INTERNATIONAL SYMPOSIUM
ECOLOGY OF APHIDOPHAGA 14
SEPTEMBER 16-20, 2019
MONTRÉAL, QUÉBEC, CANADA

PROGRAM BOOK
Share your experience with us!

@Aphidophaga14
aphidophaga14
WELCOME MESSAGE

Dear colleagues,

It is a great pleasure for us to receive all of you in Montreal for the 14th Symposium on “Ecology of Aphidophaga”. It is our turn to organize the symposium, twenty years after the Bromont venue for Aphidophaga 7 (1999). Welcome at UQAM. Welcome in Montreal, in Quebec, and Canada! Since it is only the second time the symposium is held outside Europe, we decided to invite nearctical and neotropical research scientists (Americans) for plenary conferences.

We would like to acknowledge the scientific committee of the group for selecting our institution/country for hosting the symposium, during the previous Aphidophaga in Germany. We would like also to acknowledge all the private sponsors that provide financial support (see later). We also received support from the Ministry of Agriculture of Quebec (MAPAQ) and from the entomological societies of Quebec and Canada.

We will have about 80 participants from all over the world. With 42 oral communication and 14 posters, attesting the vitality of the research on Aphidophagous natural enemies. Topics covered during the symposium include taxonomy, biology and behaviour of aphidophagous natural enemies, aphid control, non-target effects of agricultural practices on predators and parasitoids, ecological interactions and a session on invasive aphidophagous natural enemies.

The world is rapidly changing. Most aphidophagous guilds of the world are now facing new challenges generated by the global climatic change and by invasion by foreign aphidophagous species. Furthermore, in the ultimate years, several studies pointed toward a drastic reduction of insect biomass in several areas. These new conditions demonstrate that the Aphidophaga symposium is more pertinent than ever.

We wish you a nice and fruitful symposium “Ecology of Aphidophaga 14” and a nice time in Montreal.

In the name of the organizing committee,

Eric Lucas

Organizing committee:
Éric Lucas UQAM
Olivier Aubry UQAM
Daniel Cormier IRDA
Annie-Ève Gagnon AAFC
Geneviève Labrie CRAM
Julie-Éléonore Maisonhaute UQTR
DEDICATION

The symposium Ecology of Aphidophaga 14th is dedicated to Ivo Hodek, the person who has founded the Aphidophaga group.

We would like to thank Ivo Hodek, now 88, for its extensive contributions to the biology of Aphidophagous natural enemies during more than sixty years (from 1956). More specifically, Ivo published more than 100 papers on Ladybeetle nutritional biology and on insect dormancy. Furthermore, Ivo was the main architect of the recurrent “bible” on Ladybeetles: *Biology of Coccinellidae* (1973), *Ecology of Coccinellidae* (1996) and *Ecology and Behaviour of the Ladybird Beetles (Coccinellidae)* (2012). Ivo was also during several years, the editor of the *European Journal of Entomology*, and more punctually of other scientific journals.

Finally, Ivo Hodek constitutes a remarkable illustration of an exceptional scientific longevity. We wish him happiness, good health and long life.

The organizing committee

More information on Ivo’s achievements may be found in Hurka et al. (2001) and Honek and Dixon (2017).


THANKS TO OUR MEETING SPONSORS
MAPS

Cœur des Sciences - Chaufferie
Room « Chaufferie »
175, avenue du Président-Kennedy
Montréal (Québec) H2X 0A3
Botanical garden of Montreal
4101, rue Sherbrooke Est
Montréal (Québec) H1X 2B2

To get there: Metro (Green line) Tickets in your ID pocket
Place-des-arts station (direction Honoré-Beaugrand)—> Pie-IX

From Pie-IX station
Turn right onto Boulevard Pie-IX
Cross the rue Sherbrooke E
Metro network
Vieux-Port Steakhouse
39 Rue Saint Paul Est,
Montréal (Québec) H2Y 1G2

20 minutes’ walk
Go down onto rue St-Urbain
Turn left onto Avenue Viger
Turn right onto Boul. St-Laurent
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<td>8:30 am- Plenary 2</td>
<td>8:00 am – Departure EXCURSION (Laurentians, Oka) Visit of Oka Abbey</td>
<td>8:30 am - Plenary 4</td>
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<td>10:45 am - Opening remarks</td>
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<td>5:00 pm - Welcome Cocktail (Botanical Garden)</td>
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<td>5:30 pm - Back to Montréal</td>
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<td>6:30 pm - Cocktail reception</td>
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<td>6:30 pm - “Gardens of light” at Botanical Garden</td>
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<td>7:00 pm - BANQUET (Old Montréal)</td>
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EXCURSION (Lac des Sables)

Group Photo
SHORT PROGRAM

MONDAY 16

9:00 am - Registration (Coeur des Sciences, UQAM, room “Chaufferie”, see page 4)

10:45 am - Opening remarks

11:10 am - Plenary conference #1 – Challenges of IPM and biological control in urban environments
Barrette, Maryse

Session: Taxonomy of Aphidophages

11:40 am - Aphidiinae (Hymenoptera: Braconidae) parasitoids of the Middle East and North Africa: host range pattern, distribution and taxonomy
Rakhshani, Ehsan; Barahoei, Hossein; Ahmad, Zubair; Starý, Petr; Ghafouri-Moghaddam, Mostafa; Mehrparvar, Mohsen; Kavallieratos, G. Nickolas; Ćrkić, Jelisaveta and Tomanović, Željko

12:00 – Lunch break

Session: Non-target effects on Aphidophages

1:30 pm – Impact of vibration-based pest control on parasitoids
Parent, Jean-Philippe and Abram, Paul K

1:50 pm – Impact of agronomic Photoselective Net (PSN) on Coccinellid predation
Yáñez-Díaz, María Jose; Musleh, Selim; Silva, Gonzalo; Rodríguez, Marcela and Lucas, Éric

2:10 pm – Side effect of cucumber beetle massive trapping on aphidophagous predators
Fournier, Marc; Chapdelaine, Daniel; Cousseau, Camille and Lucas Éric

2:30 pm – Stability of the resistance to lambda-cyhalothrin in the neotropical ladybug Eriopis connexa (Coleoptera: Coccinellidae)
Rodrigues, Alice S and Torres, Jorge B

2:50 pm – Coffee break

3:20 pm – Differential effects of novaluron, a reduced risk insecticide, on the reproductive performance of male and female Multicoloured Asian ladybeetles Harmonia axyridis (Pallas) (Col., Coccinellidae)
Lemieux, Mathieu; De Donder, Alice; Cabrera, Paula; Cormier, Daniel; Kelly, Clint and Lucas, Eric
3:40 pm – When an insecticide affects the adaptive value of intraguild predation by an invader
Cabrera, Paula; Bessette, Marianne; Cruz, Vanessa; Cormier, Daniel and Lucas, Éric

5:00 pm – Welcome reception

IRBV-Botanical garden
4101 Sherbrooke Est, Montreal, QC H1X 2B2
30 minutes’ walk + metro (see map p.5-6)

TUESDAY 17

Session: Aphid control

8:30 am - Plenary conference #2 - Systems approach to aphid IPM in greenhouse horticulture: how research is translated into production practices
Buitenhuis, Rose; La Spina, Michelangelo; Jandricic, Sarah and Brownbridge, Michael

9:30 am - Parasitization of sugarcane aphid, Melanaphis sacchari, by commercially available parasitoids
Mercer, Nathan H.; Bessin, Ricardo T. and Obrycki, John J.

9:50 am – Coffee break

10:20 am - Aphid parasitism in winter crops of the US Southern Plains
Giles, Kristopher and Norman, Elliott

10:40 am - Enhancing the biological control of aphids on plum orchards, using intercropping
Lavandero, Blas; Montealgre, Xiomara; Alvarez- Baca, Jeniffer K.; Le Lann, Cécile; Van Baaren, Joan and Zepeda-Paulo, Francisca

11:00 am - Combining irrigation, fertilisation and pruning techniques to help control aphid populations in apple (Malus domestica) and peach (Prunus persica) orchards
Jordan, Marie- Odile, Drevet, Aurore; Vercambre, Gille and Hucbourg, Bruno

11:20 am – Seasonal population abundance of natural enemies attacking wheat aphids
Perven, Misba; Shaheen, Fouzia; Bushra; Nawaz, Mateen and Ali, Abid

11:40 am - Interaction of Aphis ruborum and its natural enemies on strawberry in southeastern USA
Riddick, Eric W.; Miller, Gary L.; Owen, Christopher L.; Bauchan, Gary R.; Schmidt, Jason M.; Gariepy, Tara; Brown, Richard L. and Grodowitz, Michael J.

12:00 – Lunch break
Session: Spatiotemporal context & Aphidophages

1:30 pm – Plenary conference #3 - Beyond borders: landscape effects on coccinellid abundance, composition and function
Grez, Audrey and Zaviezo, Tania

2:30 pm – Influence of spatial and temporal scales on the potential of biocontrol service of crop pests by their natural enemies through the analysis of activity-density and species richness
Van Baaren, Joan; Couthouis, Eloïse; Barascou, Lena, Pétillon, Julien, Le Roux, Vincent, Marrec, Ronan, Hecq, Florence and Hance, Thierry

2:50 pm – Predation pressure and habitat complexity alter indirect interactions between two aphid species.
Emery, Sara and Mills, Nicholas J.

3:10 pm – Coffee break

3:40 pm – Distribution data unveils niche segregation among aphidophagous Scymnus species in the Azores (Portugal)
Borges, Isabel and Soares, António O.

4:00 pm - Interactions between soybean aphids and their natural enemies
Costamagna, Alejandro C. and Almdal, Crystal

4:20 pm - Seasonal and diurnal patterns of predation in colonies of a native aphid
MacKay, Patricia A. and Lamb, Robert J.

5:00 to 6:30 pm – Poster session and cocktails

01 | Understanding the impact of phylloplane biocontrol agents on insects
Grenz, Kristina J.; Johnson, Louise J.; Mauchline, Alice L; Key, Georgina and Jackson, Rob W.

02 | Is Scymnus nubilus (Coleoptera: Coccinellidae) a good candidate as biological control agent of Aphis frangulae (Hemiptera: Aphididae)?
Borges, Isabel; Arruda, Patrícia; Meseguer, Roberto; Vieira, Virgilio; Pons, Gemma and Soares, António O.

03 | Factors of variation in frequency of colour morphs in invasive populations of Harmonia axyridis
Honek, Alois; Brown, Peter M.J.; Martinkova, Zdenka; Skuhrovec, Jiri; Brabec, Marek; Burgio, Giovanni; Evans, Edward W.; Fournier, Marc; Grez, Audrey A.; Kulfan Jan; Lami, Francesco; Lucas, Eric; Lumbierres, Belén; Masetti, Antonio; Mogilevich, Timofej; Orlova-Bienkowskaja, Marina; Phillips, William M.; Pons, Xavier; Strobach, Jan; Viglasova, Sandra; Zach, Peter and Zaviezo, Tania

04 | Location and plant variety influences endosymbiont communities in banana aphid from Abaca (Musa textilis Nee) in the Philippines, but does genotype?
Galambao, Marciana B.; Griffiths, Sarah M.; Preziosi, Richard F.; Zytynska, Sharon E. and Rowntree, Jennifer K.
05 | Low-risk insecticides to alternate with pyrethroids for conservation of the pyrethroid-resistant ladybug *Eriopis connexa* (Coleoptera: Coccinellidae)
Torres, Jorge B.; Nascimento, Deividy V.; Lira, R.; Barbosa, Paulo R.; and Barros, Eduardo M.

