Thaumetopoea pityocampa*, hereafter PPM) is a lepidopteran species and a major phytophagous pest of Mediterranean forests, as its larvae feed on conifers – mainly pines and cedars – causing severe defoliation and affecting public health. Generalist predators such as tits (Aves, Paridae) can affect the frequency and magnitude of insect outbreaks. Although most bird species are unable to feed on late-instar PPM larvae because of their urticating setae, the great tit (*Parus major*) is known to prey on them, exploiting this trophic resource in winter, when alternative food sources are scarce or unavailable. This study aims to (1) investigate the association between great tit abundance and PPM density in a montane pine forest in the Alps, by combining bird point counts and PPM nest surveys; (2) explore the presence of PPM in the winter diet of great tits, using morphological and molecular approaches to analyse bird faecal samples and remains of predated larvae collected in the field; (3) document the predatory behaviour of great tits on PPM larvae using camera traps; and (4) assess the impact of bird predation on PPM colonies by analysing the larval content of predated and non-predated nests. Preliminary results indicate a positive association between the winter abundance of great tits and PPM density, as well as a frequent occurrence of PPM remains in great tit faecal samples, suggesting that PPM larvae may represent a trophic resource regularly exploited by great tits during the coldest months of the year.

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### Effects of heavy metal contamination on black soldier fly larvae

A. De Benedictis<sup>1</sup>, D. Bruno<sup>1</sup>, I. Armenia<sup>1</sup>, M. Marzari<sup>1</sup>, O. Santoro<sup>1</sup>, D. Spanu<sup>2</sup>, S. Caccia<sup>3</sup>, M. Casartelli<sup>3,4</sup>, G. Tettamanti<sup>1,4</sup>

<sup>1</sup> University of Insubria – Department of Biotechnology and Life Sciences, Italy; <sup>2</sup> University of Insubria – Department of Science and High Technology, Italy; <sup>3</sup> University of Milan – Department of Biosciences, Italy; <sup>4</sup> Interuniversity Center for Studies on Bioinspired Agro-environmental Technology (BAT Center), Italy

The larvae of the black soldier fly (BSFL, *Hermetia illucens*) efficiently convert organic waste into valuable biomass, making the organic fraction of municipal solid waste (OFMSW) a promising rearing substrate due to its abundance and nutritional value. However, heavy metal (HM) contamination may affect larval physiology and compromise biomass safety.

This study investigates the physiological and molecular responses of BSFL to HM exposure and assesses potential risks to larval health and biomass safety associated with contaminated OFMSW. BSFL were reared on surrogate OFMSW contaminated with CdCl<sub>2</sub> and PbCl<sub>2</sub>. Our results showed that neither metal significantly affected larval growth and survival, although Cd significantly reduced adult emergence. However, both metals altered cellular and humoral immune responses, as indicated by changes in hemocyte counts and antimicrobial activity. Pb and Cd accumulated in all examined larval tissues, including the midgut epithelium, fat body, hemolymph and Malpighian tubules, as well as in whole larvae, frass and adults. The expression of genes associated with oxidative stress and metal detoxification was upregulated in response to both HMs. Regarding oxidative stress, Pb exposure significantly increased reactive oxygen species (ROS) levels, whereas Cd exposure did not, and neither metal significantly affected superoxide dismutase (SOD) or glutathione S-transferase (GST) activity.

Overall, these findings show that HM exposure can trigger physiological and molecular alterations in BSFL, even in the absence of significant effects on larval growth and survival. These results highlight the importance of evaluating both insect health and biomass safety when considering contaminated OFMSW as a potential rearing substrate.

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### **Adaptation of native natural enemies to emerging alien phloem-feeding planthoppers**

A. De Luigi, E. Gonella, A. Alma

*University of Turin – Department of Agricultural, Forest and Food Sciences, Italy*

In recent decades, Italy has experienced multiple introductions of alien insect pests, driven by global trade and climate change. Many of these species establish in the absence of specialized predators and parasitoids, allowing populations to grow rapidly and damage ornamental and agricultural crops.

This is particularly critical for highly polyphagous species, which feed and reproduce not only on cultivated plants but also on spontaneous vegetation and in natural habitats, acting as permanent reservoirs for re-infestation. Consequently, control based only on conventional methods, such as insecticides, is insufficient, as wild and non-agricultural areas cannot be treated under the Italian National Action Plan for the sustainable use of plant protection products (PAN). For this reason, investigating the role of native natural enemies in the control of exotic pests is of paramount importance, in order to develop alternative and complementary control strategies. Focusing on three highly polyphagous Fulgoromorpha (*Acanalonia conica*, *Ricania speculum* and *Metcalfa pruinosa*), the aim of the work is to assess the effectiveness of native parasitoids and predators targeting the egg stage, estimating and comparing parasitism and predation rates across diverse agroecosystems.

Where native natural enemies emerge and cause sufficiently high egg mortality, they may be evaluated as candidate agents for future biological control programs (either through conservation or augmentative approaches), offering a sustainable option where chemical control is not feasible. This approach would support integrated pest management strategies that are effective in both agricultural and natural environments while reducing reliance on chemical inputs.

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### **Arthropod vectors in a changing environment: why surveillance matters for human and animal health**

M. L. Di Pasquale<sup>1,3</sup>, E. Peri<sup>1</sup>, F. Vitale<sup>2,4</sup>, F. Di Gaudio<sup>3</sup>, R. A. Balbo<sup>4</sup>, F. La Russa<sup>4</sup>

<sup>1</sup> University of Palermo – Department of Agricultural, Food and Forest Sciences, Italy; <sup>2</sup> Experimental Zoophylactic Institute of Sicily “A. Mirri” – National Reference Centre for Leishmaniasis, Molecular Biology Area, Italy; <sup>3</sup> Experimental Zoophylactic Institute of Sicily “A. Mirri”, Italy; <sup>4</sup> Experimental Zoophylactic Institute of Sicily “A. Mirri” – Laboratory of Entomology and Environmental Vector Control, Molecular Biology Area, Italy

Arthropod vectors are organisms capable of transmitting pathogens between animals and humans. Dipterans such as mosquitoes, sand flies and biting midges are involved in the transmission of viruses, bacteria and parasites responsible for diseases that include West Nile fever, dengue, leishmaniasis and bluetongue. Their distribution and abundance are closely linked to environmental conditions, as temperature, rainfall and humidity influence their development, survival and reproductive activity. Climate and environmental changes can therefore alter the areas and periods in which vectors are active, potentially increasing the risk of pathogen transmission. Understanding where species are present, how their populations vary over time and how they respond to environmental stresses is essential for identifying emerging risks and planning effective surveillance and prevention measures. The project aims to study vector populations in urban, suburban and rural environments across Sicily, using an integrated approach that combines entomological monitoring, species identification, laboratory studies and environmental analysis. Data collected in the field will provide information on the diversity, distribution and seasonal dynamics of vectors, while experiments under controlled conditions will enable an assessment of their ability to survive and adapt to temperature fluctuations. Spatial and climatic data will be used to identify environments favourable to the establishment and spread of the species. Molecular investigations will also help to assess biological responses to environmental stresses and resistance to insecticides. The project will improve understanding of the relationships between vectors, pathogens and the environment, contributing to the development of proactive, risk-based surveillance strategies and early-warning systems for vector-borne diseases.

