International and interdisciplinary meeting on non-target effects of biocontrolS

7–9 October, 2025

Montpellier, France.

Program

Tuesday, October 7

Introduction

9h00 Organization team: Welcome talk & Introduction

9h15 Anne-Violette LAVOIR: Designing a matrix of pest regulation tools and their non-target effects

Pest adaptation and resistance

10h00 Bertrand GAUFFRE: Pest adaptation to biocontrolS: an emerging challenge worldwide

10h25 David CARRASCO: Pyrethroids sensory detection in Malaria mosquitoes. Insights into the mechanisms behind the potential evolution of vectors' behavioural adaptations against control methods

10h45 Silvère GIRAUD: The role of mosquito learning in behavioral adaptation to repellents

10h05 *Coffee break*

11h35 Léa GINGUENEAU: Resistance of an insect pest targeted by a viral biocontrol agent: experimental evolution reveals genetic architecture and candidate polymorphisms for multiple resistances to granulosis virus in the codling moth

11h55 Hyerin AN: Genomic and phenotypic differentiation of *Cydia pomonella* populations under varied pest management regimes in France

12h15 Sébastien LECLERCQ: Genomic epidemiology of multiresistant commensal *Escherichia coli* in broiler production systems

12h35 *Lunch*

Biodiversity, ecosystems and landscapes

14h00 **Teja TSCHARNTKE: Biodiversity conservation suffers also from alternatives to chemical pest control**

14h50 Isis POINAS: Non-target effects of exclusion netting on pests and natural enemies in apple orchards

15h10 Juliette POIDATZ: Outbreak of *Nesidiocoris tenuis* (Miridae) in la Réunion, what are the impacts on local PBI programs in tomato greenhouses?

15h30 Perrine DECOEUR: Long-term surveillance of *Dryocosmus kuriphilus*: Restructuring of parasitoid communities during the equilibrium phase of an Importation Biological Control program

15h50 *Coffee break*

16h20 **Christine MEYNARD et Guillaume FRIED: Effects of agricultural practices on field margin biodiversity: a first synthesis from a long-term monitoring effort in mainland France**

17h10 Benoit RICCI: Building a national sensor-based biodiversity monitoring network

17h30 Enric FRAGO: Indirect effects and the emergence of secondary pests

17h50 Emilio MORA VAN CAUWELAERT: Theoretical perspectives on the role of functional complementarity and intraguild predation on biocontrol services

Cocktail & poster session

Jean-Charles BAMBARA: Biopesticides in the field: practices and perceptions of farmers in Ouagadougou (Burkina Faso) confronting a contested innovation

Thomas BOURGEOIS: Mite bites and biological pest control using birds in urban areas

Quentin GUILLOIT: Combining pest management methods: A mathematical model to predict synergistic or antagonistic interactions

Armelle MAZÉ: Epistemic barriers and challenges towards an integrated approach to One Health. A study of the role of epistemic communities in the field of biocontrol research

Marina ROSENTHAL PEREIRA LIMA: Side effects of botanical pesticides: A case study on essential oils

Marine SAUVIGNET: Efficacy and non-target effects of novel biocontrol insecticide candidates: a greenhouse study against *Myzus persicae*

Julie VITTET: Toward ecological crop pest management: Behavioral effects on non-target pollinators

Conférence grand-public (en français)

19h30 **Núria ROVIRA: Pratiques agroalimentaires et stockage de céréales et légumineuses à l'âge du Fer en Languedoc : apports croisés de l'archéologie, de l'archéobotanique et de l'étude des traces d'insectes sur les semences archéologiques**

Wednesday, October 8

Risk assessment and regulation

9h00 **Korinna WEND: Biopesticides & challenges and future perspectives for testing and safety assessment**

9h50 Jana COLLATZ: Post approval monitoring of alternative methods in arthropod control

10h10 Christophe PLANTAMP: Post approval monitoring of effectiveness of alternative methods in arthropod control

10h30 *Coffee break*

11h00 Laure KAISER: Introducing an exotic macro-organism for biological control: the French regulatory procedure

11h20 Taiadjana FORTUNA: Non-target risk assessment of *Cotesia typhae*, a potential biological control agent of the Mediterranean corn borer

11h40 Mélanie TANNIERES: ~~Pre-release safety screening: microbiome analysis of promising biocontrol agents against weeds~~[a]

12h00 *Lunch*

Changing human practices and organisation

13h30 **Elodie GIROUX: Some epistemological issues in health and environmental integration**

14h20 Rose-Marie BORGES: Defining the scope of biocontrol: interests and challenges

14h40 Boris MONACHON: Comparison of metaphor use in the science popularization of biocontrol in the USA and France

15h00 Tasnime ADAMJY: Challenging the boundaries of scientific work through the development of a pesticide alternative: the case of the Sterile Insect Technique (SIT)

15h20 Aura PARMENTIER: Non target effects of biocontrol conservation and establishment strategies: considering social and organisational mechanisms that constrain their deployment

15h40 *Coffe break*

16h10 **Alexis AULAGNIER: No bans without alternative solutions': a legitimate expectation from farmers or a pitfall for anti-pesticides policies?**

16h50 Claire GACHON: The promises and bottlenecks of biocontrolling of algal pathogens in rapidly changing marine coastal environments

17h10 Monique MUL: Towards reduced number of pesticide applications in agriculture; the effect of farmer network support and possible contribution of retail

17h30 Dani LUCAS-BARBOSA: Beyond biocontrol: promoting functional biodiversity in agroecosytems to improve pest control

[a] not approved by the Trump administration

Thursday, October 9

Ecotoxicology and human health

9h00 Philip K. BETT: *Azadirachta indica* and *Ricinus communis* seed oils interrupt reproduction parameters in mice

9h20 Sunil Kumar GHOSH: Climate change impact in the population of entomophagous epilachna beetle on vegetable crops and harmful effect of insecticides

9h40 Raphaël ROUSSET: Chronic dietary ingestion of *Bacillus thuringiensis* spores promotes intestinal inflammation and aging in non-target adult *Drosophila*

10h00 Monique MUL: Flea control methods of our pets and the influence on our water quality; Action perspectives for dog owners

10h20 *Coffe break*

10h50 **Céline PELOSI: Earthworms and copper, from exposure to effects**

11h40 Organization team: Discussion

12h30 End *& Lunch*

1 Introduction

1.1 Analytical matrix for assessing non-target effects of pest control tools

Anne-Violette Lavoir

ISA, INRAE, Université Côte d'Azur, CNRS, Sophia Antipolis, France

Within the ENI-BC+ network, a pressing need was identified to consolidate multidisciplinary knowledge on the unintended effects of pest control strategies. While the environmental and health impacts of synthetic pesticides are now well documented, their influence on surrounding socio-economic structures remains less understood. As for alternative control methods, some of their unintended effects have never been identified—let alone investigated. From this observation emerged the proposal to build a comprehensive matrix that maps all known pest control strategies against both documented and hypothetical unintended effects. This analytical matrix aims to systematically cross-reference control methods with their potential consequences.

The working group's first step was to catalogue all known pest control tools and describe them in detail. At a fine scale, around fifty strategies were identified and grouped into six major categories: chemical/biological/autocidal/metabolomic control, disruption techniques and agroecosystem management. A similar exercise was conducted for unintended effects, encompassing both biological and sociological dimensions. While biological effects are often confirmed, sociological impacts remain largely hypothetical—highlighting a promising avenue for future research.

The next phase involves cross-referencing these effects with the control strategies. This congress provides an opportunity to identify and bring together experts working on these critical questions.

2

Pest adaptation and resistance

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2.1 Pest adaptation to biocontrolS: an emerging challenge worldwide

Bertrand Gauffre

PSH, INRAE, Avignon, France

Over the past decades, biocontrol and other alternative methods have been increasingly promoted to reduce reliance on synthetic pesticides. These approaches rely on living organisms, natural substances, physical control to limit crop damage caused by pathogens, insect pests, and weeds. In recent years, the range of available biocontrolS solutions have significantly expanded, raising expectations for their contribution to sustainable agriculture.

Yet, a major challenge lies in the evolutionary potential of pests and pathogens. Just as they have repeatedly adapted to chemical pesticides, they also display the capacity to develop resistance or adaptation to biocontrol agents and alternative techniques. Pathogens, for example, are well known to overcome plant varietal resistances, sometimes within only a few years of deployment, illustrating how rapidly adaptation can compromise control strategies. Documented examples also include resistance to *Bacillus thuringiensis* in several insect species, resistance to viral or microbial control agents, and even potential behavioral adaptations undermining tools such as mating disruption or protective nets in insect pests. Although less frequently studied than chemical resistance, these cases highlight the importance of considering adaptation dynamics in the evaluation and deployment of alternative crop protection methods.

In this introductory talk, I will provide an overview of different examples of pest adaptation to biocontrol agents and alternative methods, mainly focusing on cases involving insects' pests. Particular attention will be given to the ecological and evolutionary mechanisms underlying these adaptations. Key challenges include detecting and anticipating pest adaptations to biocontrolS, while opportunities lie in exploiting the adaptive potential of biocontrol agents to counter them. Understanding these processes is essential for designing strategies that ensure the long-term efficacy and sustainability of crop protection systems based on alternatives to chemical pesticides.

2.2 Pyrethroids sensory detection in Malaria mosquitoes. Insights into the mechanisms behind the potential evolution of vectors' behavioural adaptations against control methods

David Carrasco[1], Simplice Kambou[2], Adeline Valente[1], Philip Agnew[1] and Anna Cohuet[1]

(1) MIVEGEC, Univ. Montpellier, IRD, CNRS, France
(2) IRSS, Burkina Faso

Insecticide-based vector control has been recognised as the principal contributor of the malaria-incidence reduction since 2000. Recently, this trend has worryingly stalled or even reversed in some countries. One identified reason of such stall is the evolution of insecticide resistances to the widely used pyrethroid insecticides in malaria vectors (*Anopheles* sp.). Among them, behavioural resistance, i.e. behavioural modifications allowing to surpass the negative effects of insecticides, has been acknowledged but the mechanisms involved are relatively unknown in malaria vectors. The spatial sensory detection of pyrethroid molecules by malaria mosquitoes has been proposed as one of the potential mechanisms behind some forms of behavioural resistance. Indeed, several studies have identified a sensory-guided effect, such as repellency or even in some cases attraction, of malaria mosquitoes when confronted with pyrethroid-based vector control tools. Yet, the functional mechanisms of pyrethroid sensory detection in *Anopheles* sp. have not been yet described.