06 | Sub-lethal effects of the insecticide (GF-120 ©) used in organic farming on the oviposition behaviour of a biological control agent, *Aphidoletes aphidimyza* Rondani (Diptera: Cecidomyiidae)
Bernardo-Santos, Jonathan; Sentis, Arnaud; Vickery, William and Lucas, Eric

07 | Life cycle and survival rate of a new potential aphidophagous biocontrol agent *Eupeodes americanus* (Diptera: Syrphidae) and comparison with the commercial *Aphidoletes aphidimyza* (Diptera: Cecidomyiidae)
Ouattara, Téné Yacine; Fournier, Marc; Rojo, Santos and Lucas, Éric

08 | Impact of contrasted spatial and temporal crop richness on spillover of natural enemies and associated biocontrol services against aphids: a case study on *Harmonia axyridis*
Thomine, Eva; Rusch, Adrien; Supplisson, Camille, Monticelli, Lucie S, Amiens-Desneux, Edwige, Lavoir, Anne-Violette and Desneux, Nicolas

09 | Phylogenetic relationships of aphid parasitoids from the genus *Lipolexis* Förster (Hymenoptera, Braconidae, Aphidiinae) with recognition of six new species
Tomanović, Željko; Petrović, Andjeljko; Kocić, Korana; Čkrkić, Jelisaveta; Aparicio, Yahana; Arnó, Judit; Kavallieratos, G. Nickolas; Hebert, Paul D. N.; Rakshani, Ehsan and Starý, Petr

10 | Possible ways of wing vein reduction in Aphidiinae (Hymenoptera: Braconidae)
Žikić, Vladimir; Čkrkić, Jelisaveta; Petrović, Andjeljko; Stanković, Saša S; Milošević, Marijana Ilić; Klingenberg, Christian Peter, Tomanović, Željko and Ivanović, Ana

11 | Aphids out of control – How defensive symbiosis affects parasitoid biocontrol success
Donner, Helena; Pannebakker, Bart; Verhulst, Eveline; Zwaan, Bas; Dicke, Marcel

12 | Insect netting: effect of mesh size on exclusion of some natural enemies of aphids under laboratory and orchard conditions
Chouinard, Gérald; Pelletier, Francine; Larose, Mikael; Tavares, Jason; Knoch, Simon and Dumont, Marie-Josée

13 | Voracity, functional response and prey preference of *Nabis americaferus* feeding on tarnished plant bugs and aphids
Solà, Mireia; Dumont, François; Provost, Labrie, Geneviève, Caroline and Lucas, Éric

14 | Evaluation of the predatory behaviour of the hoverfly *Eupeodes americanus* (Diptera: Syrphidae)
Levi Garcia-Mourão, Alexandre; Meseguer, Roberto; Pons, Xavier and Lucas, Eric

**WEDNESDAY 18**

*7:45 am to 5:30 pm - Excursion*

**Meeting point:** *Coeur des Sciences*, 141, avenue du Président-Kennedy, H2X 1Y4
THURSDAY 19

8:30 am– Plenary conference #4 - Pesticide use and the origin of crop pests: theory and a test with pests of California crops
Rosenheim, Jay A.; Cass, Bodil N.; Kahl, Hanna; Steinmann, Kimberly P. and Pearse, Ian

Session: Biology of Aphidophages

9:30 am – A host-density-dependent decline in lifespan and estimation of the age of an aphid parasitoid in the field
Miksanek, James Rudolph and Heimpel, George E.

9:50 am - Coffee break

10:20 am - Egg-laying decisions by ladybeetles exposed to variable aphid densities
Tilmon, Kelley

10:40 am - Fecundity compensation in parasitized sugarcane aphids
Wright, Crys; Zhu-Salzman, Keyan and Medina, Raul F.

11:00 am - Responses of the aphid parasitoids Praon volucre and Aphidius ervi to low and fluctuating temperatures
Rowley, Charlotte; Klassen, Danielle; Pope, Tom. W.; Fountain, Michelle and Powell, Glen

11:20 am - Predation functional response of Aphidoletes aphidimyza (Rondani) to Rhopalosiphum padi (Linnaeus) at different temperatures
Fang, Mei-juan; He, Xiao-qing; Liu, Dong; Song Kai; Zhao, Ying and Wang, Yu-bo

11:40 am - The research and utilization of Chinese gall aphids in China
Yang, Zixiang; Chen, Xiaoming; Zhang, Yurong and Chen, Jingyuan

12:00 – Lunch break
Session: Invasive Aphidophages

1:30 pm – Plenary conference #5 - How outbreaks of invasive aphids can effect permanent change in arthropod communities
Michaud, J.P.

2:30 pm – Comparison of predator-prey interactions between native and non-native lady beetles: similarities in predation rates but differences in cue recognition between European and North American populations
Ünlü, Ayse Gül; Bertleff, Denise Diekmann, Jette; Brand, Sophia; Obrycki, John J. and Bucher, Roman

2:50 pm – Interactions between exotic and native lady beetle species stabilize community abundance
Lamb, Robert J.; Bannerman, Jordan A. and Costamagna, Alejandro C.

3:10 pm – Coffee break

3:40 pm – Role of native and exotic aphidophagous coccinellids in modulating the functional diversity of their communities in alfalfa fields
Grez, Audrey A. and Zaviezo, Tania

4:00 pm – Fluctuation of native ladybeetle body size following establishment of *Harmonia axyridis* (Coleoptera: Coccinellidae) in Catalonia (Spain).
Lafrenaye Audrey; Papineau, Jean-Philippe; Dumont, François; Pons, Xavier and Lucas Éric

4:20 pm – Ingestion efficiency under constant and variable thermal regimes: *Harmonia axyridis* feeding on *Acyrthosiphon pisum*.
Orellana, Maria and Bozinovic, Francisco

4:40 pm - The European ladybird App: a new tool for Citizen Science
Skuhrovec, Jiri; Roy, Helen E.; Kazlauskis, Karolis; Inghilesi, Alberto F.; Soares, Antonio O.; Adrians, Tim; Viglášová, Sandra; Honěk, Alois and Martinková, Zdenka

6:30 pm – Cocktail reception (Old Montréal)
7:00 pm – Banquet (Old Montréal)

Vieux-Port Steak House
39 Rue Saint Paul Est, Montréal, QC H2Y 1G2
20 minutes’ walk (see map p.7)
FRIDAY 20  
Session: Interactions

8:30 am – Plenary conference #6 - **Aphid biological control as a conservation science**
Heimpel, George E.

9:30 am - **Ladybirds’ larvae feed conspecific eggs than alien ones in prey-scarcity: Intraguild predation versus cannibalism**
Pervez, Ahmad

9:50 am **Coffee break**

10:20 am - **Community of aphidophagous in commercial crops of Capsicum spp. and reconstruction of its trophic network through molecular gut content analysis.**
Duque-Gamboa, Diana N.; Posso-Terranova, Andres and Toro-Perea, Nelson

10:40 am - **Coercive mating in ladybird, Propylea dissecta (Mulsant): male mating behaviour and reproductive output**
Singh, Priya; Mishra, Geetanjali and Omkar

11:00 am - **Intraguild predation between two lady beetle predators of pistachio psyllid: A test of its sensitivity to identity and density of extraguild prey**
Ranjbar, Fateme; Michaud, J.P.; Jalali, Amin and Ziaaddini, Mahdi

11:20 am - **Short and long term parasitoid-mediated indirect interactions between unsuitable and suitable hosts.**
Monticelli, Lucie S.; Desneux, Nicolas and Heimpel, George E.

11:40 am - **Parental diets affect selective intraguild predation of ladybirds’ eggs**
Pervez, Ahmad

12:00 End of the meeting

12:10 pm **Lunch break**
**PLENARY CONFERENCES**

**Plenary conference #1: Monday, Sep 16 11:10 am**

Dr. Maryse Barrette, *Montréal city*

Challenges of IPM and biological control in urban environments

Barrette, Maryse*

Ecological Transition and Resilience Office, City of Montreal, Montreal, Canada. *maryse.barrette@ville.montreal.qc.ca

IPM and biological control approaches have traditionally been developed and mainly applied in agriculture contexts. However, the same principles can be applied in urban settings to manage urban pests. This transposition poses challenges and requires some adaptations. Montréal city has a strict by-law that prohibits the use of pesticides outside buildings. The bylaw changed the framework for municipal employees that are responsible for maintenance of street trees, parks and green spaces. Urban pests that used to be controlled with chemical pesticides now have to be managed with more environmentally respectful alternatives. In Montréal, insects represent the 2/3 of the pests problems reported on trees. Some of these pests, such as the emerald ash borer (EAB) can be considered as real threats for tree survival, but other urban pests are mainly considered as esthetic problems. Aphids, for instance, fall in the latter category. In agriculture and ornamental, aphids are well known pests but they can also have a major environmental impact in urban areas. Linden aphid (*Eucallipterus tiliae*) (L.) (Hemiptera: Aphididae) is the second pest in importance for urban trees in Montréal (after EAB), and the second reason for pesticides use on public trees. The problem with linden aphids is largely due to the presence of honeydew. When aphids are in large numbers in linden trees (*Tilia* sp.) the honeydew produced drops down on everything below and around the tree (cars, sidewalks, balconies, etc.). Each year, aphid outbreaks lead to citizen complaints and require a lot of time, material and human resources for the city. In order to reduce or eliminate the use of pesticides for esthetic problems, the IPM team of the city of Montréal tested other methods, such as mechanical or biological control on linden aphids. The implementation of IPM and biological control approaches in urban environments represent some challenges but also opportunities.

Key words: IPM, biological control, *Eucallipterus tiliae*, urban

**Plenary conference #2: Tuesday, Sep 17 8:30 am**

Dr. Rose Buitenhuis, *Vineland Research and Innovation Centre*

Systems approach to aphid IPM in greenhouse horticulture: how research is translated into production practices

Rose Buitenhuis†*, Michelangelo La Spina†, Sarah Jandricic‡, Michael Brownbridge†

† Vineland Research and Innovation Centre, Vineland Station, ON, Canada; ‡ Ontario Ministry of Agriculture Food and Rural Affairs, Vineland Station, ON, Canada. *Rose.Buitenhuis@vinelandresearch.com
Research projects often start with a grower telling a researcher that their biocontrol program ‘did not work’. Ideally, the researcher will then ‘reverse engineer’ the IPM program and the crop production system, in order to find the part (or parts) that cause the problem. The challenge is that every IPM program is unique and has to be adapted to the crop, location, production practices and many other factors. Also, most of the time, individual research projects only look at a small part of a production system, making it hard to predict the performance of the proposed solution in the real world. Finally, it is often difficult to do scientifically sound on-farm validation trials, due to the lack of control treatments or variable natural pest infestations. This presentation will discuss different factors that influence IPM programs, including biocontrol agent quality, release methods, compatibility, host plant, production practices, lack of commercially available natural enemies and external interference. This will be illustrated by past and current projects on aphid control in greenhouse crops.