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### Seasonal abundance and spatial distribution of *Tetranychus urticae* in processing tomato fields

D. Elia, F. Tortorici, L. Tavella

University of Turin – Department of Agricultural, Forest and Food Sciences, Italy

The two-spotted spider mite *Tetranychus urticae* is a polyphagous and cosmopolitan pest that affects tomato in both greenhouse and open-field crops. Feeding on the underside of leaves reduces photosynthetic activity, causing the plant to wilt. Its management is challenged by climate change, which alters arthropod biology and life cycles, and by the European Farm to Fork strategy, which aims to reduce plant protection product use by 50% by 2030. Monitoring the spatial distribution of *T. urticae* populations is crucial for its management, and biological control using predatory mites of Phytoseiidae family represents a key strategy. The seasonal abundance of *T. urticae* and its natural enemies was monitored in 22 processing tomato fields in northwestern Italy, comparing two control strategies: release of *Phytoseiulus persimilis* by drone, and acaricide treatment. Moreover, in two additional fields, observations were fortnightly conducted in plots divided into rows and sampling blocks, proceeding from the outermost rows inward to detect infestation gradients from the field edge to the centre. Field surveys correlated mite presence with weather patterns, and determined the spatial distribution of infestations, the effectiveness of treatments and, where *P. persimilis* had been released, the predator-prey ratio. Although colonisation first appeared at the field margins, infestations did not follow a gradient towards the field centre and were therefore not uniformly distributed. Moreover, the accumulated degree-days at the time of the first detection of *T. urticae* in the fields were confirmed, and in 2026 this threshold was reached earlier than in previous seasons.

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### Investigation on the herbivore induced plant volatiles (HIPVs) of apple plants by *Eriosoma lanigerum*, the woolly apple aphid

E. Fabris<sup>1,2</sup>, S. Schmidt<sup>2</sup>, J. Pickett<sup>3</sup>, S. Angeli<sup>1</sup>

<sup>1</sup> Free University of Bozen-Bolzano – Faculty of Agricultural, Environmental and Food Sciences, Italy; <sup>2</sup> Laimburg Research Centre – Plant Protection Department, Institute for Plant Health, Italy; <sup>3</sup> Cardiff University – School of Chemistry, UK

Herbivore-induced plant volatiles (HIPVs) are volatile organic compounds (VOCs) released by plants in response to herbivore feeding. These compounds play an important role in plant defence by attracting natural enemies of herbivores, including predators and parasitoids, and may therefore contribute to biological control. The woolly apple aphid, *Eriosoma lanigerum* (Hausmann, 1802), is a major pest of apple orchards, causing damage to plant tissues and impairing tree growth. Understanding the volatile-mediated interactions between apple trees, aphids and their natural enemies could contribute to the development of sustainable pest management strategies. This study aims to characterize the volatile profile of apple plants in response to *E. lanigerum* infestation and to investigate how these emissions change over time. Volatile compounds were collected from healthy and infested one-year-old potted apple plants before infestation and at 10 and 20 days after infestation, using closed-loop stripping analysis (CLSA), followed by gas chromatography–mass spectrometry (GC–MS). The volatile profiles were compared to identify compounds potentially associated with aphid-induced plant responses and their temporal dynamics. Selected compounds will subsequently be tested in behavioural assays with *Aphelinus mali* (Haldeman, 1851), a specialist parasitoid of *E. lanigerum*, to assess their role in parasitoid attraction. This work aims to identify candidate semiochemicals involved in interactions between apple trees, the woolly apple aphid and its natural enemy, providing a basis for the development of volatile-based strategies for sustainable aphid management.

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### **Overwintering dynamics of *Eriosoma lanigerum* and its parasitoid *Aphelinus mali* in apple orchards**

A. Fassio, M. Cottura, F. Tortorici, L. Tavella

University of Turin – Department of Agricultural, Forest and Food Sciences, Italy

The woolly apple aphid, *Eriosoma lanigerum*, is a major pest of apple orchards, where it forms colonies on both aerial and below-ground tissues and may persist throughout winter, contributing to early infestations in the following growing season. Its specific parasitoid, *Aphelinus mali*, plays a key role in controlling this pest, and overwinters inside parasitized aphids. Winter conditions may influence both the aphid survival and the subsequent activity of its parasitoid. However, the overwintering dynamics of these two species have rarely been investigated together under orchard conditions. Therefore, *E. lanigerum* colony survival and *A. mali* emergence were investigated over three winters (2023/24–2025/26) in nine commercial apple orchards in northwestern Italy under integrated pest management (IPM) or organic farming. In each orchard, 100 aphid colonies located in exposed or protected positions were monitored, while parasitized aphids were collected to assess parasitoid emergence under laboratory conditions. Colony position influenced winter mortality differently depending on the year. No significant difference was observed in 2023/24, whereas mortality was higher in exposed than protected colonies in 2024/25 (4.1% vs 1.9%) and 2025/26 (6.3% vs 1.7%). This difference was more evident in IPM than organic orchards. Parasitoid emergence rate did not differ significantly between management systems. Emergence peaked approximately 20 days after field-collection, while a longer exposure to temperatures below 0°C before collection was associated with earlier adult emergence, particularly in males. These findings highlight the importance of winter conditions for aphid persistence and parasitoid emergence, with potential implications for their seasonal synchrony and biological control.

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### Eco-evolutionary insights into the colouration of bumblebees

A. Ferrari<sup>1</sup>, C. Polidori<sup>2</sup>

<sup>1</sup> Free University of Bozen-Bolzano – Faculty of Agricultural, Environmental and Food Sciences, Italy; <sup>2</sup> University of Milan – Department of Environmental Science and Policy, Italy

Bumblebees (Hymenoptera: Apidae: *Bombus*) provide a suitable system for investigating the evolution and biogeography of colouration in insects. Under Gloger's rule, warm and humid environments are expected to favour stronger eumelanin (black) and/or pheomelanin (reddish) deposition; whereas warm and dry conditions should be associated with relatively more pheomelanin-based phenotypes. Here, we present preliminary results regarding the first formal test for Gloger's rule, considering colouration across 24 body regions for more than 100 bumblebee species, addressing: (i) how strong is the phylogenetic signal on the colour composition; and (ii) test whether Gloger's rule holds true for bumblebees. Bioclimatic conditions from distributional data were summarised into three Principal Components: PC1 – warm wet to cold seasonal; PC2 – rainy to seasonal precipitation; PC3 – isothermal dry seasonal to warm wet seasonal climates. Phylogenetic signal alone was not a strong predictor of colour pattern, with  $\lambda$  values around 0.35 in all the castes. In fact, colour pattern was significantly associated with PC1 and PC2 in all castes; while PC3 was significant only in queens. Elevation also explained significant colour variation in all castes. However, these predictors accounted only for around 11-13% of variation. Upon visual inspection of colour-bioclimatic gradient associations, Gloger's rule appears to be confirmed for the three castes. Indeed, warm, wet conditions (PC1–PC2) show a stronger association with black, red and orange melanic colourations; whereas in colder, drier or seasonal conditions, yellow predominates, although some brown or red colourations are still present. Finally, high altitude species exhibited darker colours.