In a series of behavioural experiments, we determined that laboratory-reared *An. gambiae* (Gilles; Diptera, Culicidae) and wild *Anopheles* sp. mosquitoes are able to detect pyrethroid molecules without contacting the insecticide and also, we identified that antennae and tarsi are the organs involved in such detection. Finally, we confirmed using electrophysiological techniques (EAG and SSR) the presence of sensory receptors having pyrethroid molecules as agonists in *An. gambiae*.

All these findings shed light into the functional mechanisms of pyrethroid sensory detection in malaria mosquitoes, and they open the door to further study their role in the still vastly unexplored evolution of behavioural resistances in disease vectors, as well as in other pest insects.

2.3 The role of mosquito learning in behavioral adaptation to repellents

Silvère Giraud[1], Adeline Valente[1], Angélique Porciani, Lise Roy[2] and David Carrasco[1]

(1) MIVEGEC, Univ. Montpellier, IRD, CNRS, France
(2) CEFE, CNRS, Université Montpellier Paul Valéry, Montpellier, France

Insect repellents are widely employed across the globe to protect humans from arthropod bites, especially mosquitoes. While these products are readily available for personal use, repellents also represent a critical component of public health strategies aimed at mitigating the transmission of mosquito-borne diseases, such as malaria and dengue fever. These repellents may be derived from natural sources, such as plant essential oils, or produced through chemical synthesis, as in the case of DEET or IR3535. However, mosquitoes' learning capacity has been proposed to contribute to the development of behavioral adaptations against repellents. The aim of this study was to shed light on phenotypic behavioral adaptations and their mechanisms in *Aedes aegypti* to repellents. In this study, the repellent efficacy with pre-exposition to bio-sourced repellents (geraniol or essential oil of *Lippia alba*) has been evaluated using olfactometer essays. Behavioral results demonstrated a reduction in repellent efficacy after a short pre-exposure to the repellent. However, electroantennography measurements showed that pre-exposure did not modify the sensibility of olfactory receptors, thus excluding sensory fatigue. A habituation process (non-associative learning) could be the underlying mechanism. Additionally, it has been established through Pavlovian protocol that mosquitoes can be conditioned to associate a known repellent molecule with a reward. However, it should be noted that this association is influenced by the concentration of the molecules to which the mosquitoes are exposed. These first results seem to suggest that learning could play a role in the mosquito's behavioral adaptation. If non-associative phenomena can reduce repellent effectiveness, it is reasonable to question whether mosquitoes' capacity for associative learning might also impact repellent performance. Consequently, learning could influence host–vector interactions, potentially resulting in higher reproductive rates and an increased transmission of disease. The next step will be to see how learning has an impact on other behaviors associated with access to a host.

2.4 Resistance of an insect pest targeted by a viral biocontrol agent: experimental evolution reveals genetic architecture and candidate polymorphisms for multiple resistances to granulosis virus in the codling moth

Lea Gingueneau[1,2], Bertrand Gauffre[1], Miguel Lopez-Ferber[2], Jérôme Olivares[1], Samantha Besse[3], Sandrine Maugin[1], Christine Blachere-Lopez[2], Sofiane Renoult[1] and Myriam Siegwart[1]

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Like synthetic insecticides, insect pathogens used as biocontrol agents face the emergence of resistance in their target hosts. Resistance of the codling moth (*Cydia pomonella*) to the granulosis virus (CpGV) provides a striking example. Resistance to the first CpGV isolate commercialized (CpGV-M) was first reported in 2005 (Type I). In response to the rapid spread of this strong resistance, two new isolates—CpGV-R5 and CpGV-V15, effective against CpGV-M resistant populations–, were subsequently released to the market. However, in 2019, a monitoring program revealed three multi-resistant wild populations characterized by a reduced susceptibility to the three main used virus isolates (CpGV-M, -R5 and -V15). In this context, our aim was to characterise this new type of resistance and to determine its inheritance pattern, degree of dominance and genetic bases. We aimed to investigate whether and how it differs from previously described resistance mechanisms to CpGV-M.

We collected a multi-resistant wild population and performed genetic crosses with a susceptible laboratory strain, followed by selection with either CpGV-M, CpGV-R5, CpGV-V15 or no virus, to establish three selected lines (MRV-M, MRV-R and MRV-V) and a control line. This experimental design aimed to segregate resistances and to enable the identification of variations specifically associated with resistance to each virus isolate. Bioassays conducted after 13 generations of selection revealed strong resistance in all three selected lines to their respective isolates and cross-resistance among isolates, suggesting that resistance to CpGV-M, -R5 and -V15 is conferred by the same or several linked genetic mechanisms. Individual crossing experiments showed different inheritance modes for resistance to CpGV-M and to CpGV-R in both MRV-M and MRV-R. Resistance to CpGV-M appeared dominant Z-linked as in Type I resistance, while it was more likely recessive, but still Z-linked for resistance to CpGV-R. In addition, whole-genome sequencing was carried out on pools of individuals from G0 and G1, and from generations G2 and G10 of each line, to identify resistance-associated polymorphisms and selection signatures. Several candidate polymorphisms and genes were shared among the selected lines; however, most polymorphisms responding to selection were unique to each line. Further research is needed to understand the coevolution between *C. pomonella* populations and CpGV isolates, with the aim of designing CpGV-based products that provide sustainable management of *C. pomonella* populations.

2.5 Genomic and phenotypic differentiation of *Cydia pomonella* populations under varied pest management regimes in France

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Cydia pomonella, the codling moth, a major pest in apple orchards, has been subjected to varying intensities of chemical and biological control across different regions of France. While biocontrol methods have been highly effective, there is growing concern about the adaptation of *C. pomonella* that may decline its efficacy after decades of application. We hypothesized that long-term exposure to control methods, particularly mating disruption, may leave detectable genomic signatures of selection and lead to phenotypic differentiation between populations. To test this, we investigated genomic and phenotypic variation in *C. pomonella* from three distinct locations: Saint Andiol in the South (long-term exposure to insecticides and mating disruption), Nantes in the North-West (biocontrol only, over the past 15 years), and Sées in the North (no control strategies implemented). To assess potential phenotypic consequences, we performed electroantennography and found that Southern populations displayed significantly stronger antennal responses to codlemone, the main component of the female sex pheromone widely used in mating disruption strategies. These findings suggest that chronic exposure to pheromone-based biocontrol may have altered olfactory sensitivity in Southern populations. Complementary flight tunnel assays and transcriptomic analyses were performed to further characterize behavioral and gene expression differences. Analyses of whole-genome resequencing of 97 individuals, including both spatial and temporal samples (collected approximately 10 years apart in two locations), revealed clear genetic structuring between Northern and Southern populations. A locus on chromosome 27 displayed reduced genetic diversity and elevated FST and DXY, suggesting a selective sweep. By linking genomic, transcriptomic, and behavioral results, this study provides insights into how *C. pomonella* adapts to pest management practices.

2.6 Genomic epidemiology of multiresistant commensal *Escherichia coli* in broiler production systems

Sébastien Leclercq

ISP, INRAE, Université de Tours, Nouzilly, France

For more than seventy years, antibiotics were and are still used systematically in modern livestock farming to prevent potential infection by pathogenic bacteria. This massive and recurrent exposure to antibiotics led to non target emergence of antimicrobial resistance (AMR) in commensal gut bacteria of animals, which are now considered as a reservoir of AMR genes for human pathogens. It is therefore of critical importance to understand how theses genes spread and persist in the livestock setting. Using the commensal gut bacteria *Escherichia coli* as an indicator, we investigated AMR content and genetic relationships between strains isolated from faeces of chicken and their direct environment, sampled i) in a nation-wide survey of Lebanese broiler farms with high antibiotic consumption, and ii) in a multi-generational survey of French broilers from a single farm where no antibiotics are used.

Our results indicate that at a national level, AMR is disseminated by a wide range *E. coli* independent clones, with some examples of identical strains in very distant farms. On the other hand, transmission of AMR in animals of successive generations is mainly driven by the persistence of specific clones in the breeding environment, even without obvious selection pressure. These findings underscore how antibiotic usage in livestock is impacting the epidemiology of AMR in commensal bacteria.

Finding alternatives to antimicrobials in husbandry is urgently needed, as much for keeping their efficiency as for enhancing organic farming development. In this context, natural compounds such as metal-based mixtures or essential oils are more and more extensively tested for animal health. The potential extension of our results to non target emergence of resistance against these new biocontrols will be therefore discussed.

3

Biodiversity, ecosystems and landscapes

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3.1 Biodiversity conservation suffers also from alternatives to chemical pest control

Teja Tscharntke[a]

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As part of the Green Deal, the European Commission proposed in 2022 to halve the use and risk of chemical pesticides by 2030 to reverse biodiversity declines and increase food security. This decision was received positively, as relying more on alternatives to chemical control can be effective and environmentally friendly, as shown, for example, by predators suppressing pest populations or mechanical weed control.

Undoubtedly, we need to reduce environmental risks of pesticides substantially, but should also consider potential and unintentional side effects of alternative strategies. In Conservation Biological Control (CBC), the perspective is often limited to enhancing natural enemy populations and their refuges, thereby neglecting other parts of the biodiversity. Further, biocontrol agents are often less specific than promised by their users, exemplified by large-scale BTi spraying against mosquitos, which actually also affects other midge groups. The presumably most important shortcoming of banning chemical control is the fact that crop yields are typically much reduced, so that more area needs to be cultivated to keep the same productivity. For example, cereal productivity is halved by organic, compared to conventional farming, which may mean to convert large areas of natural land and their biodiversity to cropland to achieve the same productivity.

Hence, we need to identify solutions beyond chemical control with least harm to the environment, biodiversity and society. These include incentives for agricultural landscapes with high crop diversification and small fields to enhance functional biodiversity without compromising yields, as well as more than 20% semi-natural habitat (Tscharntke et al 2021).