Keywords: greenhouse, ornamentals, vegetables, foxglove aphid, generalist predators

Plenary conference #3: Tuesday, Sep 17 1:30 pm

Dr. Audrey Grez, Universidad de Chile

Beyond borders: landscape effects on coccinellid abundance, composition and function

Grez, Audrey1* and Zaviezo, Tania2
1Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, Santiago, Chile; 2Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile, Santiago, Chile. *agrez@uchile.cl

Landscape composition and heterogeneity, at different spatial scales, may have a fundamental role in shaping the natural enemy assemblages within crops and other greenspaces, and their efficiency in biological control. The majority of natural enemies must colonize fields from other crops or natural and semi-natural habitats. Nevertheless, with the intensification of agriculture, several of these habitats are lost, and with that also a reduction of natural enemies may occur, especially natives that usually depend more on less disturbed habitats. Therefore, maintaining the heterogeneity of the agricultural landscape can have a double role: 1) increase conservation biological control by increasing the abundance and diversity of natural enemies, regardless of their origin, and 2) conserve native species of natural enemies in productive ecosystems. Coccinellids are very important biocontrol agents of aphids and other pests and there is strong evidence that they move across the landscape and respond to its composition and configuration. In Central Chile, one of the biodiversity hotspots, coccinellid are very diverse, including several native and a few, but dominant, exotic species. In this talk, we will discuss how the abundance, composition and function of native and exotic coccinellids are affected by landscape composition and configuration. First, we will show how the abundance and movement of coccinellids toward alfalfa crops depend on edge vegetation. Second, we will analyze how native and exotic species differentially use cover types depending on their disturbance. Third, we will evidence how landscape composition and heterogeneity affect the abundance and diversity of native and exotic coccinellids within alfalfa fields and their biological control service, and finally, we will show in a rural-urban gradient how coccinellid assemblages are filtered by landscape characteristics. Our results highlight the importance of maintaining landscape heterogeneity at different spatial scales in order to conserve the composition and functionality of natural enemies in agroecosystems.

Key words: functional biodiversity, ladybird beetles, landscape heterogeneity, landscape composition, natural enemies
Plenary conference #4: Thursday, Sep 19 8:30 am

Dr. Jay A. Rosenheim, University of California Davis

Pesticide use and the origin of crop pests: theory and a test with pests of California crops

Rosenheim, Jay A.¹*; Cass, Bodil N. ¹; Kahl, Hanna ¹; Steinmann, Kimberly P. ² and Pearse, Ian ³
¹Department of Entomology and Nematology, University of California Davis, Davis, CA 95616 USA. ²California Department of Pesticide Regulation, 1001 I Street, Sacramento, CA 95814, USA. ³Fort Collins Science Center, US Geological Survey.
*jarosenheim@ucdavis.edu

Much of the motivation to develop effective programs of biological pest control is derived from the desire to reduce the negative impacts of agricultural pesticides on human health and the environment. What are the major drivers of pesticide use? We address this question with a broad comparative analysis of pesticide use, including pesticides targeting arthropods, plant pathogens, and weeds, across the main crops grown in California. We find that there are both economic and ecological drivers. As predicted by agricultural economics theory that models farmers as profit maximizers, the main driver of pesticide use is crop value: crop value explains much of the variation in pesticides targeting arthropods and plant pathogens. Crop value does not, however, explain variation in herbicide use, where there are abundant and effective non-chemical control options. Ecological drivers are also important: crops whose marketed parts are belowground receive fewer pesticide applications targeting arthropods, and herbicide use is greater on perennial crop plants than on annuals. We also find that use of pesticides targeting arthropods and plant pathogens is lower for crop plants that are phylogenetically more isolated from native California plants. This suggests that host-switching events are important in the assembly of pest communities, and that switching is difficult when crop plants are only distantly related to native plants. We examine variation across crops in the source of crop pests (native versus introduced) and their diet breadth to paint a picture of crop pest community assembly that forms the context for biological control programs.

Plenary conference #5: Thursday, Sep 19 1:30 pm

Michaud, J.P. Kansas State University

How outbreaks of invasive aphids can effect permanent change in arthropod communities

Michaud, J.P.
Professor, Department of Entomology, Kansas State University, Agricultural Research Center – Hays. USA. *jpmi@ksu.edu

The invasion of a novel aphid species typically occurs in three phases. The initial epidemic phase, in which large populations cause widespread economic damage to host plants, is followed by an attenuation phase, in which aphid populations decline as natural enemies respond and become increasingly effective in exploiting the novel resource. Finally, the endemic phase is reached, in which the aphid remains present seasonally in low numbers, but populations rarely reach economic levels requiring control; geographic range may contract. However, the community of arthropods associated with the affected crop may be changed significantly as consequence of these events, with some changes transitory and others permanent. Just as herbivores may occasionally undergo shifts to new host plants, so predators and parasitoids may alter their associations with particular crop plants in response to encounters with novel, abundant prey species. It has long been known that arthropod predators and parasitoids can express intrinsic attraction to specific plant species, independent of the presence of prey, and
usually mediated by olfaction. However, we understand very little about the heritability of such plant preferences, or how quickly they can evolve de novo. In this presentation, I review some historical data, and observations from the recent invasion of sugarcane aphid, *Melanaphis sacchari*, that converge in support of the rapid evolution of novel crop plant affinities by aphid predators following their response to an aphid invasion. I will argue that large populations of aphids associated with the epidemic stage of the invasion generate large populations of natural enemies, and that these large numbers alone create novel evolutionary opportunities for both the aphid and its most effective natural enemies. This is because the rate of evolution is limited by effective population size, which governs not only the range of standing variation in the population, but also the rate at which novel mutations can occur. Nevertheless, the speed with which novel crop affinities can appear in natural enemy populations seems to implicate epigenetic modes of inheritance of novel plant responses rather than changes in gene frequencies.

Plenary conference #6: Friday, Sep 20 8:30 pm

Dr. George Heimpel, *University of Minnesota*

**Aphid biological control as a conservation science**

Heimpel, George E.\(^1\#\); Miksanek, James R.\(^1\); Wyckhuys, Kris A.G.\(^2\)
\(^1\)Department of Entomology, University of Minnesota, St. Paul MN, 55108; \(^2\)Visiting Professor - China Academy of Agricultural Sciences, Beijing, China. heimp001@umn.edu

Biological control of aphids and other insect pests, weeds and pathogens achieves numerous conservation goals through benefits that protect biodiversity. Protection of biodiversity has been achieved via importation biological control through the successful biological control of invasive weed and insect species that have spread into natural areas. I will review some of these accomplishments and provide an example involving biological control of cottony cushion scale (a close relative of aphids) in the Galapagos Islands. Biological control can also lead to the reduction of pesticide use and therefore provides numerous environmental benefits. Some of these benefits, such as reduced toxic effects on wildlife, are well known, and I will provide one example from my own work on the soybean aphid that illustrates how the use of spray thresholds can be instrumental in harnessing biological control to protect endangered butterfly species from insecticide exposure. Beyond this though, reduced pesticide use results in lowered greenhouse gas emissions associated with manufacturing and applying pesticides, and I will provide an example of an estimate of the role of biological control in reducing greenhouse gas against the soybean aphid in the United States. Lastly, biological control can have a positive impact on agricultural yields and thus reduce the amount of land that needs to be converted to agriculture from natural forests or prairies. I provide an example of estimates of this type of benefit from recent successful biological control of the cassava mealybug (another close relative of aphids) in South-East Asia.

Key words: conservation, soybean aphid, Cottony cushion scale, cassava mealybug
MONDAY

MON 11:40 am | Aphidiinae (Hymenoptera: Braconidae) parasitoids of the Middle East and North Africa: host range pattern, distribution and taxonomy

Rakhshani, Ehsan; Barahoei, Hossein; Ahmad, Zubair; Starý, Petr; Ghafouri-Moghaddam, Mostafa; Mehrparvar, Mohsen; Kavallieratos, G. Nickolas; Čkrkić, Jelisaveta and Tomanović, Željko

The area of North African countries is biogeographically divided into the Mediterranean climate region in the north, and the arid Sahara in the south, albeit both of them can be subdivided into various ecozones. Although numerous faunistic and biosystematical researches on Aphidiinae have been conducted in this complex region, many parts are still unexplored. We have investigated the Aphidiinae parasitoids of the Middle East and North Africa, aiming to compare their diversity in various countries and establish a background for future research, especially within the unexplored areas. New material, originating from Saudi Arabia, has been studied and new findings are presented. A total of 108 Aphidiinae species, belonging to 18 genera, associated with 240 aphid species in 16 countries of the Middle East and North Africa are reviewed. The remarkable number of 743 host aphid-parasitoid associations have been identified. New material has been collected from various regions of Saudi Arabia. Several species from the genera Aphidius and Praon are first time recorded for the fauna of these countries. We introduce a meticulous key for the accurate identification of all known species in the area. On the basis of biogeographical complexity, Aphidiinae of the Middle East and North Africa include endemic, invasive, cosmopolitan and rare species. The presence of some important invasive aphid species and their aphidiine parasitoids as important biocontrol agents in the target area has also been investigated. Further field efforts are necessary to be conducted in the unexplored regions of the North Africa, and Western Asia, which have diverse climatic conditions, so as to shed light on the very complex plant-aphid-aphidiine tritrophic associations and reveal new species.

Key words: aphids, parasitoids, fauna, diversity, associations, Western Asia, North Africa
MON 1:30 pm | Impact of vibration-based pest control on parasitoids

Parent, Jean-Philippe*1 and Abram, Paul K.2
1Agriculture et Agroalimentaire Canada, St-Jean-sur-Richelieu, Canada; 2Agriculture and Agri-Food Canada, Agassiz, Canada.
*jean-philippe.parent2@canada.ca

Physical control methods to kill or disrupt insect pests have recently seen a resurgence as an alternative to chemical control. Some aphid species have been the target of recent work showing a negative impact caused by vibration-based pest control methods developed as a general disruptor of physiology and behaviour. Although still early in development, little knowledge is available on the potential impact of these methods on aphid natural enemies. Here, we began to investigate the potential for combining physical and biological control by measuring the impact of non-specific vibrations (substrate-borne white noise) on the aphid parasitoid *Aphidius ervi* and the pea aphid *Acyrthosiphon pisum*. We predicted that exposure of aphids to vibrations prior to parasitoid exposure, by inducing costly generalized stress responses, could increase their subsequent susceptibility to parasitism, but that continuous exposure to vibrations while parasitoids were present would reduce their efficiency (decreasing parasitism levels). Different combinations of vibration incidence and timing (no vibration, vibration for the first 24h, no vibration) and parasitoid exposure (parasitoids introduced after 24h, no parasitoids) were applied to whole plants colonized by 20 aphids. We then measured: (i) aphid survival; (ii) aphid reproduction (number of nymphs produced), (iii) aphid location on the plant and (iv) parasitism rate. Using our experiments as a case study, the impact of substrate-borne vibrations as a disruptive physical control method on higher trophic levels and its compatibility with biological control will be discussed, as well as the challenges associated with applying these methods in agricultural settings.