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### **Wing oscillations in insects with indirect asynchronous flight: a mathematical study**

G. Ferraro<sup>1</sup>, D. Agostinelli<sup>2</sup>, D. Romano<sup>1,4</sup>, A. De Simone<sup>1,3,4</sup>

<sup>1</sup> Sant'Anna School of Advanced Studies – The Biorobotics Institute, Italy; <sup>2</sup> UNIVPM – DIISM, Italy; <sup>3</sup> SISSA – MathLab, Italy; <sup>4</sup> Sant'Anna School of Advanced Studies – Department of Excellence in Robotics and AI, Italy

Insects performing indirect asynchronous flight rely on the ability of the thoracic flight apparatus to generate and sustain rapid wing oscillations through the coupled dynamics of muscles, thorax, and wings. We study a minimal mathematical model to investigate the mechanisms underlying the spontaneous generation of wing beats. The model describes a coupled wing–thorax–muscle oscillator in which muscle activation responds to thoracic deformation with a finite time delay, capturing the essential features of stretch-activated muscle dynamics. We show that self-sustained oscillations emerge through an instability driven by stretch-activated muscle forcing, and we analytically predict the onset frequency of the oscillations and the relationship between oscillation frequency and amplitude. These results provide a simple theoretical framework for understanding how the mechanical properties of the insect flight apparatus influence wing dynamics and may serve as a starting point for future experimental investigations.

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### Hide, seek and sift: efficiency of active and passive methods in sampling litter spiders

T. Fusco<sup>1</sup>, A. Di Giulio<sup>1,2</sup>

<sup>1</sup> Roma Tre University – Department of Science, Italy; <sup>2</sup> NBFC – National Biodiversity Future Center, Italy

Spiders are a diverse and abundant component of forest litter, contributing to key ecosystem functions, yet their diversity is often overlooked in invertebrate monitoring. We compared Visual Census and Winkler extraction across six oak and beech forest sites in Lazio, Central Italy, during spring and summer 2025. Generalized linear mixed models showed no overall difference in total captures (adults and juveniles) between methods, but a significant method × season interaction in mean abundance and dispersion. Winkler extraction captured more individuals, with greater variability, only in summer, mainly due to unidentifiable juveniles; methods performed similarly in spring. Adult abundance did not differ, whereas Visual Census detected 12% more adult species per sample. Both methods yielded lower abundance and richness in beech forests and summer. Multivariate analyses of 222 samples containing at least three adults revealed statistically distinct but largely overlapping assemblages. Sampling method explained only 2.0–2.5% of compositional variance, compared with habitat (6.0%) and season (4.5%). Dispersion was homogeneous between methods. SIMPER analyses indicated that Visual Census favored mobile, conspicuous species, including *Enoplognatha thoracica* and *Scytodes thoracica*, whereas Winkler extraction favored small, cryptic Linyphiidae, including *Mecopisthes latinus* and *Centromerus tongiorgii*. Across sites, 105 species were recorded, with only *C. tongiorgii* shared among all six sites. Visual Census therefore offers an efficient, non-destructive alternative for standardized ecological monitoring, detecting more adult species per sample while underrepresenting some cryptic taxa. Combining methods may nevertheless maximize species inventories in faunistic surveys.

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### Biological traits and biocontrol potential of *Eriborus* sp., a newly recorded Asian parasitoid of the invasive box tree moth

S. Gallizia<sup>1</sup>, A. K. Buhari<sup>2</sup>, C. Ferracini<sup>1</sup>, M. Kenis<sup>3</sup>, M. L. Seehausen<sup>3</sup>

<sup>1</sup> University of Turin – Department of Agricultural, Forest and Food Sciences, Italy; <sup>2</sup> University of Padua – Department of Agriculture, Food, Natural Resources, Animals and Environment, Italy; <sup>3</sup> CABI, Switzerland

The box tree moth (BTM), *Cydalima perspectalis* (Lepidoptera: Crambidae), is an invasive pest of *Buxus* spp. that has rapidly spread across Europe since its introduction from Asia, causing severe damage to ornamental and wild boxwood plants. Although several studies have investigated its native natural enemies in Europe, only a few generalist parasitoids exert limited impact on the pest populations. Recently, an Asian larval endoparasitoid of the genus *Eriborus* (Hymenoptera: Ichneumonidae) was recorded parasitising BTM in Switzerland and Germany. This study investigated key biological traits of *Eriborus* sp. to evaluate its potential as a biological control agent. Specifically, laboratory experiments assessed host-instar suitability, adult female longevity, pre-oviposition period, and potential and realised fecundity. *Eriborus* sp. successfully parasitised all tested host larval instars, although parasitism success varied among developmental stages. Under controlled laboratory conditions, adult females exhibited a mean longevity of  $35.3 \pm 3.7$  days. Newly emerged females required a 48-hour pre-oviposition period, with parasitism rates rising from 19.2% on day 3 to 98.2% by day 7. Ovarian dissections revealed that females emerged without mature eggs, confirming a synovigenic reproductive strategy. Potential fecundity increased from  $1.7 \pm 0.6$  mature eggs on day 3 to a peak of  $82.9 \pm 5.0$  by day 20. Realised fecundity followed a comparable trend, with progeny production beginning on day 3 ( $2.4 \pm 0.9$  adult offspring per female). These findings provide valuable insights into the reproductive biology and host exploitation strategies of *Eriborus* sp., emphasising its promising attributes for the sustainable management of BTM.

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### **Preliminary pathogenicity assay of the entomopathogenic fungus *Akanthomyces muscarius* on *Lymantria dispar* larvae**

F. Isoli<sup>1</sup>, F. Brugneti<sup>1</sup>, S. Turco<sup>1</sup>, M. Barta<sup>2</sup>, D. Pilarska<sup>3</sup>, A. Lentini<sup>4</sup>, M. Contarini<sup>1</sup>

<sup>1</sup> University of Tuscia – DAFNE, Italy; <sup>2</sup> Slovak Academy of Sciences – Institute of Forest Ecology, Slovakia; <sup>3</sup> Bulgarian Academy of Sciences – Institute of Biodiversity and Ecosystem Research, Bulgaria; <sup>4</sup> University of Sassari – Department of Agriculture, Italy

*Lymantria dispar* L. (Lepidoptera: Erebididae) is a phyllophagous pest that undergoes periodical population outbreaks, causing complete defoliation of extensive forest areas. In Italy it mainly affects Mediterranean oak forests. Current control methods are costly, often provide only short-term protection and may affect non-target species. Entomopathogenic fungi (EPF) have emerged as a sustainable alternative to conventional pesticides due to their lower impact on non-target organisms. Among them, *Akanthomyces muscarius* is a promising but still underexplored candidate for the biological control of *L. dispar*. This preliminary work aimed to assess the pathogenicity of a strain isolated from hazelnut galls in the province of Viterbo (Italy) against third-instar larvae. Following exposure to 0.5 ml of a conidial suspension ( $1 \times 10^7$  conidia/ml), mortality of the treated larvae reached 77% whereas no mortality occurred in the control, and fungal outgrowth confirmed mycosis in 69% of dead larvae. These results suggest that, under laboratory conditions, the tested strain has high insecticidal activity against *L. dispar* larvae and may represent a sustainable alternative to traditional control methods. Additional studies examining different fungal concentrations and larval instars, followed by semi-field and field trials, will be needed to confirm its efficacy and practical applicability.