[a]Teja Tscharntke has been Professor of Agroecology at the University of Göttingen, Germany, since 1993. He made his Master in both sociology and biology at the universities in Marburg and Giessen, did his doctorate in Hamburg and habilitated in Karlsruhe. His main research focuses on landscape perspectives on biodiversity patterns and associated ecosystem services of temperate and tropical regions, especially biological pest control, pollination and quantitative food webs. Further research addresses interdisciplinary studies integrating socio-economic and ecological analyses. He is "Highly Cited Researcher" (annually since 2015) and has been honored 2020 by the Royal Entomological Society (Award for Insect Conservation), the British Ecological Society (Marsh Award for Ecology 2020) and the Ecological Society of Germany, Austria and Switzerland (Honorary Medal 2021).

3.2 Non-target effects of exclusion netting on pests and natural enemies in apple orchards

Isis Poinas[1], Claire Lavigne[1], Hazem Dib[2], Areski Leroy[1], Pierre Franck[1], Thomas Delattre[1], Xavier Said[1], Tom Souhil[1], Filipa Knapen[1], Jean-charles Bouvier[1] and Bertrand Gauffre[1]

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Alt'Carpo exclusion nets are widely recognized for their effectiveness in controlling codling moth (*Cydia pomonella*), a major pest in apple orchards. Their use is expanding across pome fruit orchards, especially in organic orchards. However, their broader impact at the landscape scale, including potential effects on non-target pests and natural enemies, remains largely unexplored, as are interactions between their local and landscape effects.

From 2021 to 2023, we investigated the effect of exclusion nets in organic farming on target and non-target pests and natural enemies, in the main apple production area of southern France. We monitored 23 pairs of organic orchards, each consisting of a netted orchard adjacent to an unnetted orchard, to disentangle the local effects of nets from those of nets in the surrounding landscape on local infestations by codling moth, rosy apple aphid (*Dysaphis plantaginea*), woolly aphid (*Eriosoma lanigerum*), and natural enemies including spiders, earwigs, ground beetles, harvestmen, ladybirds and predatory bugs. Further studies have also investigated the local and landscape effects of netting on the Mediterranean pine vole (*Microtus duodecimcostatus*) and bird populations.

Our findings indicate that exclusion nets exert both local and landscape effects, by redistributing the populations of pests and natural enemies. A greater proportion of netted orchards in the landscape increases pressure from codling moth and rosy apple aphid in unnetted orchards, but reduces earwigs and voles in these same orchards. As nets significantly impact pest and natural enemy dynamics on the scale of agricultural landscapes, we recommend landscape-scale coordination in their deployment, along with additional protective measures to mitigate their unintended effects at the local and landscape scales.

3.3 Outbreak of *Nesidiocoris tenuis* (Miridae) in la Réunion, what are the impacts on local PBI programs in tomato greenhouses?

Juliette Poidatz[1], Hélène Delatte[1] and Jean Sébastien Cottineau[2]

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Nesidiocoris tenuis is a zoophytophagous miridae originating from the Mediterranean coasts with a cosmopolite distribution. This species is used as a biological control agent in several countries worldwide, to control aphids and leaf miners in tomato greenhouses. Recorded in 1997 in the arthropod inventories of la Réunion, a tropical island located in the South-West of the Indian Ocean, this miridae was scarce. However in the last decade, population outbreaks of this species were observed, becoming a threat to tomato. Indeed, *N. tenuis* is problematic in numerous tomato farms in the island, where it develops all year round. Even if it regulates tomato pests, this insect induces necrotic rings leading to floral abscission and plants head breaking, especially when temperatures are raising and/or preys sparse. The consequences of this invasion are strong, both on crop health, but also on local PBI programs directly and indirectly, through the use of insecticides by farmers, impactful on other biological control agents. Amongst them, the predatory bug *N. volucer* (Miridae), an indigenous locally produced biological control agent. This efficient predator of tomato pests doesn't induce damages on crops, but it struggles to install and maintain when *N. tenuis* is present. Research works are therefore conducted on the interactions between the two species at different scales (arenas, plant, crops), on their respective reproduction biology, and we explored alternative installation and maintenance strategies in the search for an ecological equilibrium under greenhouses, with the use of banker plants associated with the tomato crops.

First, we observed that even if both species adapt their respective behaviour differently in inter vs intra species situations in arenas, the intraguild predation in plants is limited, and would even be in favor of *N. volucer*, but that *N. volucer* survival is way more dependant of preys availability compared with *N. tenuis*. Second, concerning their reproductive physiology, we observed very similar sexual maturation timing, but longer sperm cells in *N. tenuis*, that could be a trace of spermatic selection; concerning their reproductive behaviour, we found that *N. tenuis* was way more willing to make contact with partners, and would mate faster and more often. Lastly, we demonstrated that some banker plants are very promising tools to maintain and enhance *N. volucer* populations, but they cannot decrease damage levels of *N. tenuis*, and more tools need to be developed to enhance *N. volucer* transfer to the crops.

3.4 Long-term surveillance of Dryocosmus kuriphilus: Restructuring of parasitoid communities during the equilibrium phase of an Importation Biological Control program

Leïla Le Friant, **Perrine Decoeur**, Ionela-Madalina Viciriuc, Nicolas Borowiec and Elodie Vercken

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Dryocosmus kuriphilus Yasumatsu (the Asian chestnut wasp) was one of the most significant pests affecting chestnut trees, *Castanea sativa* Mill.. Native from China, it was first detected in Europe in 2002. After successful control efforts in several Asian and American countries, the parasitoid *Torymus sinensis* Kamijo was also introduced in Europe, via Importation (= Classical) Biological Control programs (i.e the deliberate introduction of an exotic biological control agent for its permanent establishment and long-term pest regulation). These importations lead to a significant reduction in *D. kuriphilus* populations within the first years of its release.

Native parasitoid communities, previously associated with oak galls, used the newly available and abundant resource of *D. kuriphilus* to expand their host-range. A five-year observational study in France by Muru et al. (2019) showed that, after releasing *T. sinensis*, and in concordance with the decline of *D. kuriphilus* infestations, interspecific competition among native parasitoids increased. By the fifth year, native parasitoid communities were composed of very few species, often at low densities, or in some cases were entirely absent. These communities were largely dominated by a single species: *Mesopolobus sericeus* (Forster).

With the objective of assessing the long- term dynamics of the *D. kuriphilus* parasitoid communities, new field samplings were conducted in 2024 (i.e. 7 years after the last field samplings), in 26 sites from the original experimental design. As expected, *T. sinensis* remained the most abundant parasitoid in *D. kuriphilus* galls. Native parasitoid communities were reduced to just four species with low densities, among which *Eupelmus urozonus* Dalman is the most dominant.

3.5 Effects of agricultural practices on field margin biodiversity: a first synthesis from a long-term monitoring effort in mainland France

Christine N Meynard[1b], Isis Poinas[2], Léa Genty[3], Laura Henckel[4], Benoit Penel[1], Marie-Charlotte Bopp[5], Axel Bourdonné[1], Thomas Schneider-Brouchon[1], Benoit Ricci[6], Jean-Philippe Guillemin[5], Gael Kergoat[1], Julien Haran[7], **Guillaume Fried**[3c]

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Minimizing agricultural impacts on the environment requires empirical ecological solutions at multiple scales, coupled with monitoring efforts to detect changes in agriculture and the environment. A key objective of such efforts is to identify unintended effects of agricultural practices on biodiversity. This is precisely the goal of the 500 ENI national monitoring network presented here, which has been operating since 2012 across more than 500 sites in continental France, collecting annual data on vegetation, coleopterans, and birds in field margins, as well as earthworms in field cores, and detailed information on agricultural practices. Our results show higher biodiversity in field margins that are adjacent to organic farming; however, there is also great variability in terms of agricultural practices and biodiversity between and within conventional and organic farming, as well as between biogeographic regions and crop types. Pesticide and fertilizer drift has an overall negative impact on biodiversity and composition of field margin plant communities, with their negative impacts being particularly strong at the landscape scale, and affecting the potential ecosystem services (pollination attraction, conservation, erosion control) provided by field margin plants. Important indirect effects on coleopteran biodiversity are mostly mediated through plant diversity and vegetation

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structure. A national monitoring system also provides for an opportunity to propose and test new methods to detect spatio-temporal trends. For example here, integrating taxonomic expertise with metabarcoding makes the coleopteran identification process effective at minimal cost and improves taxonomic resolution of the national monitoring protocol. Temporal analyses also revealed that agricultural practices have not changed much over time, despite significant policy efforts to reduce chemical inputs. In parallel, climate change effects are driving plant communities towards more drought- tolerant species, generating trade-offs with adaptation to intensive agricultural practices. Importantly, the monitoring program has proven capable of detecting unintended effects of agricultural practices on biodiversity. However, finer identification of the specific practices (active ingredients) responsible for these effects remains necessary, particularly if the goal is to use such post-authorization monitoring to inform regulatory decisions or withdraw authorizations. Finally, this large spatio-temporal monitoring effort has allowed proposing vegetation and coleopteran typologies that can be used in the future for quick assessments of field margin biodiversity. Significant challenges remain to incorporate modern technologies into the monitoring system and to transform the measured biodiversity into rapid assessments of ecosystem health, as well as management and agricultural policy recommendations.

3.6 Building a national sensor-based biodiversity monitoring network

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Agroecological production systems depend on ecosystem services derived from biodiversity, particularly pollination and biological control of crop pests. These systems combine multiple levers, such as production diversification, biodiversity enrichment of agricultural landscapes, and the implementation of targeted agronomic practices. Supporting the agroecological transition towards such complex systems require new standardized methods to evaluate their multi-performance of and improve their design.

In this presentation, we will describe the BIODICAPT project starting this year and that runs for a period of five years gathering 18 research units all over France. This project, financially supported by the "PEPR Agroécologie et Numérique", aims at building a biodiversity monitoring strategy based on multiple sensors that can be deployed in agricultural landscapes at different scales: local (farm), regional, and national. The project will use existing sensors and algorithms to improve their ability to characterize biodiversity, including multiple taxa, and deploy these methods on a large scale to assess the targeted and non-targeted effects of agricultural practices and agroecological infrastructures on biodiversity and associated services (mainly biological control, pollination, and biodiversity conservation).