Key words: parasitism, physical control, *Aphidius ervi*, *Acyrthosiphon pisum*, disturbance

MON 1:50 pm | Impact of agronomic Photoselective Net (PSN) on Coccinellid predation

Yáñez-Díaz, María Jose1*; Musleh, Selim1, 2; Silva, Gonzalo3; Rodríguez, Marcela1 and Lucas, Eric 4
1Laboratorio de Entomología Aplicada, Departamento de Zoología, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción,Casilla 160-C, Correo 3 (Concepción, Chile); 2 Núcleo Milenio INVASAL, Concepción, Chile; 3Laboratorio de Entomología, Universidad de Concepción, Faculty of Agronomy, Departamento de Producción Vegetal, Chillán, Chile; 4 Laboratoire de Lutte Biologique, Département des Sciences Biologiques, Université du Québec à Montréal (UQAM), CP 8888, succursale Centre-Ville Montréal (Québec, CANADA) H3C 3P8. *mariajoseyd@gmail.com

The photoselective nets (PSN) increase agricultural crops production, by modifying light quantity and quality reaching the focal plant. Furthermore, PSN also affect arthropod pest populations and potentially their natural enemies. The aim of the present study is to evaluate the impact of PSN systems on Coccinellid aphidophagous predation. Test were carried out in laboratory studying predation efficacy of *Harmonia axyridis*, on *Myzus persicae* in potato plants *Solanum tuberosum*. Four treatments were compared (No PSN, White PSN, Red PSN and Black PSN) and tested on three different ladybeetle stages/sexes (Larvae 3, Females and males). We formulated the hypothesis 1) that PSN would delay the time before aphid colony localization by the predator, and 2) that PSN would reduce aphid predation. Results shows that 1) aphids (in absence of predators) stayed on the plant, without changing their behaviour, 2) aphid colony localization was significantly shorter for predators under white PSN, than for the other treatments, 3) aphid predation was not affected by any type of PSN. Potential consequences of such results are discussed.

Key words: Coccinellidae, photoselective net, light intensity, light quality, predation
MON 2:10 pm | Side effect of cucumber beetle massive trapping on aphidophagous predators.

Fournier, Marc*; Chapdelaine, Daniel; Cousseau, Camille and Lucas, Eric

1Laboratoire de Lutte Biologique, Département des Sciences Biologiques, Université du Québec à Montréal (UQAM), CP 8888, succursale Centre-Ville Montréal (Québec, CANADA) H3C 3P8; 2Département de Chimie, Université du Québec à Montréal (UQAM), CP 8888, succursale Centre-Ville Montréal (Québec, CANADA) H3C 3P8. *fournier.marc@uqam.ca

As a part of a massive trapping project for the cucumber beetle (Acalymma vittatum, Coleoptera: Chrysomelidae), we used yellow traps of 4 liters with an attractant in cucumber, zucchini and squash crops. Several attractive products are available on the market to trap the cucumber beetle, such as TRE 8276 from Trécé. This attractant is composed of 1,2,4-trimethoxybenzene, indole and (E)-cinnamaldehyde (TIC). We observed in the field that the presence of the attractant significantly increased the capture of aphidophagous species. Throughout the season, 5575 ladybugs were caught and more than 400 aphidophagous hoverflies. Attractive traps attracted 4.4 times, 2.1 times and 1.5 times more hoverfly than control traps, respectively for cucumber, zucchini and squash. On the other hand, the presence of attractant did not recruit more ladybugs than the control traps in the cultures studied. This is the first demonstration that TIC can attract hoverflies. The possible effects of these results on aphid biological control will be discussed.

Key words: Coccinellidae, Syrphidae, side effect, massive trapping, attractant

MON 2:30 pm | Stability of the resistance to lambda-cyhalothrin in the neotropical ladybug Eriopis connexa (Coleoptera: Coccinellidae)

Rodrigues, Alice S and Torres, Jorge B.*

1Departamento de Agronomia- Entomologia, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos, 52171-900, Recife - PE, Brazil. *jorge.torres@ufrpe.br

Natural enemies resistant to insecticides are expected to help control remaining insects after insecticide application and, hence, prevent crop damage and resistance selection. Field-evolved resistance to lambda-cyhalothrin and other pyrethroids exhibited by the neotropical ladybug Eriopis connexa (Germar) (Coleoptera: Coccinellidae) has been characterized and enhanced under laboratory selection. In this study, we investigated the stability of the resistance and its relationship with enzyme production for detoxification and biological performance. One subgroup of the resistant population of E. connexa was established without selection pressure (R-UNSEL) during eight subsequent generations and compared to either a susceptible (SUS) or a resistant (R-SEL) reference population. The resistance ratio in R-UNSEL was reduced by 50% compared to R-SEL between the first and fourth generation without selection pressure but stayed stable from the fifth to eighth generation. Despite eight generations without selection pressure and reduction in the resistance level, the resistance ratio in R-UNSEL was still ~39× greater than the SUS population. The reduced resistance in R-UNSEL correlated to reduction in detoxifying esterases, but the R-UNSEL maintained higher activity than in susceptible group. The absence of selection pressure and reduction in enzyme production in R-UNSEL did not result in reduction of the adaptive costs with ~2.7 times lower egg production compared to SUS females. The resistance to lambda-cyhalothrin in R-UNSEL has already been stabilized without selection pressure. Although the resistance ratio and detoxifying enzymes were reduced in R-UNSEL subgroup, the impact on fecundity was maintained. Furthermore, these findings suggest that in the absence of crossing with wild SUS individuals, the R-UNSEL offspring will maintain stable resistance level to survive lambda-cyhalothrin application even at the highest recommended field rate.

Key words: pyrethroid, resistance stability, natural enemy, adaptive cost
**MON 3:20 pm | Differential effects of novaluron, a reduced risk insecticide, on the reproductive performance of male and female Multicoloured Asian ladybeetles *Harmonia axyridis* (Pallas) (Col., Coccinellidae)**

Lemieux, Mathieu¹; De Donder, Alice¹*; Cabrera, Paula¹; Cormier, Daniel²; Kelly, Clint³ and Lucas, Eric¹

¹Laboratoire de lutte biologique, Département des sciences biologiques, Université du Québec à Montréal (UQAM), CP 8888, succursale Centre-Ville Montréal (Québec, CANADA) H3C; ²Institut de recherche et de développement en agroenvironnement, 335, rang des Vingt-Cinq Est, Saint-Bruno-de-Montarville (Québec, CANADA) J3V 0G7; ³Département des Sciences Biologiques, Université du Québec à Montréal (UQAM), CP 8888, succursale Centre-Ville Montréal (Québec, CANADA) H3C; *de_donder.alice@courrier.uqam.ca

Novaluron is a reduced risk insecticide used in apple orchards against the codling moth, *Cydia pomonella* (L.) (Lep., Tortricidae). Several studies have demonstrated that novaluron has sublethal effects on non-target species found in apple orchards, including the Multicoloured Asian ladybeetles *Harmonia axyridis* (Pallas) (Col., Coccinellidae). A laboratory study showed that the consumption of novaluron-treated aphids reduced the reproductive performance of adult *H. axyridis*. The aim of the present study was to compare the effect of novaluron on fecundity and fertility when either adult male or adult female ladybeetles were exposed to contaminated preys. Males and females were given novaluron-treated preys, and paired 24h later with non-exposed reproductive mates. Fecundity was recorded for 5 days, then egg hatching and fertility were recorded over a 96h period. Fecundity did not differ between the sexes, but exposed ladybeetles produced fewer eggs than unexposed ones. Exposed females had a lower number of egg hatching and fertility compared to reproductive mates with exposed males and with the control. These results illustrate a differential effect of novaluron between exposed males and exposed females ladybeetle, where reproductive performance was more hindered when females consumed contaminated preys.

Key words: *Harmonia axyridis*, Novaluron, reduced risk insecticide, reproduction

**MON 3:40 pm | When an insecticide affects the adaptive value of intraguild predation by an invader**

Cabrera, Paula¹*; Bessette, Marianne¹; Cruz, Vanessa¹; Cormier, Daniel² and Lucas, Eric¹

¹Laboratoire de lutte biologique. Département de sciences biologiques. Université du Québec à Montréal. CP 8888, succ. Centre-Ville, Montreal, Canada; ²Institut de recherche et de développement en agroenvironnement. 335, rang des Vingt-Cinq Est. St-Bruno de Montarville, Canada. *pcabrera blanco@outlook.com

The Multicolored Asian ladybeetle, *Harmonia axyridis* Pallas (Col, Coccinellidae), recognized as one of the most invasive insects in the world, has reduced native coccinellids populations in several areas and it is considered a threat for biodiversity at large. A significant trait, favoring its invasiveness and its dominance over indigenous ladybeetles, is intraguild predation (IGP). IGP has advantageous adaptive value for individuals, removing competitors, potential predators, and providing an alternative nutritive resource when main resources are scarce. Previous research has shown that this invasive ladybeetle is highly susceptible to the reduced-risk insecticide novaluron, a chitin synthesis inhibitor. Unlike its invasive competitor, the North American indigenous *Coleomegilla maculata* DeGeer (Col, Coccinellidae) is not susceptible to this insecticide. Our study explores the adaptive value of IGP for each of the two coccinellids after preying on each other’s larvae previously treated with novaluron. The results show that an insecticide can completely remove the adaptive value of IGP for the invasive predator. In contrast, the adaptive value for the indigenous ladybeetle is not altered by the insecticide. Moreover, the study demonstrates that if the intraguild prey (non-susceptible to novaluron) undergoes molt after being topically exposed to the insecticide, the adaptive value for the intraguild predator is restored over time.

Key words: intraguild predation, *H. axyridis*, *C. maculata*, adaptive value, novaluron, reduced risk insecticide
TUESDAY

TUES 9:30 am | Parasitization of sugarcane aphid, *Melanaphis sacchari*, by commercially available parasitoids

Mercer, Nathan H*1; Bessin, Ricardo T1 and Obrycki, John J1
1Department of Entomology University of Kentucky, Lexington US. *n.mercer@uky.edu

Kentucky grows over 2000 acres of sweet sorghum with an annual value over $20 million. Until recently there were no economic insect pests. Infestations of the sugarcane aphid (SCA), *Melanaphis sacchari*, were first discovered in Kentucky in 2015. Infestations can cause up to 100% yield loss when left unmanaged. Currently, planting early, early harvest and the insecticide Sivanto Prime are the only available management tactics against SCA on sweet sorghum. Biological control options have yet to be fully explored. The aim of this study was to determine the host acceptance and suitability of SCA for several commercially available parasitoids: *Aphelinus abdominalis* (Hymenoptera: Aphelinidae), *Aphidius ervi* (Hymenoptera: Braconidae), *Aphidius colemani*, and *Aphidius matricariae*. Host acceptance was assessed by exposing 30 SCA on sweet sorghum leaves to a single female parasitoid for 24 hours and counting the number of oviposition attempts and oviposition strikes at three different time points. Host suitability was tested by transferring the SCA infested leaves used for host acceptance (without parasitoids) to caged eight-week-old sweet sorghum plants. Cages were monitored every other day for SCA abundance, aphid mummies and eclosed adult parasitoids. Enclosed female (F1) parasitoids were collected and allowed to mate with male F1 parasitoids for 48 hours before the experiment was repeated with F1 females. *Aph. abdominalis* was the only parasitoid species which did not attempt to oviposit during the host acceptance experiment and did not produce adult parasitoids. The most aphid mummies and adult parasitoids were produced by P generation *Aphi. colemani*, and this species had the largest negative impact on SCA population growth. *Aphi. ervi* and *Aphi. matricariae* successfully produced adults but in lower numbers than *Aphi. colemani* and did not have as great an impact on SCA populations. F1 *Aphi. colemani* and *Aphi. ervi* produced similar number of adults from SCA, both producing more than *Aphi. matricariae*. *Aphi. colemani* demonstrated strong potential as a biocontrol agent of SCA with the ability to use SCA as a host and prevent aphid population growth. Further testing is needed to determine the ability of *Aphi. colemani* to manage SCA in field conditions.