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### ***Hermetia illucens* frass extract and *Trichoderma afroharzianum* T22 increase the susceptibility of *Spodoptera littoralis* to entomopathogens**

C. Le Boffe, I. Di Lelio, M. Gebiola

University of Naples Federico II – Department of Agricultural Sciences, Italy

Insect frass, the main by-product of insect farming, is increasingly used as a fertiliser and has been reported to modulate plant defenses. We tested whether conditioning the root zone of tomato with an aqueous extract of heat-treated *Hermetia illucens* frass and/or the beneficial fungus *Trichoderma afroharzianum* T22 alters the susceptibility of *Spodoptera littoralis* larvae to two biological control agents with unrelated modes of action: the entomopathogenic nematode *Steinernema carpocapsae* and *Bacillus thuringiensis* subsp. *Aizawai* (*Bt*). The extract was first characterized for elemental composition, chitin content (proton nuclear magnetic resonance) and microbial community (shotgun metagenomics). Chitin, present in the solid frass (1.4%), was not detected in the extract, which instead carried a distinct microbial community dominated by Firmicutes and enriched in genes associated with plant immunity. The frass extract was then applied to the substrate at a non-phytotoxic dose defined by a germination assay. Fifth-instar larvae were fed leaf discs from control, frass, T22 and combined plants, with or without a sublethal dose of either agent. Without entomopathogens, survival did not differ among plant treatments. With the nematode, survival decreased from 65% on control plants to 35% (frass), 26% (T22) and 12% (combined); with *Bt*, from 95% to 62%, 40% and 13%, respectively. Factorial analysis showed significant effects of plant treatment and agent but no significant interaction, suggesting additive effects. These results suggest that frass extract, alone or combined with T22, can enhance the biological control of *S. littoralis*, possibly through microbially mediated priming of plant defenses.

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### Effects of insect pollination on soybean yield

E. Lincetto

*University of Padua – Department of Agronomy, Food, Natural Resources, Animals and Environment DAFNAE, Italy*

Soybean is a globally important crop, mainly used in the production of edible oil and for livestock feed. Soybean's dependence on pollinators has been overlooked for a long time, since soybean is autogamous and self-compatible, being able to produce seeds by itself. However, recent studies have reported that the absence of pollinators can reduce soybean production by 10-40%. At the same time, agricultural intensification is one of the main causes of the decline of pollinator insects, mostly because of habitat loss and fragmentation, landscape simplification, and the intensive use of agrochemical inputs. In our field experiment, we want to further investigate this dependency of soybean on pollinator insects. First, we aim to determine whether there is a difference in the seed set and fruit set between the margin and the center of the soybean field. We expect higher seed sets and fruit sets in the field margin, as pollinator activity may be higher near the field edge. After this, we aim to investigate whether there is a landscape effect on soybean production. Soybean fields nested in more heterogeneous landscapes may receive a better pollination service than the fields surrounded by highly simplified landscapes. Heterogeneous landscapes, having a higher diversity of seminatural habitats, may sustain richer and more abundant pollinator communities, allowing a spillover of pollinators to the nearby soybean crops, therefore enhancing yield.

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### Impact of vibrational signals on leafhopper feeding behaviour and phytoplasma transmission

G. Lucetti<sup>1</sup>, L. Prodi<sup>2</sup>, R. Nieri<sup>3</sup>, C. Marzachi<sup>4</sup>, D. Bosco<sup>5</sup>, A. Fereres<sup>6</sup>, V. Mazzone<sup>2</sup>

<sup>1</sup> Polytechnic University of Madrid, Spain; <sup>2</sup> Edmund Mach Foundation, Italy; <sup>3</sup> University of Trento, Italy; <sup>4</sup> National Research Council (CNR) – Institute for Sustainable Plant Protection (IPSP), Italy; <sup>5</sup> University of Turin – Department of Agricultural, Forest and Food Sciences, Italy; <sup>6</sup> Spanish National Research Council (CSIC), Spain

Flavescence dorée (FD), caused by a quarantine phytoplasma, represents one of the major phytosanitary emergencies in European viticulture. While management of its primary vector, the leafhopper *Scaphoideus titanus*, relies on strict monitoring protocols and mandatory insecticide treatments, there is an urgent need for sustainable control strategies. In this context, disruptive vibrational signals represent an innovative frontier in biotremology applied to pest management. This approach interferes with substrate-borne intraspecific communication, crucial for leafhopper mating and reproductive success. While the effectiveness of these signals in controlling population density through mating disruption has been documented for *S. titanus*, their impact on feeding behaviour and phytoplasma acquisition and transmission remains unexplored. To address this gap, we investigated the effects of vibrational disruption on both the primary vector, *S. titanus* and the laboratory vector, *Euscelidius variegatus*. For both species, newly emerged adults were exposed to continuous vibrations during acquisition and inoculation access periods on their respective host plants (grapevine and broad bean). The impact of vibrational treatment was evaluated by comparing exposed insects against non-disrupted controls. Molecular analyses revealed variations in phytoplasma infection levels between treated and control groups, suggesting that vibrational disruption may affect vector-pathogen interactions during acquisition and transmission processes. Although preliminary, these findings pave the way for further research into the potential of vibrational disruption to impair feeding behaviour and reduce transmission efficiency.

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### Development of transgenic black soldier fly larvae for polyethylene terephthalate (PET) degradation

M. Marzari<sup>1</sup>, D. Bruno<sup>1</sup>, D. Roma<sup>2</sup>, C. Fontana<sup>1</sup>, E. Caruso<sup>1</sup>, A. Grapputo<sup>3</sup>, I. Alyagor<sup>4</sup>, I. Nevo<sup>4</sup>, G. Molla<sup>1</sup>, F. Sandrelli<sup>3</sup>, S. Caccia<sup>2</sup>, M. Casartelli<sup>2,5</sup>, G. Tettamanti<sup>1,5</sup>

<sup>1</sup> University of Insubria – Department of Biotechnology and Life Sciences, Italy; <sup>2</sup> University of Milan – Department of Biosciences, Italy; <sup>3</sup> University of Padua – Department of Biology, Italy; <sup>4</sup> FreezeM, Israel; <sup>5</sup> Interuniversity Center for Studies on Bioinspired Agro-environmental Technology (BAT Center), Italy

Black soldier fly larvae (BSFL; *Hermetia illucens*) are considered a biotechnological tool for the valorization of organic waste and agro-industrial by-products due to their efficient conversion of low-value substrates into insect biomass. However, organic waste streams may contain persistent contaminants, including microplastics (MPs), which can limit the safety and sustainability of waste valorization strategies. Among the most widely detected synthetic polymers, the plastic polyethylene terephthalate (PET) is particularly recalcitrant to degradation. Here, we developed a genetically engineered *H. illucens* line expressing the F243T/C292A- $\Delta$ LCC (TA- $\Delta$ LCC) variant of leaf-branch compost cutinase (LCC), an optimized thermostable enzyme with PET-degrading activity. To this purpose, the TA- $\Delta$ LCC expression cassette was introduced into the *H. illucens* genome through piggyBac-mediated transgenesis. Transgenic larvae were characterized by assessing TA- $\Delta$ LCC expression, protein distribution along the larval midgut, and PET-degrading activity through *ex vivo* and *in vivo* assays.