The sensors usedwill be (i) audio recorders to characterizebird, bat, insect communities, and the associated ES; and (ii) proxy- and remote sensing-based images to characterize plant communities, structure, composition, ecological properties and management of agroecological infrastructures and agricultural practices at the landscape scale. To consider a wide variety of production systems and biogeographical contexts, these sensors will be deployed on eight regional field networks already in place and experimented on a larger scale with existing institutional monitoring networks at the national level (500 ENI network). Statistical models will be developed to analyze these multi-taxa and multi-sensor data in relation to agricultural practices, agroecological infrastructures, and the landscape to produce biodiversity indices. Tools will then be developed to transfer knowledge produced to farmers, citizens, and policymakers, and to support the design and management of agroecological systems beneficial to biodiversity and associated ecosystem services. This sensor-based biodiversity monitoring network at national scale will help identify and quantify non-target effects of agricultural practices.

3.7 Indirect effects and the emergence of secondary pests

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Insect herbivores maximise their fitness by exploiting plants of high nutritional quality while minimising the risk of enemy attack or competitive displacement. In ecological networks, these three factors often interact in intricate ways through indirect effects. Indirect effects arise when two species interact via a third.

I will present two experiments in which such indirect effects may represent important sources of unintended negative consequences in biological control. The first experiment was conducted in population cages in the laboratory. We studied a community composed of two plant species, two specialist insect herbivores each restricted to one of the plants, their respective specialist natural enemies, and one generalist herbivore capable of feeding on both plants. We hypothesised that natural enemies could induce a shift in the plant preference of the generalist herbivore. Consistent with this prediction, we found that the generalist herbivore switched between plants depending on which natural enemy was present, even when the available plant was of relatively poor nutritional quality.

The second experiment was carried out in commercial greenhouses, where different combinations of natural enemies were mass-produced and released, and their effects on pest population dynamics were assessed. We tested the idea that cocktails of multiple enemies are more likely to control a diverse community of pest insects, whereas using single specialist enemies can trigger outbreaks of secondary pests. This occurs if suppression of the targeted pest reduces interspecific competition, thereby indirectly benefiting non-target herbivores. We found that some combinations of natural enemies slightly affected the diversity of pests and their enemies in greenhouses, but none of the pests reached outbreak levels or attained the status of secondary pests.

Both experiments show that both in the laboratory and in the field, in diverse herbivore communities, the effects of natural enemies on pest suppression are often unpredictable, particularly due to indirect effects. I will discuss the importance of these indirect effects as key sources of negative non-target effects in augmentative biocontrol.

3.8 Theoretical perspectives on the role of functional complementarity and intraguild predation on biocontrol services

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The use of synthetic pesticides has raised important public health and environmental issues that have led to the development of alternatives like biocontrol services. An important constraint for the success of using natural enemies to biocontrol is that it relies on deep ecological knowledge of species interactions, particularly because potential pests are usually attacked by multiple enemies. These interactions can dampen the biocontrol services in some cases, or affect non-targeted organisms in others.

Studying simple community modules can help to disentangle the main mechanisms driving the interactions between multiple natural enemies and ensure lasting biocontrol services. This would include community coexistence with sufficiently low levels of the targeted with sufficiently low levels of the targeted pest. One example is the intraguild predation (IGP) module which occurs when two predators that share a common prey can also eat each other. This simple module involves a complex balance of predation and apparent and exploitative competition that can promote or hinder coexistence. IGP module might also be affected by the functional differences of the organisms involved (e.g. feeding habits of the different ontogenetic stages of the predators, or prey specialization). From a functional hypothesis, higher functional dissimilarity or complementarity could reduce competition and counteract the antagonist effects of predation.

Our work is part of the Enemy Cocktail project which asks some of these fundamental ecological questions and seeks to propose applicable alternatives for biocontrol in greenhouses. Using mechanistic models, we explored how functionally different natural enemies promote or hinder coexistence in IGP modules. In particular, we combined previously reported mechanisms that in isolation affect coexistence (e.g. alternative prey, non-feeding, or unvulnerable stages). From this, we identified the main determinants and conditions under which the intraguild predation between functionally different natural enemies can lead to coexistence and long-term lasting biocontrol.

Finally, we confronted our results with the functional hypothesis and compared them with the results obtained in some microcosmos experiments done by other partners in the project. We hope that these perspectives can shed light on the principal mechanisms of IGP modules, and inform some specific biocontrol implementations in order to prevent undesirable ecological and economic scenarios.

3.9 Beyond biocontrol: promoting functional biodiversity in agroecosystems to improve pest control

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In this talk I would like to provide you with an overview on different strategies that we currently study and that aim at promoting functional biodiversity in agroecosystems to improve pest control. By diversifying farm landscape, pest control can be promoted and a more resilient cultivation system can be developed. While diversification measures in time such as crop rotation or cover crops are already well-established in agriculture, in-field diversification measures, such as companion plants and the implementation of flower reservoirs, remain largely unused due to economic concerns or technical aspects of integrating them into common cultivation practices. Promoting habitat for the establishment of biocontrol in agroecosystems can in fact reduce costs in the long run. In this talk, I will share with you how we think such strategies may be used to increase the diversity of beneficial insects on potatoes, which is subjected to rotation, as well as on cherry orchards, which is perennial cropping system. Our focus, in both cases, is on the promotion of generalist predators to improve the control of the most important insect pest in these systems, the Colorado potato beetle (CPB) and the black cherry aphids *Myzus cerasi*. During this presentation, I will walk you through the initial challenges, how far we got on the different projects, and well as the positive benefits we harvested so far. We use a flower mixture developed in house for this project in the case of flower reservoirs, and test two different companion plants in comparison with the potato plants monoculture. I will discuss how these strategies could be effective in the long run, requiring relatively low investments for farmers and is thus likely to increase their acceptance.

4

Risk assessment and regulation

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4.1 Biopesticides - challenges and future perspectives for testing and safety assessment

Korinna Wend[a]

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Biopesticides are increasingly recognized as sustainable alternatives to conventional chemical pesticides, offering environmentally friendly solutions for pest and disease control. Among them, microbial pesticides represent the most widely used and studied group. They offer several advantages, including lower toxicity, high specificity toward target pests, rapid environmental degradation, and a reduced likelihood of resistance development. However, challenges such as inconsistent efficacy, higher production costs, and complex regulatory requirements may hinder their broader adoption.

A key distinction between microbial and chemical pesticides lies in the ability of the former to replicate and persist in the environment and on treated crops after application. This biological complexity introduces unique challenges for risk assessment, particularly in regulatory contexts. Safety evaluations are required for authorisation, but standard testing frameworks are often not fully applicable to microbial products.

In regions lacking specific national regulations, international frameworks such as the European Union and the United States Environmental Protection Agency are frequently used. While these provide valuable guidance, they are not always well-suited to the unique characteristics of microbial pesticides. The use of New Approach Methods (NAMs), developed for chemical pesticides, is increasingly explored for microbial applications. However, the direct transfer of these methods is often inappropriate without adaptation due to the distinct nature of living organisms.

This talk highlights current regulatory gaps and discusses the need for improved test guidelines for biopesticides, especially in relation to human health risk assessment. Proposals for refining existing approaches are presented to support the safe and efficient evaluation of microbial pesticide formulations.

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4.2 Post approval monitoring of alternative methods in arthropod control

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Methods such as macro- and microorganisms, semiochemicals and botanicals are used as alternatives to conventional plant protection products. Although these methods are generally perceived safer than synthetic pesticides, regulatory approval is usually required before they can be placed on the market or released into the environment. This includes an assessment of potential risks and sometimes benefits to the environment and society. However, once these methods have been approved, their long-term effects on the environment and society are rarely investigated. This means that an opportunity is missed to counteract undesirable effects, to improve the approval process and, not least, to provide evidence of the safety and efficacy of the methods. During an international expert workshop, we used participative science to investigate strategies for post-approval monitoring. From the outcomes of this workshop, we define the most relevant effects to be considered and suggest methods for assessing them. A case study for one of those effects will be presented in a subsequent talk. We address the major challenges that arise during post-approval monitoring and identify future research needs. To promote implementation, we further suggest ideas for organization and funding of post-approval monitoring programs. While we do not advocate for a stricter scrutiny for alternative pest control methods than for synthetic pesticides, we here provide a first baseline for the development of post-approval monitoring from a scientific, application-oriented and regulatory perspective.

4.3 Post approval monitoring of effectiveness of alternative methods in arthropod control

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Effectiveness of plant protection methods is based on their ability to effectively prevent pest damage on the crop and alternative methods can be less efficient than conventional ones. Non-sufficient effectiveness may lead to loss of confidence into pest control methods, reduced crop yield and revenue for the farmers. During a recent expert workshop on post approval monitoring of alternative pest control methods, effectiveness was considered among the most relevant aspects to be assessed in the long term and we thus address the finds on effectiveness monitoring in this talk.

While effectiveness is evaluated during the pre-approval phase, variability may arise post-approval due to various factors. Pest resistance to alternative methods can arise leading to a significant decrease of effectiveness but we particularly focus on other factors in this talk. Macroorganisms, microorganisms and entomopathogenic viruses may lose effectiveness due to genetic drift, challenges in the production, storage and transport. Macroorganisms face further specific challenges such as establishment failure, host asynchrony, competition, dispersal and prey/host switching. Semiochemicals' effectiveness depends on insect physiology, geography, and environmental conditions, while substances from natural origin (plant, animal, mineral) and micro-organisms are rather more sensitive to conditions during their application including environmental conditions, conditions linked to the crop and linked to the pest.

Effectiveness can be assessed indirectly via crop yield and farmer-reported data or directly through field monitoring using established protocols, e.g. from EPPO, including statistically sound evaluation and measures of pest density, crop damage, and yield differences between treated and control areas. For semiochemicals or macroorganisms, the evaluation of effectiveness is more complex due to their complex mode of action. It can be challenging to design an experimental replicated trial that adequately considers the mobility of organisms or the potential presence of interfering factors in the treatment area.