Key words: host acceptance, host suitability

TUES 10:20 am | Aphid parasitism in winter crops of the US Southern Plains

Giles, Kristopher1* and Norman, Elliott2
1Department of Entomology and Plant Pathology, Oklahoma State University. Stillwater, Oklahoma. United States; 2USDA-ARS, WPOFCRU. Stillwater, Oklahoma. United States. * kris.giles@okstate.edu

A unique set of winter climatic conditions in the US Southern Plains allow for the production of locally-adapted winter crops and the survival of aphid pests and their parasitoids. Native parasitoids appear to be well adapted to finding and attacking aphids during cooler autumn, winter and spring months and reliable pest suppression is incorporated into IPM programs for the region. Multiple studies have been conducted to describe the biology of aphid parasitoids in winter crops and in particular recent work has defined how spatial and temporal vegetation diversity influences parasitoid competition and aphid suppression. We report on the results of recent and ongoing research which examined how crop diversity influences aphid parasitism during autumn and spring. Intensive sampling and sentinel aphids were utilized in crop landscapes to measure pest suppression. Results indicate that summer crops and winter wheat are important source habitats of aphid parasitoids, and that both spatial and
temporal diversity increases aphid suppression in winter wheat. However, in winter canola, a relatively new crop in the region, low parasitism is common and may be the result of intensive competition.

Key words: parasitism, winter wheat, canola, *Lysiphlebus testaceipes*, *Diaeretiella rapae*, landscape diversity, integrated pest management

**TUES 10:40 am | Enhancing the biological control of aphids on plum orchards, using intercropping**

Lavandero, Blas*; Montealgre, Xiomara1; Alvarez- Baca, Jeniffer K.1,2; Le Lann, Cécile 2; Van Baaren, Joan2 and Zepeda-Paulo, Francisca 1
1 Laboratorio de Control Biológico, Instituto de Ciencias Biológicas, Universidad de Talca, Chile; 2UMR-CNRS 6553 Ecobio, Université de Rennes 1 (UniR), 263 Avenue du Général Leclerc, 35042, Rennes, France. *blavandero@utalca.cl

The use of intercropping to decrease herbivorous populations, through the increase and consequent effect on natural enemies’ populations, can be considered as a remedy for agricultural intensification. Non-crop or alternative-crop resources could affect natural enemy diversity and activity by providing refuge, in which they may seek shelter from deleterious environmental factors, different food resources and habitat for alternative prey or hosts. Parasitoids are frequently used in biological control given that they are considered as specialist and efficient agents of control. The presence of alternative hosts in habitats adjacent to crops may provide a source of parasitoids at the beginning of the growing season, thereby maximizing biological control. The aphid species *Brachycaudus helichrysi*, *Aphis spiraecola* and *Myzus persicae* on plum orchards and *Rhopalosiphum padi* in cereals share natural enemies, such as the parasitoid *Aphidius platensis*. During winter months in Chile, *R. padi* is parasitized by *A. platensis* on the first stages of winter cereals. However, their ability to reduce aphid populations in plum trees in spring has never been studied. We studied the effect of alternative hosts surrounding plum orchards on the control of plum aphids by *A. colemani*. We hypothesized that alternative hosts on a intercrop of oats represent a source and refuge for natural enemy populations to ensure the early arrival of *A. paltensis* to plum orchards for the control of aphids in spring. To test this hypothesis, we compared the composition and abundance of parasitoids and aphids between plum orchards with an interrow of *Avena sativa* and a control without the interrow crop. The most abundant aphid species during the winter on the cover crops was *R. padi* and the parasitoid *A. platensis*, the most abundant parasitoid. On the other hand, during spring, the abundance of aphids on plums was higher on the controls compared to treatments. However, the difference in aphid populations at this stage cannot be explained by the general parasitism rates (overall parasitism rates of all species) alone, as there were no differences among treatments. Species composition of parasitoids and the effects of predators present are discussed in terms of the results.

Key words: conservation biological control, *Aphidius*, *Brachycaudus helichrysi*, *Rhopalosiphum padi*, *Prunus sativa*, *Avena sativa*
TUES 11:00 am | Combining irrigation, fertilisation and pruning techniques to help control aphid populations in apple (Malus domestica) and peach (Prunus persica) orchards

Jordan, Marie-Odile1*; Drevet, Aurore2; Vercambre, Gille1 and Hucbour, Bruno2
1UR 1115 Plantes et Systèmes de culture Horticoles (PSH), Domaine Saint-Paul, INRA, 228 route de l’aérodrome, CS 40509, F-84914 Avignon Cedex 9, France; 2GR-Ceta de Basse Durance, 2 route de Mollèges 13210 Saint Rémy de Provence, France. *Marie-Odile.Jordan@inra.fr

The increase of environmental concerns and the apparition of aphid strains resistant to pesticides require the development of alternative control methods. Among them, biological control methods are well documented while our knowledge on how the hots plant condition affect the infestation dynamics (i.e. on the bottom up processes) is rather poor. Tree susceptibility to phloem feeders is determined by the functional balance between nutrient (including water) acquisition and use, i.e. allocation to growth and development, storage or defence. This functional balance could be manipulated by usual cultural practices such as pruning, irrigation or fertilisation. Nonetheless, their application to perennials like trees having contrasting life backgrounds, and differing therefore by their overall condition (size, shape and composition), could produce opposite results. The plant key variables for susceptibility are thus to be defined prior to their optimization, adapting a combination of cultural practices to each situation. In this perspective, several experiments focused on peach green aphid (Myzus persicae) and rosy apple aphid (Dysaphis plantaginea) were performed, first in controlled conditions on young peach and apple trees whose functional balance had been modulated before artificial infestation, and then in commercial orchards submitted to various fertilisation and irrigation regimes for two years. Our results were summarized in a conceptual framework describing how the balance between tree development (analysed from an architectural viewpoint) and nutrient status affected its susceptibility to aphids, and could be manipulated by various practices. Aphid abundances appeared to be positively related to shoot development (leaf expansion, secondary ramification), to shoot growth (stem length and diameter), and to apex concentrations in amino acids and non-structural carbohydrates. Polyphenols had an opposite effect. These relationships were modified by tree water status, and were species and cultivar dependant. Moreover, aphid infestations affected slightly the shoot N content and the fruit sugar content. Photosynthesis tended also to decrease on infested shoots which could not be compensated for by the healthy shoots. In conclusion, well fertilized trees submitted to moderate deficit irrigation were the most susceptible to aphids. These treatments had only a little effect on shoot development but limited photosynthesis and carbohydrate accumulation.

TUES 11:20 am | Seasonal population abundance of natural enemies attacking wheat aphids

Perven, Misbah1,2,3; Shaheen, Fouzia1,2; Bushra1,2; Nawaz, Mateen1,2 and Ali, Abid1*
1Department of Entomology, University of Agriculture, Faisalabad 38040, Pakistan; 2 Department of Zoology, Wildlife and Fisheries, University of Agriculture, Faisalabad 38040, Pakistan; 3Department of Zoology, Government Postgraduate College (W), Jaranwala 37250, Faisalabad, Pakistan. *abid_ento74@yahoo.com

Application of insecticides is not recommended for the control of insect pests (e.g., wheat aphids) in wheat field because after harvesting, consumed as staple food in Pakistan. There is need to avoid the yield losses caused by aphids for which prediction and monitoring of natural enemies attacking wheat aphids is vital for the integrated pest management (IPM) strategy. Therefore, study was conducted during two wheat growing seasons (2017-2018 and 2018-2019) to determine the seasonal population abundance of natural enemies and wheat aphids by open wheat field survey at heading stage (early), flowering stage (middle) and milk maturity stage (late) at the Entomological Research Area, University of Agriculture, Faisalabad, Pakistan. Field survey was conducted using five fixed tillers sampling method to record the abundance of wheat aphids, coccinellids, syrphids, Araneae and...
aphid parasitoids. As a result of weekly visual observation of fixed tiller as a whole during 2017-2018 season, among potential natural enemies, coccinellids (0.00, 27.77 and 12.22), syrphids (0.00, 70.0 and 16.66), Araneae (0.00, 70.0 and 16.66) and aphid parasitoids (3.33, 66.66, 26.66) per 100 tillers were observed at early, middle and late stages of wheat, respectively. However, during 2018-2019 season, Coccinella septempunctata (33.33, 106.66 and 93.33) and Harmonia axyridis (23.33, 0.00 and 30.00) while areenae (6.66,3.33 and 0.00), aphid parasitoids (0.00, 3.33 and 166.66) and syrphids (3.33, 0.00, 0.00) per 100 tillers were recorded at early, middle and late stages of wheat, respectively. Mean aphids (1970.00, 6103.33 and 193.33 per 100 tillers) in 2017-2018 while during 2018-2019, aphids were identified to species level with Schizaphis graminum (966.66, 1843.33 and 1860.00) and Sitobion avenae (1083.33, 1676.67 and 1290.00) per 100 tillers at early, middle and late wheat growth stages, respectively. Overall, the natural enemy abundance was observed higher at flowering stage (1320) in 2017-18 and milk maturity (1640) stage per 100 tillers in 2018-19. Overall, this study will be helpful to identify the significant use of potential natural enemies by delaying the use of insecticides and integrate with the sustainable IPM strategy for wheat cropping ecosystem in Pakistan.

Key words: Coccinella septempunctata, Harmonia axyridis, aphid parasitoids, Sitobion avenae, Schizaphis graminum, integrated pest management

TUES 11:40 am | Interaction of Aphis ruborum and its natural enemies on strawberry in southeastern USA

Riddick, Eric W.1*; Miller, Gary L.2; Owen, Christopher L.3; Bauchan, Gary R.4; Schmidt, Jason M.5; Gariepy, Tara6; Brown, Richard L.7 and Grodowitz, Michael J.8

1-8USDA, National Biological Control Laboratory, Stoneville, MS, USA; 2,3USDA, Systematic Entomology Laboratory, Beltsville, MD, USA; 4USDA, Electron and Confocal Microscopy Unit, Beltsville, MD, USA; 5University of Georgia, Department of Entomology, Tifton, GA, USA; 6Agriculture and Agri-Food Canada, London Research and Development Centre, London, ON, Canada; 7Mississippi State University, Mississippi Entomological Museum, Mississippi State, MS, USA. *eric.riddick@ars.usda.gov

Aphis ruborum (Börner & Schilder) is a pest of Rubus and Fragaria species in north Africa, south-west and central Asia, India, Pakistan, Chile, Argentina, Europe, Canada, and western USA. The only known occurrence of A. ruborum in eastern USA was an interception in a shipment of blackberries from Mexico to Florida. In this paper, the discovery of A. ruborum, a new host-parasitoid association, and native predators on cultivated strawberry (Fragaria x ananassa Duch. cv. Chandler; Fragaria x ananassa Duch. cv. Camarosa) in Mississippi, southeastern USA, are reported. Notes on the density and distribution of the aphid on plants in high tunnels are reported. The aphid was first discovered in high tunnels on foliage, often on leaflets of daughter plants, in the Fall of 2016. Augmentatively-released and naturally-occurring coccinellid larvae, Coleomegilla maculata (DeGeer) and Scymnus loewii Mulsant, respectively, consumed the aphid. By 2017, A. ruborum nymphs and associated black-colored mummies were observed on leaflets of mother plants of both cultivars. Using morphology and DNA barcoding techniques, the aphid was identified to species. In addition, morphologically indistinct parasitoid adults emerging from aphid mummies were identified using DNA barcoding. The emerged parasitoids were two species, Aphelinus varipes (Foerster) and Aphelinus albipodus Hayat and Fatima. Occurrence of A. ruborum in Mississippi is a new state record and the eastern-most established recording of this aphid in the USA. The A. ruborum – A. varipes or A. albipodus host-parasitoid association in Mississippi is previously unreported anywhere else in the world, to our knowledge. Ongoing research should seek to discover other populations of A. ruborum in southeastern USA on wild Rubus or Fragaria and to identify new parasitoids, which could be utilizing A. ruborum as host.