The results demonstrated that TA- $\Delta$ LCC was highly expressed throughout the anterior, middle, and posterior midgut, while protein was primarily detected in the posterior region. PET-degrading activity was confirmed both with *ex vivo* and *in vivo* assays. Importantly, no alterations in midgut morphology and physiology were observed, indicating that the transgene expression did not adversely affect gut functionality.

Overall, this study provides the proof of concept for the generation of transgenic BSFL expressing a functional PET-degrading enzyme in the midgut, opening new perspectives for the use of engineered *H. illucens* larvae in the bioconversion of organic waste containing plastic contaminants.

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### Experimental releases of pupal parasitoids to control *Piophilidae* (Diptera: *Piophilidae*) in ham production

D. Missere<sup>1</sup>, R. Girodo<sup>1</sup>, A. Martini<sup>1</sup>, N. Patelli<sup>2</sup>, G. Burgio<sup>1</sup>

<sup>1</sup> University of Bologna – Department of Agricultural and Food Sciences, Italy; <sup>2</sup> Bioecology S.r.l., Italy

Biological control is gaining importance in stored-product protection, but strategies for preserved foods of animal origin remain lacking. Cured ham can be damaged by the cheese skipper *Piophilidae* (Diptera: *Piophilidae*), whose larvae feed inside the meat and leave it to pupate in floor crevices, where sanitation and insecticides often fail. This behavior makes pupal parasitoids promising agents, as they attack the pest away from the product. This study evaluated, for the first time inside a ham production facility in Northern Italy, *Pachycrepoideus vindemmiae* (Rondani) and *Muscidifurax raptor* Girault and Sanders (Hymenoptera: Pteromalidae) against *P. casei*. Three mesh cages, each holding 25 hams, were built in a curing room and artificially infested with the fly; one cage received *M. raptor*, one *P. vindemmiae*, and one served as a control. Each parasitoid was released three times, about 21 days apart. Fly pupae were sampled 7, 14 and 21 days after each release, kept in the laboratory and dissected when no adult emerged. Both parasitoids parasitized *P. casei* pupae, mated successfully under production conditions, as shown by progeny strongly biased towards females, and did not contaminate the hams. *Pachycrepoideus vindemmiae* achieved a much higher total parasitism than *M. raptor* (44.8% versus 3.6%) and a higher parasitoid emergence rate (11.4% versus 3.6%), whereas longevity and sex ratio did not differ. Although based on one cage per species, these results identify *P. vindemmiae* as the more promising candidate and support replicated trials with inundative releases under commercial conditions.

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### SENIOR LECTURE

#### **New approaches to insect pest management in cultural heritage**

R. Nieri

*University of Trento, Italy*

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### Evaluation of an attract-and-kill device against *Ceratitis capitata* Wiedemann under semi-field conditions

V. Papili<sup>1</sup>, E. M. D. Bali<sup>2</sup>, M. Colacci<sup>1</sup>, E. Verykouki<sup>2</sup>, N. T. Papadopoulos<sup>2</sup>,  
A. Sciarretta<sup>1</sup>

<sup>1</sup> University of Molise – Department of Agriculture, Environmental and Food Sciences, Italy; <sup>2</sup> University of Thessaly – Department of Agriculture Crop Production and Rural Environment, School of Agricultural Sciences, Greece

*Ceratitis capitata* Wiedemann (Diptera: Tephritidae), known as medfly, is one of the most destructive insects in orchards and it is traditionally managed using broad spectrum insecticides. Within Integrated Pest Management programs, it can be controlled using Attract-and-Kill (A&K) devices, which contain an attractant that lures the pest onto a surface coated with insecticide. However, limited information is available on the persistence of attractiveness and insecticidal activity over time and on how environmental conditions affect efficacy. In the present contribution, we aimed to investigate how the insecticidal effect, the attractiveness and the performance of an A&K panel after exposure to four different environmental conditions (sunlight, rainfall, shade, tree canopy) change over time, testing the commercial product BioMagnet Amber™ (BA) under semi-field conditions over four months.

The insecticidal effect of BA declined over time, passing through 48% of mortality after contact with new panels, to 32% with 4-month old panels.

Attractiveness decreased over time, but BA panels remained more attractive than the control, with the new panel showing the highest attractiveness.

Environmental exposure strongly affected performance: panels exposed to direct sunlight became ineffective at four months, with mortality comparable to that of the negative control, whereas panels hung within the tree canopy remained well effective after four months, with efficacy comparable to that of new devices.

These results indicate a correlation between exposition in field and efficacy, whereas direct sunlight exposure accelerates performance loss. Replacement schedules should therefore consider residual insecticidal activity rather than lure attractiveness alone to ensure effective medfly suppression.

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### SENIOR LECTURE

#### **Insect multitrophic interactions for sustainable plant protection**

F. Pennacchio

*University of Naples Federico II – Department of Agricultural Sciences, Italy*

A growing body of evidence supports the hypothesis that the soil microbiome and its interactions with other microbiomes in trophic networks are central to “One-Health”. However, our understanding of how microbial communities interact with and are influenced by upper trophic levels remains fragmented, and a comprehensive framework connecting soil microbiome to plant and animal health is still incomplete. Here, I discuss mechanisms governing interactions among holobionts that affect energy and material flow in insect trophic networks and outline how this knowledge can enhance crop health and support sustainable plant protection strategies with low impact on functional biodiversity and ecosystem services. Unravelling resource competition in insect multitrophic interactions enables identification of molecules and genes for developing plant protection tools that mimic natural pest suppression. However, predicting ecosystem responses to human perturbations remains difficult, and robust approaches to assess their impact on trophic interactions underlying ecosystem stability and resilience are still lacking. A holistic understanding of trophic interactions among holobionts, underpinned by thermodynamic principles and systems theory, provides a robust framework for this objective. Multi-scale modelling based on trophic resource dynamics offers a novel integrative biology approach to advance ecosystem study. Interdisciplinary collaboration, funding, and data sharing are essential to progress this framework.