4.4 Introducing an exotic macro-organism for biological control: the French regulatory procedure

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Non-native pests may lack natural enemies. These are sought in their area of origin for introduction. This is an old and often successful practice (over 2000 successful introductions worldwide, Bale et al. 2008). Few introductions have had environmental negative impact, such as exotic natural enemies becoming invasive. Over the past twenty years, many countries have regulated these introductions and environmental risk assessment has become mandatory. In France, the introduction of non-native macro-organisms beneficial to plants has been regulated since 2012. Here we present the regulatory procedure and its application to obtain authorisation to introduce the exotic insect parasitoid *Cotesia typhae*(Hymenoptera, Braconidae) for the biological control of a maize pest, the Mediterranean stemborer *Sesamia nonagrioides* (Lepidoptera, Noctuidae). The applicants must compile a file documenting several aspects. The first part deals with the characteristics of the macro-organism such as systematics, distribution area, life history traits, ecology. The second part is required when the application concerns an introduction into a contained environment for research purposes and must document the containment protocols and quarantine facilities. The third part is required when the application is for an introduction into the environment. It provides information and data to assess the risks and benefits associated with the introduction of the macro-organism. The decision to authorize is based on the balance between risks and benefits. For *C. typhae*, we estimated it establishment probability based on its overwintering survival and host life-cycle, its dispersal probability and its potential environmental risk, identified as a risk to non-target species. The efficacy and benefits were assessed through greenhouse trials, an economic sustainability study, the feasibility of mass-rearing the insect for annual release, and the reduction of insecticide use associated with this biological control strategy. We will give an overview of the results. A detailed risk assessment for non-target species will be presented in Taiadjana Fortuna's communication. We will present the steps of the procedure until obtaining the visa, and how we will monitor environmental risks after field releases.

4.5 Non-target risk assessment of *Cotesia typhae*, a potential biological control agent of the Mediterranean corn borer

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Biological control of exotic insect pests can be achieved by introducing natural enemies from their natural range. This method has successfully controlled many pests worldwide, but has sometimes had negative effects on local non-target species. Before introducing an exotic macro-organism useful for crop protection, a risk assessment is mandatory under EU regulations. In this study, we assessed the non-target risks of the larval parasitoid *Cotesia typhae* (Hymenoptera, Braconidae), a potential agent for biological control by inundation against the European corn borer, *Sesamia nonagrioides* (Lepidoptera, Noctuidae), both natives to sub-Saharan Africa. To determine the host range of *C. typhae*, we measured the effect of parasitism on 8 non-target species by sequential analysis under laboratory conditions, including tests of acceptance, developmental monitoring, olfactory attractiveness and in planta parasitism. Results varied considerably from one species to another. By multiplying the probability of outcome of the successive stages of the parasitism process, we estimated that non-target species had on average a lower risk of *C. typhae* development (1% of non-target larvae at risk) and lower induced mortality (5%) than *S. nonagrioides* larvae (41 and 42% respectively). The highest *in planta* mortality risk was observed for the cattail stemborer, *Nonagria typhae* (9%), although it was still lower than for the target species (33%). These results on the host range of *C. typhae* and the parasitoid's low survival capacity at winter temperatures suggest a low long-term environmental risk, which is confirmed by the overall risk index estimate proposed by van Lenteren et al. in 2003. The host range and impact of *C. typhae* under field conditions will soon be determined.

4.6 Pre-release safety screening: microbiome analysis of promising biocontrol agents against weeds

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Classical biological control has been widely and successfully applied for over 100 years to manage many invasive plants worldwide. Before releasing a biocontrol agent, its efficacy and safety must be evaluated. Whereas efficacy refers to the impact of a biocontrol agent on the target weed, safety mostly refers to its host-specificity to avoid adverse impact on non-target plant species. A much less known non-target impact is the possible transmission of plant pathogens by the biocontrol agent to native plant species. Preventing or minimizing this risk of introducing associated pathogens should always be a consideration when introducing potential vectors of plant pathogens, such as sap sucking insects in the Hemiptera group. However, a knowledge gap exists in the assessed sanitary status of exotic weed biocontrol agents intended to be released in a new environment. There are no existing guidelines regarding screening for pathogens that could be transmitted by biocontrol agents. Microbiome investigations may become important for pre-release safety screening for weed biocontrol agents from taxonomic groups, particularly Hemiptera, known to have the potential to vector plant pathogens. This would be a useful addition to risk assessment analysis to limit the risk of introducing currently undetected or unknown pathogens.

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5

Changing human practices and organisation

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5.1 Some epistemological issues in health and environmental integration

Élodie Giroux[a]

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Integration is currently in vogue in many fields of research dealing with phenomena that are often described as 'complex' in the sense that they are multifactorial and multidimensional and highly dependent on contextual variation. But what exactly is meant by integration or the multidisciplinarity that is generally associated with it? Conceptual analysis can be used here to examine the unity of objectives behind a term that sometimes serves as a unifying slogan. Multidisciplinarity is a complex undertaking that takes different forms depending on the nature and type of integration envisaged. Upon examination, the latter proves to be very heterogeneous, covering projects that can be both highly reductionist and holistic. Explaining this diversity can help to clarify the project and communication between actors in a given field. To illustrate my point, I will take the example of the exposome and its promises of integration, which can lead in very different directions. The challenge is therefore to put forward a few proposals in favour of caution and even epistemic humility, which are necessary in any integrative project.

[a]Elodie Giroux is associate professor of philosophy of sciences and medicine at Jean Moulin Lyon 3 University and a researcher at the Institut de Recherches Philosophiques de Lyon (IRPhil). Her work falls within the field of philosophy of medicine and public health, and is rooted in the philosophy of epidemiology. It focuses on the relations and tensions between individual and population levels in the construction of health knowledge and practices. Her main publications have focused on the epistemology and history of modern epidemiology, the definition of health and disease (notably Après Canguilhem, définir la santé et la maladie, P.U.F., 2010), precision medicine and psychiatry and, more recently, environmental health and the exposome. In addition to numerous articles (available on Academia or HAL) and editorships of special journal issues on these subjects, his latest book, co-edited with Y. Fayet and F. Merlin, analyzes the development of integrative approaches in the field of health-environment studies: Integrative Approaches in Environmental Health and Exposome Research: Epistemological and Practical Issues (Palgrave Macmillan Cham, 2023).

5.2 Defining the Scope of Biocontrol : Interests and Challenges

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Biocontrol refers to solutions employed in agriculture to protect crops against pests and diseases, while minimizing their impact on the environment and human health. The term "biocontrol," whose origin remains uncertain, was incorporated into the French Rural Code in October 2014. Article L.253-6 of said code defines biocontrol as the use of "agents and products that employ natural mechanisms within the framework of integrated pest management. These include, in particular: 1° Macro-organisms; 2° Plant protection products comprising: – Micro-organisms; – Chemical mediators such as pheromones and kairomones; – Natural substances of plant, animal, or mineral origin."

The use of biocontrol methods is promoted by both national and European authorities, notably within the framework of the "From Farm to Fork" strategy. However, this virtuous trend is hindered by various obstacles, particularly of a regulatory nature, and especially regarding the definition of the term "biocontrol."

The French legislature has opted to define biocontrol by reference to the products that may be used, whereas other countries also include certain agricultural practices within the scope of biocontrol. These purely national definitions may lead to the recognition of a product or process as biocontrol in one country, while it is rejected in another.

The difficulty in defining the scope of biocontrol at a supranational level is reflected in the multiplicity of terms employed by institutions and professionals alike, each stakeholder having their own vision and, consequently, a different understanding of the concept. Terms such as biosolutions, agroecology, plant protection, integrated protection, and natural substances are commonly used. However, these terms are not necessarily synonymous, and the divergent interpretations they give rise to slow down the approval and adoption processes for these new products and procedures. Our analysis will therefore focus on the following questions :

- What are the regulatory implications of these semantic distinctions in the governance of biocontrol practices ?
- Is a harmonized definition of biocontrol conceivable at the European level?

This study will draw upon relevant legal and scientific literature addressing biocontrol, with particular emphasis on a comparative analysis of national definitions within European Union member states, where such definitions exist.

5.3 Comparison of metaphor use in the science popularization of biocontrol in the USA and France

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Owing to several differences in the plant protection legislation of the United States of America and France, biological control is implemented differently in both countries. Multiple other factors also play a role in these variations, such as the overarching political systems (bipartisan vs. multipartisan) that influence the visibility and access to power of ecological political movements, the average size and total number of farms, etc. The cultivation of genetically modified organisms (GMOs) is also permitted in the USA while it is strictly prohibited in France, due to the European Union legal framework. Despite these differences, both countries make use of the four main categories of biological control: microbials, macrobials, natural substances and semiochemicals. The conceptual diversity of these methods tends to make understanding biocontrol harder for non-initiates.

Based on these observations, our study aims to analyze the way biological control is presented to the public in the main sources of science popularization available in both countries between 2016 and 2021. Our approach focuses on how conceptual metaphors are used to describe and explain biocontrol across five levels of popularization, based on their authorship and readership. Conceptual metaphors are seen as a didactical tool which allows the understanding of a target domain (biological control) in terms of a source domain (for instance war). Describing a beetle as a soldier protecting a field is a conceptual metaphor. The use of these metaphors will be studied in terms of their quantitative frequency, positioning (in titles, subtitles, etc.) and enunciative source.

This analysis shows where communication about biological control happens in science popularization, how it happens in terms of metaphor use, and what conceptual barriers remain in the development of biological control as tool for plant protection.

5.4 Challenging the boundaries of scientific work through the Development of a pesticide alternative: the case of the Sterile Insect Technique (SIT)

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Developing a biocontrol solution in the laboratory represents a form of commitment by researchers who work toward facilitating change and contributing to a different future. This involvement not only disrupts established scientific trajectories but also redefines the boundaries of the researcher's role, as well as the traditional borders drawn between the laboratory and society. Based on qualitative research conducted as part of a sociology PhD project, including semi-structured interviews with scientists, participant observations of research practices on the Sterile Insect Technique (SIT), and document analysis, this presentation draws on the analytical framework of Actor-Network Theory (ANT) to examine how the development of an alternative to pesticides reshapes relationships among human and non-human actors, scientists and non-academics. By focusing on the social dynamics surrounding SIT, the study highlights the shifting boundaries between science, society, politics, and industry, while also opening a discussion on how such biocontrol strategies may generate indirect or unforeseen "non-target effects," not only on ecosystems but also on scientific work and human practices.