Key words: aphids, biological control, molecular, parasitoid, predator, taxonomy
TUES 14:30 pm | Influence of spatial and temporal scales on the potential of biocontrol service of crop pests by their natural enemies through the analysis of activity-density and species richness

Van Baaren, Joan¹*; Couthouis, Eloïse¹; Barascou, Lena¹; Pétillon, Julien¹; Le Roux, Vincent²; Marrec, Ronan²; Hecq, Florence³ and Hance, Thierry³

¹UMR-CNRS ECOBIO, Université de Rennes 1, Rennes, France; ²Université de Picardie Jules Verne, Amiens, France; ³Centre de recherche agroalimentaire de Mirabel, Mirabel, Canada; ⁴Université Catholique de Louvain-La-Neuve, Louvain-La-Neuve, Belgique. *joan.van-baaren@univ-rennes1.fr

Intensive agriculture and climate change have profoundly altered biodiversity and trophic relationships in agricultural landscapes, leading to the deterioration of ecosystem services such as biological control of crop pests by their natural enemies. The main objective of our study is to understand the spatial and temporal factors influencing the potential of biocontrol by evaluating the relative proportions of pests and natural enemies in function of these factors. Five taxa containing both crop pests (aphids and slugs) and natural enemies (spiders, carabids and parasitoids) were sampled in winter wheat crops in 2017 and 2018 in three regions (Brittany, Haut-de-France and Wallonia). The spatial scale was studied at the landscape scale via a gradient of landscape complexity and at the local scale via the study of two types of borders (hedge and grass strip). The potential of biocontrol was greater and earlier in Brittany than in the two other regions. Complex landscapes were favourable to all taxa compared to open landscapes. In addition, natural enemies were more abundant within crops contrary to pests, majoritary present in the borders. Finally, the grassed strips appeared to be more favourable for potential of biocontrol than hedges. Our results suggest the importance of taking into account the regional scale in order to predict the consequences of climate change on the biocontrol service. In addition, they highlight the importance of taking into account both abundance and species richness in the management of landscapes and borders which can be improved by increasing plant diversity.

Key words: hedges, grass strip, landscape, conservation biological control, food web

TUES 14:50 pm | Predation pressure and habitat complexity alter indirect interactions between two aphid species

Emery, Sara¹ and Mills, Nicholas J.¹*

¹Department of Environmental Science, Policy and Management, University of California, Berkeley CA 94720-3114, USA  
*nmills@berkeley.edu

Indirect interactions between prey species that share a generalist predator can be symmetric or asymmetric and vary along a continuum from positive (apparent mutualism) to negative (apparent competition). Such interactions are common and are increasingly being recognized as important drivers of community dynamics. Though the impact of generalist predators makes an important contribution to conservation biological control and has been studied frequently, it is often in the context of a single prey species with either single or multiple predator species. Consequently, further consideration of how indirect interactions between prey species can affect biological control by generalist predators is critical. Cage experiments with *Acythosiphum pisum* and *Aphis gossypii* were performed with varying levels of predation by adult *Hippodamia convergens* as well as varying levels of habitat complexity (numbers of plants per cage). Across predation pressure the initial growth of *A. gossypii* appeared beneficial to the net change in abundance of *A. pisum* over a period of 8 days, however the initial growth of *A. pisum* provided no explanatory power for the net change in abundance of *A. gossypii*. A linear mixed effects model that included initial growth of both aphid species and level of predation pressure explained 96% of the variation in the net change in abundance of *A. pisum* and 92% of the variation in net change in abundance of *A. gossypii*. 
Both increasing predation pressure and decreasing habitat complexity appeared to change the sign and strength of the indirect interactions between *A. gossypii* and *A. pisum*. In conclusion, the contribution of generalist predators to conservation biological control will vary both in space and time due to changes in predation pressure, relative abundance of prey species and the dynamics of direct versus indirect interactions.

Key words: *Acyrthosiphum pisum, Aphis gossypii*, biological control, *Hippodamia convergens*, indirect interactions

**TUES 3:40 pm | Distribution data unveils niche segregation among aphidophagous *Scymnus* species in the Azores (Portugal)**

Borges, Isabel¹* and Soares, António O.¹
¹Centre for Ecology, Evolution and Environmental Changes, and Azorean Biodiversity Group (cE3c-GBA), University of the Azores, Portugal.*isabel.mm.borges@uac.pt

To better understand food relationships in aphid-aphidophagous ladybird systems in the Azores (Portugal), a 4-years field study was conducted in the two main habitats of these predators. A total of 20 prey species and 5 predator species were recorded. Prey species richness in the coastal prairie was extremely high when compared with the corn agroecosystem, but the number of predator species was similar. In the coastal prairie prey diversity was larger, despite low evenness, whereas in corn, prey and predator biodiversity trends were similar and 90% of the predator counts represented *Scymnus nubilus*. *Scymnus interruptus* was dominant in the coastal prairie with 75% of the predator counts. In this habitat, predator-prey associated occurrence differed both at the interspecific and intraspecific levels for the *Scymnus* species. In the prairie, the predators’ population dynamics seemed more closely synchronized with the prey species to which larvae were most frequently associated with, *A. parietariae*. Thus, food relationships, as well as habitat use appear to differ between aphidophagous *Scymnus* species, that is, they are spatially segregated. Evidence of intraspecific niche differentiation at the trophic level was also found. Further research is required to unravel if the interspecific spatial segregation is mediated by habitat type or prey resource.

Key words: aphid, ladybird, *Scymnus nubilus, Scymnus interruptus*, food relationships, spatial segregation

**TUES 4:00 pm | Interactions between soybean aphids and their natural enemies**

Costamagna, Alejandro C.¹* and Almdal, Crystal¹
¹Department of Entomology, University of Manitoba. *ale.costamagna@umanitoba.ca

Soybean aphids are major pests in North America and reach outbreak levels in some fields in Manitoba every year, despite widespread control by generalist predators. The ecosystem service of pest control depends on the presence and quality of habitats supporting predator populations in agricultural landscapes. Predator manipulation experiments were conducted in 12 (2017) and 11 (2018) soybean fields in Manitoba. Each soybean field was located beside canola, spring wheat, alfalfa, or woody vegetation. Predator exclusion cages were set up in each of the soybean field sites, for a period of three weeks in July, for a total of 5 exclusion and 5 open cages per field. Destructive plant counts were conducted weekly within soybean fields to determine the abundance of aphids within the fields during the predator exclusion experiment. Sweep net samples were conducted weekly in each habitat 25 m from the shared border during the experiment. During the same period, one bi-directional malaise trap was placed between soybean and the selected adjacent habitat in each of the soybean field sites. In
2017, there was an outbreak year of soybean aphids in the majority of our fields, with high levels of alate immigration into the experimental fields and lack of difference between open and predator exclusion treatments. We saw increased numbers of lady beetles, hoverflies and nabids in response to the high aphid populations. In 2017, we saw larger seven-spotted lady beetle (Coccinella septempunctata, Coleoptera: Coccinellidae) females in alfalfa earlier in the season than in soybean and found male weight to be affected by aphid abundance, but not habitat type. In 2018, we observed a 7-fold increase in aphid populations protected from predation compared to the open treatment. Nabids, seven-spotted lady beetles and hoverflies were more abundant in 2017 (the outbreak year) than in 2018, but there were no differences in the number of minute pirate bugs (Orius insidiosus, Hemiptera: Anthocoridae) or green lacewings between years. We observed higher immigration of seven-spotted lady beetles from wheat to soybean. Our results suggest that the presence of different crops surrounding soybean fields affects the interactions between soybean aphids and their natural enemies.

Key words: predation, biological control, ecosystem services, *Aphis glycines*, predator movement

**TUES 4:20 pm | Seasonal and diurnal patterns of predation in colonies of a native aphid**

MacKay, Patricia A.\(^1\)* and Lamb, Robert J.\(^1\)
\(^1\)Department of Entomology, University of Manitoba, Winnipeg, Canada

Weekly data are presented for 10 years, following the abundance, prevalence and mean intensity of the aphid *Uroleucon rudbeckiae* on *Rudbeckia laciniata* in Manitoba, and the natural enemies attacking this species. Sampling was entirely non-destructive with photographic confirmation of predation. Predators were not usually identified to species, but classified into eight higher taxonomic groups, most containing several species. Listed from highest to lowest frequency, they were: parasitoids, hover flies, spiders, midges, lacewings, lady beetles, mites, and true bugs. For the months of June, July, August and September, the prevalence of predation was similar, as was the mean number of taxa in the colonies. Parasitoids and spiders were equally abundant throughout the sampling period. Hover flies and midges were most common in the first half of the sampling period. Lady beetles and lacewings occurred primarily in June and September. Based on twice-daily assessments, predation events occurred equally during the day and night, but the number of larvae and adults predated during the day increased from June to August before declining in September. Nocturnal predation was uniform throughout the sampling period. The presence of exclusively nocturnal predators was not documented, although, if present, exclusively nocturnal predators replaced rather than adding to the impact of predators observed during the day. These data will be used to assess the importance of predation in determining the stability of aphid population dynamics.

Key words: *Uroleucon rudbeckiae*, predator prevalence, parasitoids, hover flies, spiders, midges
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THURSDAY

THUR 9:30 am | A host-density-dependent decline in lifespan and estimation of the age of an aphid parasitoid in the field

Miksanek, James Rudolph\(^1\)* and Heimpel, George E.\(^1\)
\(^1\)University of Minnesota, Saint Paul, Minnesota, United States. *miks0007@umn.edu

Parasitoids require nutrients for reproduction and survival. For parasitoids of plant-feeding hemipterans, proteins are acquired directly from the host hemolymph by host feeding and sugars are obtained primarily from the honeydew produced by their hosts. We hypothesized that lifespan would be negatively affected by low host densities and reduced overall in field conditions, and used *Aphelinus certus* (Hymenoptera: Aphelinidae) and soybean aphid (*Aphis glycines*; Sternorrhyncha: Aphididae) as a study system. *A. certus* is an introduced parasitoid of soybean aphid in North America and obtains its nutrients through honeydew and host feeding. We exposed *A. certus* females to different host densities until death and used a logistic model to calculate the critical host density, which is the amount of hosts required for parasitoids to reach 95% of their maximum lifespan. We found that parasitoid survival decreased with host density. At death, we recorded the number of damaged forewing setae and correlated this value with parasitoid age. Using these data, we constructed a wing wear index to estimate the age of a sample of field-collected parasitoids, which were found to have a lower (but similar) life expectancy compared to parasitoids in the lab. These results detail a relatively unstudied phenomenon, and we discuss their relevance within the contexts of population dynamics and biological control.

Key words: biological control, soybean aphid, Aphelinidae, lifetime reproductive success

THUR 10:20 am | Egg-laying decisions by ladybeetles exposed to variable aphid densities

Tilmon, Kelley\(^1\)*
\(^1\)Ohio State University Agricultural Research and Development Center, Wooster, OH, USA

Predatory insects may make decisions about reproductive allocation based on the available density of prey. In this study we exposed gravid ladybeetles of different species to variable densities of soybean aphids (*Aphis glycines*) and quantified oviposition over a short time period to assess egg laying decisions in response to the immediate environment. Results are pending completion of the study this summer.