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### Understanding variation in entomopathogenic nematodes' virulence against spittlebugs

P. Perfetto<sup>1</sup>, G. Logreco<sup>1</sup>, E. Tarasco<sup>1</sup>, A. R. Dillman<sup>2</sup>, D. Cornara<sup>1</sup>

<sup>1</sup> University of Bari – Department of Soil, Plant and Food Science, Italy; <sup>2</sup> University of California, Riverside – Department of Nematology, USA

Current control strategies of *Philaenus spumarius*, a key vector of the bacterium *Xylella fastidiosa* in European agroecosystems, have so far produced inconsistent results in terms of mitigating pathogen spread, highlighting the need for sustainable alternatives. Entomopathogenic nematodes (EPNs) are promising biological control agents, but their efficacy against spittlebugs and the factors underlying their virulence remain poorly understood. To address this, we conducted a structured screening of EPN strains to characterize their virulence against adults of *P. spumarius*. Strains of *Steinernema arenarium*, *S. feltiae*, *S. carpocapsae*, and *Heterorhabditis bacteriophora* from diverse global agroecosystems were evaluated to estimate virulence and strain-related variations. Standardized bioassays enabled the identification of strains with contrasting virulence profiles, grouping them into distinct virulence clusters. We then investigated the bioactivity of excreted-secreted proteins (ESPs) derived from the symbiotic bacteria associated with a highly virulent and a non-virulent strain of the same EPN species via microinjection. Interestingly, the ESP toxicity profiles did not mirror the whole-organism virulence tests, suggesting that invasion dynamics rather than bacterial toxicity primarily govern host mortality. In parallel, we are investigating the determinants of virulence through whole-genome sequencing of strains from contrasting clusters to identify genomic underpinnings of pathogenicity. By integrating phenotypic screening with genomic and metabolite analyses, this work aims to uncover multi-omics determinants of virulence and support the development of targeted biocontrol strategies against *X. fastidiosa* vectors.

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### **Harnessing *Wolbachia* for sustainable control of psyllid-transmitted phytoplasmas**

M. Pernter<sup>1</sup>, H. Schuler<sup>1,2</sup>

<sup>1</sup> Free University of Bozen-Bolzano – Faculty of Agricultural, Environmental and Food Sciences, Italy; <sup>2</sup> Free University of Bozen-Bolzano – Competence Centre for Plant Health, Italy

Insect-transmitted plant pathogens pose a growing threat to crop production, while conventional vector-control measures can have limited effectiveness and undesirable environmental impacts. This project investigates whether *Wolbachia*, a widespread insect-associated bacterium known to alter host reproduction and pathogen transmission, can be harnessed to suppress the spread of phytoplasmas by psyllid vectors. Laboratory-based artificial transmission assays and semi-field experiments will be combined with advanced molecular, genetic, and genomic approaches to characterize interactions among *Wolbachia*, the insect vector, and the plant pathogen, and to determine how these interactions influence vector competence. By establishing the mechanistic and experimental basis for a *Wolbachia*-based control strategy, the project aims to advance an innovative and environmentally sustainable approach to crop protection. The results may also provide a transferable framework for managing other insect-borne plant diseases and contribute to broader One Health objectives of protecting environmental health and resilient food-production systems.

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### Optimizing digital radiography for the detection of hidden insect damage in bamboo

P. Rodrigues<sup>1,2</sup>, R. Guedes<sup>1</sup>, R. Tedeschi<sup>2</sup>

<sup>1</sup> Federal University of Viçosa – Department of Entomology, Brazil; <sup>2</sup> University of Turin – Department of Agricultural, Forest and Food Sciences, Italy

The interaction between wood-boring insects and their substrate can affect material integrity, making it important to understand how infestations develop internally. The bamboo powderpost beetle, *Dinoderus minutus* (Fabricius, 1775) (Coleoptera: Bostrichidae), is a relevant pest of dried and stored bamboo products worldwide. This study investigated the colonization dynamics of *D. minutus* in *Bambusa vulgaris* using digital X-ray imaging and established imaging parameters for detecting internal infestation. A no-choice bioassay was conducted under controlled conditions ( $26 \pm 4$  °C,  $60 \pm 10\%$  RH, 12 h photoperiod), with ten adult beetles exposed to a bamboo specimen. Images were acquired before, during, and after 120 days, covering the beetle's life cycle. Four replicates were performed, and the resulting images were examined to characterize gallery development and quantify entry holes and progeny larvae. Data were analyzed using the Kruskal–Wallis test. Samples presented an average of  $3.25 \pm 2.75$  entry holes and  $1.5 \pm 1.91$  larvae. The most suitable imaging conditions were 31 kV and approximately 13.5 s exposure, allowing differentiation among developmental stages, including larvae, pupae and adults. The images also revealed distinct tunneling orientations: horizontal galleries associated with adults and vertical galleries associated with larvae. These findings demonstrate the potential of X-ray imaging to characterize infestation progression and reveal internal colonization patterns without damaging the bamboo. The technique provides a valuable approach for investigating insect–bamboo interactions and supporting pest surveillance in bamboo production and storage systems.

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### Host choice and diet shape gut bacterial communities and survival of the southern green stinkbug (*Nezara viridula*) of pampeana region in Argentina

B. E. Rosso<sup>1,2,3</sup>, V. Medina<sup>1</sup>, M. Soria<sup>1</sup>, J. A. Zavala<sup>1</sup>

<sup>1</sup> University of Buenos Aires – School of Agriculture, Institute of Agricultural and Environmental Biosciences Research (INBA-CONICET), Argentina; <sup>2</sup> University of Turin – Department of Agricultural, Forest and Food Sciences (DISAFA), Italy; <sup>3</sup> National Research Council (CNR) – Institute for Sustainable Plant Protection (IPSP), Italy

The southern green stinkbug, *Nezara viridula*, is the main pest of soybeans in agroecosystems of Argentina pampeana region. However, the relationship between host use and gut bacterial communities, and its effect on adult survival, remains unclear. Using 16S rRNA gene metabarcoding, we investigated associations among host plants (soybean and alternative hosts: maize and amaranth), gut microbiota and survival, combining field surveys, a free-choice assay and controlled-feeding experiments. Across transects of soybean crops, stinkbug abundance declined by an estimated 11.8% for every 20 metres from field edges, with secondary hosts, towards field centres. Field-collected insects from soybean had lower bacterial richness and Shannon diversity than those collected from maize and amaranth, and the bacterial communities differed among the different hosts ( $P=0.001$ ). In the free-choice assay, 58.9% of feeding observations were on secondary hosts rather than soybean ( $P=0.006$ ), and this proportion did not vary significantly over eight days ( $P=0.511$ ). In the controlled-feeding experiments, we observed that diet was associated with shifts in gut bacterial communities, including changes in the relative abundances of *Yokenella* and *Pantoea*. Soybean-fed insects had lower bacterial richness. Adult survival differed among diets ( $P=0.006$ ), with lower survival on soybean than on maize ( $P=0.008$ ) or amaranth ( $P=0.041$ ), but did not differ significantly from the free-choice assay ( $P=0.377$ ). These findings link host use, variation in diet-associated microbiota and adult survival in *N. viridula*. Alternative hosts may influence the distribution and performance of stinkbugs in Argentina's soybean agroecosystems. However, it remains to be tested whether host-switching directly alters gut bacteria and fitness.