5.5 Non target effects of biocontrol conservation and establishment strategies: considering social and organisational mechanisms that constrain their deployment

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The concept of unintended effects originated in the 1950s, as a reaction to the adverse effects observed after using plant protection products in agriculture. An existing framework, that of pharmaceutical products, inspired the framework developed at the time. This choice made sense because of the common nature of these two groups of products. The core principle is establishing indicators to measure the adverse effects not initially anticipated. These indicators ultimately aim to develop the standards to be applied, particularly in terms of health and safety. In both cases, this is an ex-post principle which, in pharmacy, is known as pharmacovigilance.

Over and above the ex-post nature of these procedures, we emphasise here that the logic of these evaluation frameworks is inherently associated with the concept of "products". Biocontrol strategies that do not rely on single levers, such as conservation or establishment strategies, are therefore excluded, even though these strategies are promising both for farmers and for designing systems within global limits.

This paper aims to show that there are many organisational and social unthinkables associated with the use of complex biological control strategies. We will discuss the obstacles associated with the organisation of a silo-based agriculture (at least) in France and an agri-food system based on the systematization of processes, and we will show through various examples of the implementation of principles of biological control by conservation and establishment that, for these approaches, rather than unintended effects thinking about the contexts of implementation, the support and transformation of public policies should be central lines of reflection.

5.6 No bans without alternative solutions': a legitimate expectation from farmers or a pitfall for anti-pesticides policies?

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For the past twenty years, public authorities have been trying to reduce the use of pesticides in French agriculture. Heated controversies have also led to the withdrawal of certain substances or restrictions on their use. Reducing pesticide use has therefore become a legitimate goal of public action. However, some agricultural and industrial stakeholders oppose these policies. One of the most common arguments used by opponents of measures to reduce pesticide use is: 'No ban without alternative solutions.' The slogan's rhetoric appears to be irrefutable: banning chemicals without providing farmers with viable and immediate alternatives would be unacceptable. This logic underlies the decisions to grant exemptions for banned products (such as neonicotinoids) and plans to phase out controversial substances (such as glyphosate). In this presentation, I will discuss the consequences of this logic spreading into anti-pesticides policies. Firstly, I will demonstrate that 'no ban without solutions' appears highly legitimate, even obvious, in agricultural policies that continue to prioritise maintaining production. On the other hand, I will demonstrate how the spread of this rhetoric strongly influences debates surrounding the identification and promotion of alternatives to pesticides by public authorities. I will demonstrate that, within the context of French policies, the prevalence of this logic has the effect of distancing or even disqualifying a systemic approach to plant protection.

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5.7 The promises and bottlenecks of biocontrolling of algal pathogens in rapidly changing marine coastal environments

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Collectively, algae account for nearly half of Earth's primary production; increasingly, their interactions with parasites are recognised as key drivers of pelagic, coastal and lacustrine food webs and biogeochemical cycles. Across the globe, algal (especially seaweed) aquaculture is a booming and relatively young industry: the global production has tripled between 2000 and 2020, when it reached 34.7 million tonnes. Fuelled by soaring demand for food, animal feed and other commodities, the growth of algal cultivation sits in the wider context of intensifying use and increasing dependency of mankind on the oceans, especially in developing countries. The raise of algal aquaculture represents to coastal environments a mutation similar to the appearance of agriculture on land, that only occurs at a vastly higher pace than the latter spread historically. This pressure is compounded by a faster rate of climate change in the sea compared to terrestrial systems, which includes more dramatic biogeographic and community shifts. Alarmingly, reports of diseased, declining wild macroalgal populations as well as significant losses in seaweed farms accumulate worldwide, with previously unreported algal pathogens being discovered at an increasing pace.

My group and others have started using metabarcoding and other omics technologies, combined with microbiology, to characterise the diversity, physiology and ecology of these pathogens and their impact on seaweeds. This emerging knowledge on the composition, structure and dynamics of algal microbiomes has been paving the way for their engineering towards improved disease resistance. In particular because the use of harmful chemicals in the open seas poses major containment issues, the concept of engineering algal microbiomes to biocontrol pathogens is rapidly gaining traction, for example through the Marie Curie Doctoral network PHABB (Pathogens of Algae for Biocontrol and Biosecurity). However, whilst biosecurity and biocontrol frameworks exist for animals and plants, scientific knowledge on this topic remains scant and the development of novel governance is also warranted, as algae mostly fall outside the scope of extant national and supranational regulations that govern plant and animal trade. To achieve this within the timescale imposed by the current pace of change, algal stakeholders would immensely benefit to build on the wealth of experience acquired through biocontrol initiatives run in other ecosystems and other biological models.

5.8 Towards reduced pesticide applications in agriculture; the role of farmer network support, retail and redesign of agro-systems

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Pesticide-use in the agricultural sector may contribute to environmental pollution and resistance of pests and diseases. To minimize the negative effects of pesticides, the focus of three described projects was to reduce the number of applications of chemical-synthetical pesticides. In these projects, we provided the agricultural entrepreneurs knowledge, tools and solutions to control pest and diseases, mostly resulting in reduced input of chemical-synthetical pesticides.

1) To control fungal diseases, Lily growers apply pesticides 17 times per growing season, on average. Decision support systems (DSS) for predicting the growth of Botrytis infestation, the most important fungal lily disease, could help to reduce 50% of the applications without loss of revenue (Kok, 2019). Farmers, however, were reluctant to trust the advice of the DSS. Support and improved advice of the DSS, which was on request of the growers, resulted in improvement of the farmers' trust in the DSS advice and consequently in a reduction of 10-47% of the treatments with pesticides (Mul and Veenenbos, 2023).

2) In the production of eggs, pesticides are mostly used to control Dermanyssus gallinae. This tiny bloodsucking mite negatively impacts egg production, animal welfare and farm income (Keeling en McAdie, 2001; Bijleveld, 2017; Mozafar, 2017). During a period of two years, thirty laying hen farmers were followed; twenty farmers retrieved insight in the pest and monitoring and control methods (e.g. Integrated Pest Management for D. gallinae), and ten farmers did not. During regular meetings farmers advised each other to improve control without relying on the chemical-synthetical products. Both groups applied more treatments and hygienic measures to control D. gallinae. We expect that being part of the research and carrying out the monitoring, created awareness about the problem also in the control group (Mul et al.,2020).

3) In both crop- and animal production, reduced number of applications of chemical-synthetical products and pesticides may result in loss of revenue. This hampers the reduction in use of such products. A Dutch retailer set up a sustainability certification scheme for arable-, horticulture-, dairy-, pig- and poultry producers. This certification scheme comprises a ban of certain unsustainable pesticides and antibiotics, measures which contribute to ecology based farming and measures to increase biodiversity. The extra costs for the measures and loss of revenues were discussed with both the producers and retailer and, when agreed upon, compensated by the retailer. This is an example of how retail can contribute to more sustainable agricultural production and reduction of chemical- synthetical pesticides use (https://betervoornatuurenboer.nl/index.html). Even though in most projects, the number of applications of chemical-synthetical pesticides was reduced, they did not prevent its use. For the total absence of pesticide use in agricultural production, an investment in ecology is needed (Hossain et al., 2017). With the application of the Technology for Ecology (T4E) design approach and mindset, solutions for agricultural sustainability challenges are sought in ecological mechanisms and practices. Technologies are designed to make the application of such mechanisms and practices, easier for farmers (Mul et al., 2025 in preparation). With the application of T4E design approach, the designed future agro-systems may direct the route to pesticide free agricultural production.

6 Ecotoxicology and human health

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6.1 Earthworms and copper, from exposure to effects

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The assessment of environmental risks associated with pesticide use requires moving beyond single-organism laboratory tests to understand their impacts on ecosystem functioning. A way forward is to extend classical ecotoxicological approaches to examine how a contaminant such as copper affects the functioning of agroecosystems, across multiple levels of biological organization.

Laboratory experiments can be used to characterize the effects of copper on non-target organisms from sub-individual to population levels. For example, studies on cellular damage or earthworm life cycles have shown that endpoints at the sub-individual level are more sensitive than those at higher levels of organization. At the individual level, reproduction and growth are the most sensitive endpoints. Hormetic growth has been observed at copper concentrations below 80 $mg.kg^{-1}$ dry soil, while sub-individual effects occur at lower concentrations. In addition, earthworms consistently avoid copper, irrespective of the concentrations tested, which can have implications on ecosystem functionning.

Long-term field studies provide complementary insights by assessing effects under realistic conditions. A two-year field experiment investigated the impact of commercial copper formulations, applied alone or in combination with another pesticide. Regular monitoring of earthworm populations enabled the analysis of not only total abundance but also community structure, i.e. the dynamics among species and functional groups (anecic, endogeic) and species. Copper concentrations in soil and organisms were also measured to establish exposure–effect relationships.

This combined approach connects mechanisms identified under controlled conditions at the individual scale with the complex dynamics of populations and communities over time. The results demonstrate that contaminant effects can be delayed and specific to functional groups. Understanding such community-level reorganizations is essential for evaluating how agricultural practices, including the use of biocontrol products, influence soil functionality and the resilience of agroecosystems.

[a]Ecologist and ecotoxicologist, Céline Pélosi is working on the effects of human activities on soil organisms and the functions they perform. She is particularly interested in the sensitivity of earthworm and enchytrid populations and communities to environmental factors (humidity, temperature, agricultural practices including tillage, pesticide use, organic matter inputs, etc.) and their functional complementarity (soil structure, water flow regulation, organic matter degradation) in systems that are more or less disturbed.

Her work addresses issues related to the ecological intensification of agrosystems, climate change, and the preservation of natural resources (soils, biodiversity, water). Soil organisms are used as indicators of the vulnerability and adaptive capacity of agricultural systems, but also as agroecological levers for more sustainable systems.