Key words: predation, oviposition, *Aphis glycines*

THUR 10:40 am | Testing for fecundity compensation in parasitized sugarcane aphids

Wright, Crys*; Zhu-Salzman, Keyan and Medina, Raul F.
Department of Entomology, Texas A&M University, TAMU 2475, College Station, TX 77843, USA. *cwright02@tamu.edu

The sugarcane aphid, *Melanaphis sacchari*, (SCA) (Hemiptera: Aphididae) is an economically important pest of grain sorghum, *Sorghum bicolor*, in southern United States. This aphid reproduces parthenogenetically, and under
favorable conditions, its populations can exceed a thousand individuals per leaf. While some studies have assessed the effects of natural enemies (predators, pathogens, parasites, and parasitoids) on SCA populations, no study has measured SCA defenses. Fecundity compensation (i.e., a rapid increase in reproduction in response to natural enemies) is a defense mechanism that has been studied in few aphid species. If this were to occur in SCA, which is parasitized by *Aphelinus nigritus* Howard (Hymenoptera: Aphelinidae) and *Lysiphlebus testaceipes* (Hymenoptera: Braconidae) in Texas, the suitability of parasitoids for aphid biological control might be hindered. This study assessed the likelihood of fecundity compensation in SCA by testing its response to parasitoid oviposition.

Key words: parasitoids, field crops, insect defense

**THUR 11:00 am | Responses of the aphid parasitoids *Praon volucre* and *Aphidius ervi* to low and fluctuating temperatures**

Rowley, Charlotte; Klassen, Danielle; Pope, Tom. W.; Fountain, Michelle and Powell, Glen*

*Centre for Integrated Pest Management, Harper Adams University, Newport, Shropshire, TF10, 8NB, UK; Department of Pest and Pathogen Ecology, NIAB EMR, East Malling, Kent ME19 6BJ, UK. glen.powell@emr.ac.uk*

In recent years the control of early season aphids such as the potato aphid (*Macrosiphum euphorbiae*) in strawberry crops has become more problematic due to the withdrawal of commonly used insecticides. The potato aphid may reproduce all year round on strawberry crops if conditions allow and growers are recommended to release aphid parasitoids in late winter or early spring, before aphid populations become established. However, there is little evidence for the effectiveness of this approach in unheated polytunnels and glasshouses, which show large fluctuations between daytime and night-time temperatures. Such fluctuations mean that temperatures will exceed those required for parasitoid development and adult activity for only part of the day early in the season. The aim of this study was to determine the effect of low and fluctuating temperatures on the ability of *Aphidius ervi* and *Praon volucre* to parasitise *M. euphorbiae*. Results indicate that under constant temperatures *A. ervi* is able to parasitise aphids successfully at temperatures as low as 8°C. For *P. volucre*, the minimum temperature tested at which parasitism of aphids occurred was 12°C. Both species of parasitoid were able to parasitise aphids during periods of as little as two hours at temperatures above those required for activity, after having previously been held at temperatures below (2°C) those required for activity. The relevance of these results will be discussed in the context of early-season releases of aphid parasitoids.

Key words: biological control, *Macrosiphum euphorbiae*, potato aphid

**THUR 11:20 am | Predation functional response of *Aphidoletes aphidimyza*(Rondani) to *Rhopalosiphum padi* (Linnaeus) at different temperatures**

Fang, Mei-juan; He, Xiao-qing; Liu, Dong; Song, Kai; Zhao, Ying and Wang, Yu-bo*

*Dryland Farming Institute, Hebei Academy of Agricultural and Forestry Sciences, Key Lab of Crop Drought Tolerance Research of Hebei Province, Hengshui ,China. *wybnky@126.com*

*Aphidoletes aphidimyza* (Rondani) is an effective natural enemy to control aphids in greenhouse crops, environmental temperature is one of the most important factors that can influence the predation potential of carnivorous predators. Laboratory tests were conducted to evaluate the predation functional response of *A. aphidimyza* 3rd instar larvae by using the host, *Rhopalosiphum padi*(Linnaeus), at constant temperatures (10, 15,
20, 25, 30) and fluctuating temperature (15~30°C). The results showed that predation efficiency increased with increasing host density. Functional response of A. aphidimyza, at six different temperatures to R. padi were in fitted to Holling II formula. Maximum daily predatory amount (Na max) was the highest at 25°C (35.65 aphids preyed per day), but the lowest at 10°C (2.81 aphids preyed per day), the order was 25°C > (15~30°C) > 30°C > 20°C > 15°C > 10°C. On the contrary, the order of handling time (T h) was 10°C > 15°C > 20°C > 30°C > (15~30°C > 25°C, the shortest of T h (0.0281d) was at 25°C, the longest (0.3556d) at 10°C. These results demonstrate that the predation functional response of A. aphidimyza is significantly affected by temperature. It lay a foundation for further large amount of breeding of the A. aphidimyza, and can provide theoretical basis for biological control of the A. aphidimyza.

Key words: Aphidoletes aphidimyza; Rhopalosiphum padi; temperature; predation functional response

THUR 11:40 am | The research and utilization of Chinese gall aphids in China

Yang, Zixiang1*; Chen, Xiaoming2; Zhang, Yurong2 and Chen, Jingyuan3

1Research Institute of Resource Insect, Chinese Academy of Forestry, Kunming, China; 2Hunan Academy of Forestry, Changsha, China; 3Hubei Academy of Forestry, Wuhan, China. *yzx1019@163.com

Chinese gall aphids (Hemiptera: Aphididae: Eriosomatinae) produce galls on the Chinese sumac (Rhus chinensis). The gall is called Chinese gallnut (Wubeizi) which is rich in gallotannins and has been used in traditional Chinese medicine and other industries for more than two thousand years in China. The gallnut contains the highest level of natural tannin, approximately ranging from 50 to 70% by dry weight. Tannin acids and other components from Chinese gallnutes are continuously used for a wide range of applications in modern industries including pharmaceutics, inks, brewing, wine, food, cosmetic antioxidants and organic synthesis. The average annual yield of gallnut chemicals is roughly 10,000 tons in China, accounting for 95% of the total worldwide production. Many efforts have been made to study the artificial breeding techniques of aphid in order to increase the yield. There are 14 species of gall-making sumac aphids reported in China, each producing a different type of gallnuts. All 14 aphid species have similar biological characteristics such as complex life cycles with cyclical parthenogenesis and multiple generations with alternative hosts. Their life cycle includes sexual and asexual reproduction, and alteration between the primary hosts (Anacardiaceae: Rhus) and certain secondary host, mosses. Three primary host plants and more than 50 secondary host mosses have been reported. The gall aphids induce closed, pouch-shaped galls on their certain primary hosts, which are highly species-specific in shape, size, structure, and gallingsite. Generally, each gall is initiated by a single fundatrix, which reproduces parthenogenetically for three generations within the gall. Gall initiation and growth are likely achieved through aphid salivary secretions, which are also critical in active interactions between the galling aphid and its host plants. Among the aphids, the most studied species is Schlechtendalia chinensis, which induces horned-like galls on Rhus chinensis. Salivary protein identification in S. chinensis showed that high proportion of proteins with binding activity, including DNA-, protein-, ATP-, and iron-binding proteins which maybe involved in gall formation. These results provide a framework for future research to elucidate the molecular basis for gall induction by galling aphids. Therefore, the galling aphids have been viewed as a useful model system for studying mechanism of gall formation.

Key words: galling aphid; gallnut; tannins; Schlechtendalia chinensis; salivary protein; gall formation
Non-native species are among the major threads interacting within native communities. Novel species interactions can determine the invasion success of non-native species. The lack of co-evolutionary history can lead to a competitive advantage for non-native predators, due to missing predator recognition of native prey. Lady beetles were introduced globally as biological control agents against aphids. Among these, the Asian lady beetle *Harmonia axyridis* is associated with a lady beetle species decline in Europe and in North America. We compared predator-prey interactions between aphidophagous native and non-native lady beetle species and native pea aphids (*Acyrthosiphon pisum*) in Europe and in North America. In Europe, our study species set consisted of four common native species and the invasive *Harmonia axyridis*. For the transcontinental comparison, we selected congeneric native and non-native species of European origin (genus *Coccinella* and *Hippodamia*) and the invasive *Harmonia axyridis*, in North America. We compared predation rates of non-native lady beetle species and native lady beetle species in the laboratory. In addition, we conducted a leaf-choice experiment to test for aphid avoidance behavior upon contact with lady beetle cues. Here we expected stronger avoidance of native lady beetle cues compared to cues of non-native lady beetles, due to missing predator recognition. The largest species tested (i.e. *Harmonia axyridis* and *Coccinella septempunctata*) consumed the most pea aphids. Our findings are consistent with previous results, showing that mainly body size drives predation regardless of species origin. Pea aphids avoided *Harmonia axyridis* cues in North America but not in Europe. The existence of avoidance behavior of *Harmonia axyridis* in North America indicates adaptation of native aphids towards novel predators within few decades. We suggest that larger non-native lady beetle species, but not smaller European species are likely to expand their impact in North America due to their competitive advantage in aphid consumption. However, lady beetle competition further depends on the overlap in phenology and habitat preference. Native aphids develop antipredator behavior to non-native lady beetles within few decades, indicating that (relatively) short co-evolutionary history between novel predators and native prey is sufficient to overcome predator-prey naïveté.

Key words: *Harmonia axyridis*, *Acyrthosiphon pisum*, invasion success, predator-prey naïveté, avoidance behavior
the real community and negative correlation between the abundance of exotics and natives fit this linear relationship precisely, although in this case the correlation coefficient reflected competition and resurgence by natives when exotic populations declined. The three most abundant species, and negative correlations in their abundance, explained much of the low population variability. Stability of the dominant species, an exotic, increased over 23 years, stabilizing the community over time. Contrary to expectations, PV of the community was most stable in habitats where beetle abundance was high (perennial crops) and least stable in habitats with high diversity and stability of vegetation cover (forests). Competition between exotic and native lady beetles stabilized the abundance of this community, but the effect may not last if populations of native species continue to decline.

Key words: Coccinellidae; portfolio effect; diversity-stability; competition; population variability

THUR 3:40 pm | Role of native and exotic aphidophagous coccinellids in modulating the functional diversity of their communities in alfalfa fields

Grez, Audrey A.¹ and Zaviezo, Tania²*
¹ Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, Santiago, Chile; ² Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile, Santiago, Chile. *tzaviezo@uc.cl

There is evidence of a positive relation between biodiversity and ecosystem functioning. In agroecosystems, a higher biodiversity of natural enemies usually results in a more efficient biological control service because of niche complementarity among species. Typically for studying this relationship only taxonomic diversity has been considered, but niche complementarity may depend more on functional traits of natural enemies which do not always corresponds with taxonomy. Exotic species usually homogenize communities in terms of taxonomic diversity but it is less clear how exotics and natives, and their traits, affect functional diversity of coccinellid assemblages. In alfalfa fields in Central Chile, coccinellids are very common, including several native species and fewer exotic species that dominate the assemblages. In this work we analyze the role of native and exotic coccinellids in modulating the functional diversity of their communities in alfalfa fields. We sweep-sampled coccinellids in nine opportunities in 20 alfalfa fields in Central Chile, from August to December 2018. We classified species according to their body size, habitat specialization, diet, origin and phenology and, based on their abundance in each field, we calculated different functional diversity indices (functional richness, equitability, divergence, dispersion) and Community Weighted Mean (CWM) for several traits. Using Partial Least Square regressions, we looked for the associations among these variables with the abundance and species richness of native and exotic species, and with the proportion of native species in each field. In the whole season, we collected 13957 coccinellids (24% natives), of 8 native and 4 exotic species. We found a positive association between functional divergence and native richness. Also we found a positive association between functional dispersion and the abundance and proportion of native coccinellids, but a negative association with the abundance of exotics. CWM for diet associated positively with native richness, while CWM for habitat specialization associated with exotic abundance. These results highlight the importance of conserving native species in alfalfa fields in order to increase functional diversity and probably a better biological control service.