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### Uncovering viral partners: how the virome shapes fitness in *Philaenus spumarius*

P. Royer<sup>1,2</sup>, B. Rosso<sup>1,2</sup>, C. Marzachi<sup>2</sup>, N. Bodino<sup>1</sup>, D. Bosco<sup>1</sup>

<sup>1</sup> University of Turin – Department of Agricultural, Forest and Food Sciences (DISAFA), Entomology, Italy; <sup>2</sup> National Research Council (CNR) – Institute for Sustainable Plant Protection (IPSP), Italy

Viruses are the most abundant biological entities on Earth. They play a crucial ecological role by shaping communities, biological processes, and the behaviour of many species. Yet despite their importance, their impact remains widely understudied—especially among insects, where our knowledge is even more limited. Beyond purely theoretical interest, studying viruses in insects could lead to significant practical advances, particularly in agriculture and biological control programs. Some viruses are highly pathogenic to insects, some cause only covert infections, while others can switch between covert and overt states through poorly understood mechanisms. A common strategy used by parasites to thrive is to weaken the host just enough to allow for proper development, without killing it. In insects, due to their small size, such weakening can be difficult to detect. For this reason, basic parameters such as fitness are useful for assessing the potential impact of viruses on their hosts. The objective of this doctoral project is to determine whether there is a causal relationship between the viral community of the spittlebug, *Philaenus spumarius* L. (Hemiptera: Aphrophoridae), and the species fitness. The experiments focus on identifying the core virome of different insect populations, measuring individual fitness of the insects with different virus infection patterns, also by comparing isogenic population infected, or not by viruses, and by analysing modes of viral transmission. This presentation will explore these elements in greater detail, providing results obtained after two years of Ph.D.

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### New lure combinations to monitor the ash bark beetle, *Hylesinus varius*

E. Sala<sup>1</sup>, M. Marchioro<sup>1</sup>, S. Savoldelli<sup>2</sup>, M. Faccoli<sup>1</sup>

<sup>1</sup> University of Padua – Department of Agronomy Food Natural Resources Animals and Environment, Italy; <sup>2</sup> University of Milan – Department of Food Environmental and Nutritional Sciences, Italy

*Hylesinus varius* (Coleoptera, Curculionidae: Scolytinae) is a phloem-feeding bark beetle distributed throughout the Palearctic region and primarily associated with declining or severely damaged ash trees (*Fraxinus* spp.). The spread of Ash Dieback Disease in northern Italy, a disease that compromises ash health and promotes tree decline, raises concerns about a potential increase in the number of *H. varius* individuals in response to the weakening of host trees. The concurrent spread of the disease and a potential increase in ash-associated bark beetle populations may pose a threat to forest ecosystems, highlighting the need to develop effective and selective monitoring methods. However, the effectiveness of *H. varius* aggregation pheromones, exo- and endo-brevicomin, under field conditions remains unclear. This study assesses the performance of the two brevicomins, applied individually and in combination, to maximize catches of the target species. Field trials conducted in 10 plots in Val Camonica (BS, northern Italy) between April and July 2026, using 40 purple funnel traps baited with pheromone dispensers releasing 0.3 mg/day, indicated that exo-brevicomin was attractive to *H. varius*, both when used alone and in combination with endo-brevicomin, whereas catches in the control (ethanol, 20 mg/day) and endo-brevicomin-only treatments were low. Exo-brevicomin also attracted the associated predator *T. formicarius* indicating low selectivity of the compound. Future studies should investigate the effects of different release rates on *H. varius* capture efficiency and on the accidental catches of associated predators.

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### **Chemical ecology of ambrosia beetle communities: response patterns to ethanol and other host volatiles**

E. Scabbio<sup>1</sup>, G. Santoiemma<sup>1</sup>, G. Cavaletto<sup>1</sup>, C. M. Ranger<sup>2</sup>, A. Gugliuzzo<sup>3</sup>, D. Rassati<sup>1</sup>

<sup>1</sup> University of Padua – Department of Agronomy Food Natural Resources Animals and Environment, Italy; <sup>2</sup> USDA – Agricultural Research Service, Horticultural Insects Research Laboratory, USA; <sup>3</sup> University of Catania – Department of Agriculture, Food and Environment, Italy

Ethanol serves as a primary olfactory cue for ambrosia beetles (Coleoptera: Curculionidae: Scolytinae and Platypodinae), signaling suitable, physiological-stressed or decaying host trees. However, the interaction of ethanol with a broader spectrum of stress-related host volatiles, including Green Leaf Volatiles (GLVs), terpenes, and organic acids, to shape species-specific responses remains poorly understood in field conditions. To address this gap, a comprehensive field trapping experiment was conducted from April to July across nine forest sites in the Euganean Hills (northeastern Italy). We deployed eight hand-made panel traps per site, testing an ethanol-only control against traps baited with ethanol plus an additional candidate VOC. Prior to field placement, release rates were empirically calibrated to ensure a standardized 10:1 ethanol-to-VOC emission ratio. Insect catches were collected weekly, while VOC dispensers were replaced and weighed to evaluate mass loss and ethanol levels were measured and refilled. Trap collections captured a species-rich community of ambrosia beetles. Spatio-temporal analyses demonstrate how individual VOCs modulate ethanol attraction, evaluating whether distinct volatile profiles trigger species-specific preferences and shape ecological stratification among co-occurring species. Overall, this study provides a robust methodological framework to clarify complex chemical interactions, offering valuable insights into ambrosia beetle chemical ecology and potential applications for targeted monitoring and management strategies.

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### Mining the plastic-degrading midgut community of *Hermetia illucens*

C. J. R. Scott<sup>1</sup>, D. Roma<sup>1</sup>, F. D. Filippis<sup>2</sup>, M. Casartelli<sup>1</sup>, S. Caccia<sup>1</sup>

<sup>1</sup> University of Milan – Department of Biosciences, Italy; <sup>2</sup> University of Naples Federico II – Department of Agriculture, Italy

The growing volume of environmental plastic waste highlights the urgent need to develop sustainable processes for its degradation. The larvae of the Black Soldier Fly (BSFL), *Hermetia illucens*, may offer both a bioconversion strategy to reduce plastic-contaminated waste volumes and the opportunity to exploit the capacity for plastic degradation associated to their complex and adaptable midgut microbiota. In this study, a combination of bioinformatic and microbiological approaches was used to investigate the plastic-degrading potential of the BSFL midgut microbial community. Midgut community profiling of larvae reared on plastic-based diets revealed the enrichment of bacterial taxa with the encoded enzymatic capacity for plastic breakdown. Processing of these community sequences through the newly developed metaLoc pipeline (<https://github.com/scottc-bio/metaLoc>) in combination with sequence modelling approaches enabled the identification of candidate enzymes potentially involved in the oxidative depolymerisation of plastic polymers. Additionally, the midgut microbial community of larvae reared on different types of plastics was used as an inoculum in plastic containing cultures which allowed the isolation of bacterial and fungal strains with potential plastic-degrading activity. Further investigation revealed that some of these candidates could metabolise hydrocarbon compounds representative of functional bonds and groups found in plastic polymers. Overall, BSFL provided a useful platform for investigating microbiota-mediated plastic degradation and a source of candidate sequences and microorganisms for further characterisation, both of which could contribute to the development of bio-based plastic remediation strategies.