6.2 *Azadirachta indica* and *Ricinus communis* seed oils interrupt reproduction parameters in mice

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Despite botanical pesticides having a broad spectrum of activity, being easy to process and use/apply, having a short residual activity and for not accumulating in the environment or in fatty tissues of warm blooded animals because they are highly biodegradable. However, it is important to note that botanical pesticides, despite being derived from plants, may not necessarily be safe to humans, non-target organisms and the environment. In an effort to find out the effects of plant extracts on reproduction process in mammals, effects on reproduction parameters were evaluated in albino female mice. Mature fertile female mice received *A. indica* and *R. communis* seed oils at doses (0.0-0.8 ul/kg body weight) for 14 days. *Azadirachta indica* and *R. communis* seed oils caused disruption of the oestrous cycle by increasing the frequency of diestrus and metestrus phases. At higher doses *A. indica* and *R. communis* seed oils reduced mating success to 67% and 83% respectively with a similar significant reduction in fertility index by 17% compared to the negative control. At a dose of 0.4ul, *A. indica* and *R. communis* seed oils caused a significantly prolonged gestation period to 24.33±0.33 and 23.33±0.33 days with reduced litter size of 3.33±0.33 and 2.67±0.88 young ones respectively. Subsequently, at higher dose none of the mice littered compared to the negative control. At higher concentration of 0.6ul and 0.8ul, *A. indica* and *R.communis* showed anti-implantation activity of 100% compared to the negative control. Therefore *A. indica* and *R. communis* seed oils do affect reproductive process in rodents and may be used as potential rodenticides.

6.3 Climate change impact in the population of entomophagous epilachna beetle on vegetable crops and harmful effect of insecticides

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Various predators cause natural suppression of pests of different vegetable crops particularly brinjal, tomato, chilli, ladysfinger etc. Among the different predators, epilachna beetles play an important role in natural suppression of destructive pests viz, jassid, aphid, thrips, mites etc. *Coccinella* sp., an important epilachna beetle in West Bengal province, India was found active on different pests of brinjal throughout the year. The population varied from year to year depending on host and weather conditions. Its population was recorded higher during March-April and then declined. Highest population (4.87 Coccinella/plant) was recorded during March (11th standard week) when the mean temperature, mean relative humidity and weekly rainfall were 23.8°C, 74.2 % and 8.2 mm respectively. *Coccinella* incidence showed significant positive correlation (p= 0.05) with maximum temperature and significant negative correlation with relative humidity whereas with minimum and mean temperature and rainfall the correlation was negative but non-significant. The population of *Coccinella* was found throughout the growing period of ladysfinger feeding on destructive pests. In the kharif season, population was found higher (3.5/plant) during 3rd and 4th week of July in active vegetative growth of the crop. Destructive insect pests on vegetable crops can be controlled with synthetic insecticides but cause harmful effect to the bio-agents. The control of pests through synthetic pesticides is difficult as there is possibility to retain toxic residues in vegetables, which cause health hazard and environmental pollution. From field evaluation, it was revealed that bio-pesticides were less harmful to *Coccinella* than synthetic ones. The pathogens, *Bacillus thuringiensis* Berliner and *Beauveria bassiana* (Bals.) Vuillemin caused significant lower killing of the predator (less than 40 %) whereas the synthetic insecticides, DDVP and chloropyrephos, acephate etc caused significantly higher killing (more than 50 %). Biopesticides can be incorporated in IPM programms and organic farming.

6.4 Chronic dietary ingestion of *Bacillus thuringiensis* spores promotes intestinal inflammation and aging in non-target adult *Drosophila*

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Bacillus thuringiensis (Bt) is widely used (second most used insecticide in the world, including synthetic insecticides) in organic and conventional agriculture, forestry and mosquito control as an alternative to chemical pesticides. Bacteria of the genus *Bacillus* have a two-state life cycle: the vegetative cell capable of proliferation and the spore, a form resistant to adverse environmental conditions. The *Bt* species is characterized by the production, during the sporulation process, of a protein crystal composed mainly of Cry toxins, which confer its entomopathogenic properties. After dissolution of the toxin crystals in the gut of target pest larvae, the activated Cry proteins bind to receptors present on the surface of the intestinal epithelium (ALPs, APNs, Cadherins, ABCC transporters) and cause the formation of pores, leading to the death of the pest by septicemia.

Classification of members of the *Bacillus cereus* group, to which *Bt* belongs, is complex and regularly revised, in part because of their very highly conserved genomes. The founding member of the group, *Bacillus cereus* sensu stricto is a well-known food poisoning pathogen worldwide, causing diarrhea and/or emesis. It is the leading cause of foodborne outbreaks (FBOs) in France. As a result, the safety of *Bt* insecticides for the environment and for the health of non-target animals and humans has become highly controversial. Recent studies have shown that several strains of *Bt* from commercial products have been found in FBOs, suggesting that Bt insecticides may pose a real risk to food safety. In addition, there are no reliable data in the literature on the effects of chronic ingestion of *Bt* spores (Rousset and Gallet, 2025).

Our work aims to study the unintended effects of chronic dietary consumption of *Bt* spores. The team has recently demonstrated that once ingested by adult *Drosophila* (a non-target dipteran organism of *Bt* insecticides), *Bt* spores germinate in the posterior part of the gut and lead to increased production of enteroendocrine cells (Jneid et al., 2023, Hachfi et al., 2024). We now show that chronic ingestion of agricultural doses of spores in the diet reduces Drosophila lifespan. Our results demonstrate that *Bt* spore ingestion affects gut morphology, promotes dysplasia, alters septate junctions and enhances epithelial permeability. In addition, we observed increased levels of inflammatory signaling pathways and reactive oxygen species. Taken together, our results indicate that chronic consumption of *Bt* spores promotes inflammation and oxidative stress, leading to premature aging of the gut and early lethality in *Drosophila* (Joly, Soltys, Finkelstein et al., 2025). Extended to non-target insects, which account for 85% of animal biodiversity, our study suggests that highly persistent *Bt* spores may have unintended long-term effects on the environment.

6.5 Flea control products for dogs and their effect on water quality; Perspectives for sustainable actions by dog owners

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Active substances of a number of flea control products (veterinary medicines, biocides) are found in surface water and may pose a risk to the environment (European Medicines Agency, 2023; Kools et al., 2023). To reduce the risk, insight in emission routes of flea control products from dogs to surface water is necessary. The emission routes were collected by means of a literature search and discussions with water quality experts who were involved in the project "Knowledge Impulse Water Quality-Veterinary medicines". A number of emission routes were added after two workshops with professionals working with and for dogs. During the same workshops perspectives for sustainable action were explored to prevent these emissions (Mul et al., 2021; Kools et al., 2023).

Different types of flea control products are available; spot-on, sprays, collars, tablets and shampoos. Nine different emission routes for these products were determined. The routes end in surface water, soil, sewage or waste incinerator. Due to knowledge gaps it is not possible to indicate the most important emission route. The most important knowledge gap is the way and amount of excretion of the different products by the dog. An important way to prevent emission of flea control products is to reduce the use of the products and change the behavior of the dog owner. Better information for dog owners is necessary to create awareness of the risks of flea control products on water quality. Dog owners can (partially) prevent emission of flea control products by acting differently when allowing the dogs to swim after a treatment or when dogs are wearing an anti-flea-collar, when bathing and washing dogs, drying off dogs, cleaning dog beds and house, and when cleaning up feces.

Flea control products for pets are registered to control fleas on pets. At the same time those products are found in surface water with negative effects on water biology. Therefore emission of such products from the dog to surface water should be prevented. This research focused on the determination of those emission routes and the possible action perspective to prevent the emission via those routes.

7 Posters

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7.1 Biopesticides put to the test in the field: between practices and perceptions of market gardeners in Ouagadougou (Burkina Faso) faced with a controversial innovation

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In a context where concerns about the harmful effects of chemical pesticides on human health and ecosystems are growing, biopesticides are increasingly being presented as a more environmentally friendly alternative that is compatible with sustainable agriculture. By biopesticides, we mean crop protection products derived from natural substances (plant extracts, minerals) used to prevent or reduce pest and disease attacks without resorting to the synthetic products commonly used in conventional agriculture. In Burkina Faso, their promotion is part of agricultural policies aimed at agroecological transition and initiatives by various development actors, including certain NGOs. However, their use remains limited, especially in urban market gardening in Ouagadougou, where the pursuit of productivity, economic constraints and established socio-technical standards strongly influence practices.

This research employed a qualitative approach combining semi-structured interviews with 35 market gardeners spread across several production sites in the capital, field observations carried out directly on the plots to document actual practices, and focus groups to compare experiences and gather shared or divergent perceptions. This approach, which takes a socio-anthropological perspective, focuses on social representations, relationships with technical knowledge, and the cultural and economic dimensions that influence agricultural innovation.

The results indicate that the adoption of biopesticides is still very limited, as they are often perceived as ineffective, expensive or difficult to access. In addition, socio-cultural resistance persists, linked to an attachment to so-called "traditional" practices, a certain mistrust of the technical discourse of agroecology and the low institutional recognition of these products in extension programmes.

7.2 Mite bites and biological pest control using birds in urban areas

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Tits are among the biocontrol agents that are being promoted in urban areas through the installation of nestboxes. This practice aims notably to limit the proliferation of the pine processionary caterpillar, which poses a significant health and veterinary risk. As with many birds, tit nests can harbor blood-sucking mites. These mites are capable of traveling tens of meters in a few hours, and cases of human bites in homes with bird nests are regularly reported around the world. Given that knowledge about their vector role is very limited and that the distribution of zoonotic pathogens found in birds is changing as a result of global changes, studying the risk of human bites by these mites could help anticipate new epidemics. Human bites are generally associated with *Dermanyssus gallinae* L1, a cryptic species within the *gallinae* complex of genus *Dermanyssus*, associated with pigeons, and *Ornithonyssus bursa*, a largely generalist species found on various urban birds. Could increasing the presence of tits in urban areas contribute to the spread of these species and increase the risk of human bites? To obtain initial answers to this question, we compared the blood-feeding acarofauna of tit (Great and Blue Tits), pigeon and other birds' nests collected in and around Montpellier. To do so, nest material was collected shortly after the young had fledged (peak infestation) between spring 2024 and fall 2025. Then, dermanyssoid mites were isolated and identified using a morpho-molecular approach. The results of this pilot study show that the prevalence of species commonly found in human cases is very low in tit nestboxes in the Montpellier region. *Dermanyssus gallinae* L1 was found with a high prevalence in pigeon nests and only in these nests. While *Ornithonyssus bursa* was detected from all of the urban bird species under scrutiny, it was found in only one of the 156 tit nests studied. Apart from this anecdotal case, the blood-feeding mites isolated from tit nests in this study belonged either to *D. carpathicus*, a species typically found in tit nests, or to a previously unreported variant of the *gallinae* complex, whose status as a species or intraspecific variant remains to be established. Further experiments are needed to state whether their absence from reports in humans is due to the lack of opportunity due to isolation in the nestboxes, or because of host-mite incompatibility. However, the risk associated with installing tit nestboxes in cities is probably very low.