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### Unravelling the structural principles of desert locust hindwings through bioinspired modelling

L. Spadoni, D. Romano

*Sant'Anna School of Advanced Studies – The BioRobotics Institute and the Department of Excellence in Robotics and AI, Italy*

Insect wings exhibit remarkable structural adaptations including flexibility, mechanical stability and resistance to deformation, while enabling specialised functions such as controlled folding and deployment. Understanding how these properties emerge from wing architecture is a key challenge in insect biomechanics, with implications for the functional interpretation of wing morphology and its relationship with mechanical performance. In the desert locust *Schistocerca gregaria*, the hindwing provides a particularly interesting model, combining a fan-like folding pattern with a corrugated membrane and an interconnected venation network. How these structural features contribute to the mechanical behaviour of the wing remains an important question. This study investigates the structural organisation and kinematics of the desert locust hindwing through computational modelling, using engineering methods to examine the potential mechanical contributions of its main architectural components. A MATLAB-based model is developed to reconstruct wing geometry and represent its three-dimensional flapping kinematics, while a progressive finite element analysis (FEA) framework is used to investigate the contributions of the membrane, longitudinal and cross-veins, and surface corrugation to wing structural behaviour. By analysing these features individually and in combination, the study aims to clarify how the organisation of the hindwing supports the balance between flexibility, structural integrity and foldability. Beyond advancing the mechanical understanding of locust wing architecture, this approach may help identify biological design principles relevant to the development of foldable flapping wings for micro air vehicles and other bioinspired robotic systems.

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### **Two *Akanthomyces* species associated with *Toumeyella parvicornis*: isolation and preliminary assessment of their entomopathogenic activity**

F. Turillazzi<sup>1,2</sup>, G. P. Barzanti<sup>2</sup>, G. Mazza<sup>2</sup>, A. Strangi<sup>2</sup>, L. Giovannini<sup>2</sup>, E. Russo<sup>1</sup>,  
P. F. Roversi<sup>2</sup>, A. P. Garonna<sup>1</sup>

<sup>1</sup> University of Naples "Federico II" – Department of Agricultural Sciences, Italy; <sup>2</sup> Council for Agricultural Research and Economics (CREA) – Centre for Plant Protection and Certification, Italy

The invasive pine tortoise scale, *Toumeyella parvicornis* (Hemiptera: Coccidae), is a sap-sucking pest of several *Pinus* species and has emerged as a severe threat to pine forests and to iconic urban and coastal landscapes in Italy. To mitigate the pest impact, intensive field surveys were carried out in the infested area near Pisa (central Italy), in search of native biocontrol agents, able to limit the spread of this harmful pest in forest environment. Naturally infected adult females of *T. parvicornis* were found at several sites within the infested area, yielding nine isolates of a *Lecanicillium*-like entomopathogenic fungus. Molecular analyses indicated the presence of two *Akanthomyces* species associated with the pine tortoise scale: *A. muscarius* and another undescribed species of the genus *Akanthomyces*. Pathogenicity tests with both species of EPF were performed on different developmental stages of *T. parvicornis*. The results showed a notable efficacy of both species against the first-instar nymphs ('crawlers') and adult females, of the spring, summer and fall generations. Moreover, the most effective EPF isolate, belonging to the unknown species, applied against adult females in laboratory tests, was investigated in a field scenario and its potential biocontrol activity assessed. Two weeks post-treatment, isolate FGP89 gave the highest estimated mortality ( $12.8 \pm 3.6\%$ ), significantly above the controls, but external mycosis was confirmed in only 3.7% of females; efficacy was insufficient to reduce the field population. Further studies are needed to evaluate if *Akanthomyces* species can be included in IPM strategies to control this invasive soft scale insect.

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### Intraspecific crop diversification promotes pollinator coexistence

M. Zanardi, G. Gargano, L. Marini

*University of Padua – Department of Agronomy Food Natural Resources Animals and Environment, Italy*

The simplification of agricultural landscapes, characterized by the dominance of few mass-flowering crops, can intensify competition for floral resources between managed and wild pollinators. We conducted a three-part experiment using multiple genotypes with different attractiveness to investigate how crop genotype identity influences competition and complementarity between *Apis mellifera* and *Bombus terrestris* foraging on sunflower. Under natural field conditions, the two species exhibited distinct genotype preferences, suggesting either competitive displacement or genuine niche complementarity. To elucidate the underlying mechanisms, we removed preferred resources in the presence and absence of *A. mellifera* and followed *B. terrestris* preference changes. Bumblebee foraging patterns were consistent between greenhouse (no *A. mellifera*) and open-field conditions (+ *A. mellifera*) across all genotype-removal scenarios, indicating that its genotype preferences were independent of the presence of *A. mellifera*. Intraspecific crop heterogeneity promoted niche partitioning between pollinator species, thereby representing a promising strategy to support pollinators in crop-dominated landscapes.

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### Differential compatibility of essential oil nanoemulsions with aphid predators: high selectivity towards Diptera Syrphidae

L. Zavatta<sup>1</sup>, J. L. Casas<sup>2</sup>, J. R. Guerrero Martínez<sup>2</sup>, M. L. Santos-Olmo<sup>2</sup>, G. Burgio<sup>1</sup>,  
M. Á. Marcos-García<sup>2</sup>

<sup>1</sup> University of Bologna – Department of Agricultural and Food Sciences (DISTAL), Italy; <sup>2</sup> University of Alicante – Research Institute CIBIO (Ibero-American Centre for Biodiversity), Spain

Control of aphid pests for defence of commercial crops is crucial, as their demand increases over the years. Since traditional pesticides are widely demonstrated to have critical effects on humans and the environment, great attention should be paid to alternative methodologies. Integrated Pest Management (IPM) combines biological, physical, and chemical methods sustainably, emphasizing biological and low-impact approaches such as biopesticides and natural predators. We tested four essential oils (EOs): *Laurus nobilis* L., *Cupressus sempervirens* L., *Pinus halepensis* Mill. and *Santolina chamaecyparissus* L. against the green peach aphid *Myzus persicae* (Sulzer, 1776) and three natural enemies: *Sphaerophoria rueppellii* (Wiedemann, 1830), *Adalia bipunctata* (Linnaeus, 1758), and *Chrysoperla carnea* (Stephens, 1836). Mortality rates highlighted *L. nobilis* as the most effective EO against the aphid, while the syrphid *S. rueppellii* was proved to be immune to all EOs. After identifying the most effective EO and the most resistant predator, a second assay was carried out on plants. Laurel and pine EO nanoemulsions were sprayed on *Capsicum annuum* L. leaves of plants infested with aphids and then, *S. rueppellii* larvae were added to test combined effects. The results showed that EO nanoemulsions alone reduced aphid population to zero in only a small fraction of plants (15%), while rose to 60% when combined with the predator. These findings suggest the potential to further increase mortality rates by optimizing timing of predator introduction following the nanoemulsion treatment. These results are promising for identifying optimal timing of product application and predator release in the framework of an IPM strategy.