7.3 Combining pest management methods: A mathematical model to predict synergistic or antagonistic interactions

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To reduce reliance on synthetic pesticides in pest management, the simultaneous use of different alternative methods is essential. The interactions between these methods can be synergistic, strengthening pest suppression, or antagonistic, weakening it by mutually reducing their effectiveness. For holometabolous insect pests, the nature of these interactions may strongly depend on which developmental stage is affected by the different methods. To understand the emergence of non-target effects resulting from combining methods, a key question is: How do interactions between control methods depend on the developmental stages of the targeted pest?

To address this question, we developed a mathematical model that simulates the temporal dynamics of the pest. In this model, the life cycle of the pest is represented with four developmental stages (egg, larva, pupa, adult). A competition for resources is present during the larval stage. All juvenile pest stages can be attacked by a parasitoid, for which we distinguish two development stages (juvenile in the host and adult). Other pest management levers are likely to reduce fecundity (like pheromone disruption) or increase mortality of one of the stages (like a non-specialist predator).

Our model shows that interactions between the parasitoid and an additional method heavily depend on their relative position in the pest's life cycle. If mortality is increased at the parasitized stage or if an egg-parasitoid is combined with a decrease in the pest fecundity, the parasitoid may be excluded. However, increased mortality before or during competition, or reduced fecundity, may favour the persistence of parasitoids of larvae or pupae.

With this model, we identify the conditions under which interactions among fecundity control, mortality, and parasitoids lead to synergism or antagonism. The objective of this mechanistic framework, is guiding the design of effective combinations of pesticide alternatives, by highlighting general patterns.

7.4 Epistemic barriers and challenges towards an integrated approach to One Health. A study of the role of epistemic communities in the field of biocontrol research

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The objective of this communication is to analyze, based on the concept of "epistemic community" (Knorr-Cetina, 1999; Amin and Cohendet, 2004), the nature of epistemic barriers and possible areas of convergence existing between research communities engaged in the field of biocontrols strategies in the different fields of the 4 healths (plant, human, animal, environmental) surrounding the concept of One Health. Biocontrol is understood here as the set of means of managing bioaggressors (parasites and pathogens) of humans, livestock, cultivated plants and any other object linked to humans constituting alternatives to synthetic pesticides. It provides an interesting field of study on the concept of One Health, which remain a complex process (Lerner and Berg, 2017). Our key hypothesis made here is that the current structuring modes of these research communities (or epistemic communities), as "places" of production of knowledge and know-how and knowledge recombination (Knorr-Cetina, 1999; Amin and Cohendet, 2004) constrains the production of new knowledge and know-how necessary for the development of alternative biocontrol solutions, as well as for the evaluation of their effects (intentional and unintentional) in connection with approval procedures. To illustrate the nature of these issues and these epistemic barriers, the analysis will be based on several cases of alternative biocontrol strategies. Empirical data are based on a targeted review of the literature for each case study, complemented by a set of 20 semi-structured interviews conducted with researchers engaged in the study of biocontrol strategies in the different fields of plant, animal, human and environmental health. Our results highlight existing challenges with regards to the development of an integrated approach to the concept of One Health.

7.5 Side effects of botanical pesticides: A case study on essential oils

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Synthetic pesticides have been widely used to protect crops from insect pests. However, their overuse has raised significant concerns, including toxicity to humans and non-target organisms, chemical residues in food, environmental pollution, and the development of resistant pest populations. As a result, alternative solutions such as biopesticides are being explored to reduce reliance on synthetic chemicals. Among these, botanical pesticides, particularly essential oils (EOs), have gained attention due to their rich composition of bioactive aromatic compounds, which can exert toxic, repellent, and deterrent effects against pests and pathogens.

Essential oils are generally considered safe, as demonstrated by their use in food and cosmetic products, and are expected to degrade rapidly in the environment due to their chemical instability. Nevertheless, it is crucial to assess potential side effects before widespread adoption, considering past experiences with synthetic pesticide overuse.

Within the framework of Integrated Pest Management (IPM), evaluating the impact of botanical pesticides on beneficial organisms, especially natural enemies of pests, is essential. Although often perceived as safer alternatives, EOs can still adversely affect non-target species. This study evaluates the sublethal effects of anise and fennel essential oils on the aphid predator *Chrysoperla affinis*, focusing on survival and predation rates. It aims to assess the feasibility of integrating botanical pesticides into IPM programs to promote sustainable agriculture while preserving the effectiveness of natural pest control agents.

7.6 Efficacy and non-target effects of novel biocontrol insecticide candidates: a greenhouse study against *Myzus persicae*

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As demand grows for sustainable crop protection, biocontrol products are increasingly considered as viable alternatives to synthetic insecticides. However, beyond efficacy, their potential unintended impacts on non-target organisms must be considered in development stages. This study evaluated the efficacy and ecological compatibility of several new biocontrol insecticide candidates against *Myzus persicae* (green peach aphid) under greenhouse conditions, while monitoring effects on beneficial arthropods.

A controlled greenhouse trial was conducted using pepper plants (*Capsicum annuum*) uniformly infested with *M. persicae*. Several biocontrol candidates were tested alongside a conventional insecticide reference (Teppeki, 50% flonicamid WG). Treatments were applied weekly for three weeks, except Teppeki, applied only in weeks 1 and 3. Aphid populations were assessed through weekly non-destructive counts on marked leaves from one day before the first application (-1DAA) through 12 days after the final treatment (12DAC). Naturally occurring beneficial arthropods (e.g., ladybirds, spiders, parasitoids) were recorded throughout to evaluate potential non-target effects.

Clear differences in aphid control were observed among treatments. The chemical reference consistently achieved near-total suppression (e.g., 100% efficacy at 6DAC). Several biocontrol candidates showed promising, dose-dependent efficacy. One candidate, in particular, increased steadily in performance, from 56% early in the trial to 78% at 6DAC and up to 84% at 12DAC, demonstrating strong residual activity.

Regarding non-target impacts, the untreated control had the highest cumulative abundance of beneficials. The chemical reference, while highly effective, resulted in a noticeable decline in beneficial arthropods—likely due to prey scarcity rather than direct toxicity. According to existing side-effects databases, Teppeki is classified as non-toxic to slightly toxic to certain beneficials, such as *Aphidius colemani* and *Coccinella septempunctata* larvae. Notably, several biocontrol candidates, especially at lower doses, preserved significantly higher levels of beneficials, indicating a favorable ecological profile. Some candidates effectively balanced moderate to high aphid control with minimal non-target effects, making them strong candidates for integrated pest management (IPM) programs.

These findings highlight the importance of considering non-target effects early in biocontrol product development. Although ecological compatibility is a core aspect of such products, early assessments refine their ecological profile and guide decision regarding formulation, application, and integration strategies. This trial demonstrates the value of holistic greenhouse screening approaches to support the development of next-generation biocontrol tools that are both effective and environmentally friendly biocontrol solutions.

7.7 Toward Ecological Crop Pest Management: Behavioral Effects on Non-Target Pollinators

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Recent approaches to managing invasive pests, such as *Drosophila suzukii*, focus on alternative, pesticide-free methods such as behavioral disruption using volatile organic compounds (VOCs). In this context, we identified two VOCs, propanoic acid and butyric acid, that significantly affect both the invasive species and the model organism *Drosophila melanogaster*, which can be used as efficient crop protectants. These compounds act through controlled. When released into the environment in a controlled manner, these compounds are as effective as conventional insecticides and do not damage the fruit. Behavioral assays revealed that the acids strongly repel adult flies, disrupting courtship and completely inhibiting mating (patent PCT/EP2020/075386).

However, little is known about how these volatiles might affect non-target beneficial insects. Pollinators such as honey bees (*Apis mellifera*) play a vital role in maintaining biodiversity and ensuring global food security by pollinating plants. Their cognitive abilities, including learning and memory, are crucial for efficient foraging. However, environmental contaminants may interfere with these behaviors. This raises the question: to what extent could they alter the cognitive and behavioral functions of pollinators?

Here we show that honeybee learning capacity is slightly affected following exposure to these VOCs. Using olfactory conditioning based on the proboscis extension reflex, we observed that bees could discriminate between the two acids and a plant-emitted odorant, although exposure to VOCs led to a slight reduction in their learning performance. These findings suggest that the tested volatiles do not induce sublethal off-target effects on the cognitive function of this pollinator and can safely be used in crop cultivation.

These results underscore the importance of evaluating the broader ecological impact of pest control tools. As VOC-based strategies are integrated into sustainable agriculture, standard behavioral assessments on pollinators will be essential for ensuring crop protection and biodiversity conservation.

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Conference in French

Pratiques agroalimentaires et stockage de céréales et légumineuses à l'âge du Fer en Languedoc : apports croisés de l'archéologie, de l'archéobotanique et de l'étude des traces d'insectes sur les semences archéologiques

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L'archéobotanique est la discipline qui étudie les restes végétaux conservés sur les sites archéologiques. Cette présentation se structure en deux parties. Dans un premier temps, seront présentées les spécificités méthodologiques de l'étude de l'économie agricole des sociétés du passé par le biais de la carpologie, sous-discipline qui étudie les graines et les fruits préservés notamment par carbonisation et imbibition. Dans un second temps, nous introduirons l'utilisation de l'analyse des traces d'insectes ravageurs sur des semences archéologiques, de céréales et légumineuses, afin d'acquérir des connaissances sur les pratiques agroalimentaires et de stockage de denrées végétales durant l'âge du Fer en Languedoc (France).