Key words: Chile, functional traits, ladybird beetles, niche complementarity
THUR 4:00 pm | Fluctuation of native lady beetle body size following establishment of *Harmonia axyridis* (Coleoptera: Coccinellidae) in Catalonia (Spain)

Lafrenaye, Audrey*; Papineau, Jean-Philippe; Dumont, François; Pons, Xavier and Lucas, Eric  
1Laboratoire de Lutte Biologique, Département des Sciences Biologiques, Université du Québec à Montréal (UQAM), CP 8888, succursale Centre-Ville Montréal (Québec, CANADA) H3C 3P8; 2Centre de recherche agroalimentaire de Mirabel, 9850, rue de Belle-Rivière, Mirabel (Québec, CANADA) J7N 2X8; 3Universitat de Lleida- Dept. Producció Vegetal i Ciència Forestal, Av. Rovira Roure 191, (Lleida, España) 25198. *lafrenaye.audrey@gmail.com

The multicoloured Asian lady beetle, *Harmonia axyridis* (Pallas), is an invasive species in numerous countries around the world. The arrival of the invader has been associated with drastic changes in Coccinellid assemblages. The objective of the present study was to evaluate if the arrival of an invader may have generated fluctuations in native Coccinellid body size. The measures were taken in Catalonia (Spain) where the Asian ladybeetle established in 2011. The general hypothesis stated that the arrival of the invader would increase exploitative competition for food and also intraguild predation. Consequently, we expect a decrease of the body size of native species. The methodology was based on body size measures of adult ladybeetle in governmental and private collections, and also in the field. The coccinellid species were; (1) *Coccinella septempunctata* L., (2) *Hippodamia variegata* G., (3) *Propylea quatuordecimpunctata* L. and (4) *Adalia bipunctata* L. The maximum width of the pronotum and the length of the elytron were measured using photos of ladybugs collected over the period 1909-2019 in Catalonia. The sex and the elytral form of the specimens were also noted. The results showed different pattern depending on the focal species, some increasing their body size, while others decreasing or without variations.

Key words: multicoloured Asian ladybeetle; invasive species; exotic species, interspecific competition, intraguild predation

THUR 4:20 pm | Ingestion efficiency under constant and variable thermal regimes: *Harmonia axyridis* feeding on *Acyrthosiphon pisum*.

Orellana, Maria* and Bozinovic, Francisco  
Departamento de Ecología, Center of Applied Ecology and Sustainability, Facultad de Ciencias Biológicas, Pontificia Universidad Católica de Chile, Santiago, Chile. *mjorella@uc.cl

Environmental temperature affects trophic dynamics through multiple mechanisms. The most reviewed of these mechanisms is the attack rate. Also called trophic interaction strength, it consists of a dynamical perspective of the predator’s functional response. However, other under-reviewed and under-tested temperature involving mechanisms can play a major role on trophic dynamics. To consider all these components we propose an empirical and theoretical model using temperature as a driver for physiological mechanisms underlying a predator – prey dynamic. We test this model on a predator coccinellid (*Harmonia axyridis*) and a prey aphid (*Acyrthosiphon pisum*). Both species have a significant impact on agroecological systems since the aphid is a wide rage global plague and the ladybug is a worldwide-introduced species used as a natural controller to cope whit this pest. In this work we focus on ingestion efficiency, the relation between energy gain and energy loss, measured as the rate ingestion/metabolism, responding to three constant thermal regimes, (15/20/25°C) and three daily variable regimes (15±5/20±5/25±5°C) among the thermal tolerance range for this two species. As expected, increase on temperature also lead to an increase on ingestion and metabolism, but the reaction norm is steeper on the second component, leading to a reduction on ingestion efficiency. We also observed Kaufmann effect on variable thermal regimes when compared to constant regimes. Low variable regime shows increased ingestion efficiency while high variable regime displays a lower efficiency. This data is crucial to the understanding of temperature effects in...
predator – prey dynamics, increasing the ecological applicability to crop yield, agro-ecological systems, and food supply in the context of global change.

Key words: predation, metabolism, Kaufmann effect, biological control

THUR 4:40 pm | The European ladybird App: a new tool for Citizen Science

Skuhrovec, Jiri*; Roy, Helen E.; Kazlauskis, Karolis; Inghilesi, Alberto F.; Soares, Antonio O.; Adrien, Tim; Vígľašová, Sandra; Honěk, Alois and Martinková, Zdenka.

The citizen science initiatives have rapidly increased in popularity in the last years. The involvement of volunteers (i.e. citizens, scientists, diversity managers, policy-makers, local authorities, industry, schools, and other participants) could be an effective solution to ensure the realisation of the enormous potential of Citizen Science for biodiversity surveys, or early detection of new invasions. Ladybirds (Coleoptera, Coccinellidae) are well known beneficial predators, which are very often used as biological control agents. On the other hand, among ladybirds, we observed one textbook case with „invasive“ species, Harmonia axyridis (Pallas). Seminal national citizen science projects were successful tools to follow the dispersal of the invader. However, the establishment of a trans-national project for Europe would be essential to coordinate efforts for the study ladybird diversity as well as for the early detection of new invaders. Ladybirds are very popular and charismatic insects, which can be relatively easily recognised via photos. In this case, they are the perfect target group for citizen science projects. On the strengths of the citizen science survey on ladybirds in the UK (www.ladybird-survey.org), we have developed a smartphone Application for European ladybird recording and identification. The main aim of the Application is to engage people in providing their sightings of ladybirds while gaining an appreciation of the diversity and value of these insects. Firstly, we prepared a detailed database of appropriate ladybird species from the UK, Czech Republic, Slovakia, Italy, Belgium and Portugal. Then we chose some specific morphological features (e.g. size, main colour, pronotum pattern, habitat) and country-based ranking of the probability of occurrence were provided as app filters to enable the users to reduce the number of likely species in the process of recording. This project is the first collaborative approach involving the recording of ladybirds through citizen science across Europe (https://european-ladybirds.brc.ac.uk/home). The success of the app will depend on the engagement of the general public though we anticipate excellent participation because of both the popularity of ladybirds and the usability of the app.

Key words: diversity, dispersal, public engagement, invasion biology
FRIDAY

FRI 8:30 am | Ladybirds’ larvae feed conspecific eggs than alien ones in prey-scarcity: intraguild predation versus cannibalism

Pervez, Ahmad
Biocontrol Laboratory, Department of Zoology, R. H. Govt. P.G. College, Kashipur, Uttar Pradesh, India.
*ahmadpervez@yahoo.com

The hypothesis was tested that the developing ladybird-larvae indulge more in intra guild predation rather than egg-cannibalism in prey scarce condition to protect their gene pool. The larvae of ladybirds, *Propylea dissecta* (Mulsant), *Menochilus sexmaculatus* (Fabricius) and *Coccinella septempunctata* Linnaeus were reared from neonates to adults in a cafeteria setup of scarce aphids (*Aphis craccivora* (Koch)), conspecific and heterospecific eggs. The three ladybirds exhibited a similar response towards the egg-diets by consuming more conspecific eggs compared to those of heterospecific eggs of other two species in prey (*Aphis craccivora*) scarcity. It seems that developing larvae might have recognized the eggs due to the possible cues in the form of egg surface chemistry. The ladybirds were reluctant to consume heterospecific eggs. The rate of development increased when the ladybirds consumed conspecific eggs rather than heterospecific eggs. This resulted in heavier developing instars and pupae when the immature stages were fed on conspecific eggs compared to heterospecific eggs. Conspecific eggs were better food than heterospecific eggs in aphid scarcity for producing fitter generation in terms of developmental period and weight. The consumption rate, conversion efficiency and growth rates of the three ladybirds were optimal on cannibalizing eggs than consuming heterospecific eggs. Greater number of larvae developed into adults after egg-cannibalism than intraguild predation. Hence, the pragmatic data reject the above hypothesis. It is inferred that ladybirds’ larvae ensure their own survival by not risking their own fitness by showing reluctance towards intraguild predation.

Key words: aphids, *Propylea dissecta*, *Menochilus sexmaculatus*, *Coccinella septempunctata*

FRI 10:20 am | Community of aphidophagous in commercial crops of *Capsicum* spp. and reconstruction of its trophic network through molecular gut content analysis

Duque-Gamboa, Diana N. 1,2*; Posso-Terranova, Andres1 and Toro-Perea, Nelson1,2
1Universidad del Valle, Cali, Colombia. 2Centro de Investigación e Innovación en Bioinformática y Fotónica (CIBIOFI), Cali, Colombia. *diana.nataly.duque@correounivalle.edu.co

Aphids (Hemiptera: Aphididae) of the genera *Myzus* and *Aphis*, are the main phytosanitary problem of chilli pepper *Capsicum frutescens* L. and cayenne pepper *Capsicum annuum* L. (Solanales: Solanaceae) in Colombia, as direct pests of crops and as virus vectors. In agricultural systems of chilli pepper and cayenne pepper in Colombia, the implementation of biological control in integrated pest management programs (IPM) for aphids is hindered by the lack of basic information on the community of natural enemies such as parasitoids and generalist aphidophagous. Hence, this research aimed to characterize the community of aphidophagous in pepper crops, chilli pepper *C. frutescens* and cayenne pepper *C. annuum*, in the inter-Andean valley of the Cauca river in southwestern Colombia and to analyze their diet through a molecular gut-content analysis using high-throughput sequencing methods (NGS). Analysis of similarity (ANOSIM) was carried out to test for differences in the community of aphidophagous between crop plants species, phenological status of the plants and sampling points, however, no significant differences were found. The species *Cycloneda sanguinea* (Coleoptera: Coccinellidae),
**Hippodamia convergens** (Coleoptera: Coccinellidae) and **Pseudodorus clavatus** (Diptera: Syrphidae) were the most frequent predators in commercial crops of chilli pepper and cayenne pepper. These species were selected for molecular gut-content analysis and it was found that they preyed on aphids that attack the chilli pepper and cayenne pepper plants. The characterization of the diet of predators with molecular tools allowed the detection of intraguild predation, secondary predation of aphid parasitoids and consumption of alternative prey available in the crop. Based on these results, the trophic network associated with these predators was reconstructed. Differences in diet composition were found when comparing the gut content of larval and adult stages of the coccinellids (ANOSIM p=0.0304), and between coccinellids and the syrphid species (ANOSIM C. sanguinea/P. clavatus p=0.0121, H. convergens/P. clavatus p=0.0117). Our results provide useful information for IPM program against aphids in chilli pepper and cayenne pepper crops in the valley of the Cauca river.

Key words: food web, metabarcoding, predation, biological control, *Aphis gossypii, Myzus persicae*

**FRI 10:40 am | Coercive mating in ladybird, Propylea dissecta (Mulsant): male mating behaviour and reproductive output**

Singh, Priya; Mishra, Geetanjali* and Omkar
Ladybird Research Laboratory, Department of Zoology, University of Lucknow, Lucknow 226007, India.
*geetanjalimishra@hotmail.com

Coerced matings are common phenomenon across the animal world. Our previous data as well as observations have shown that coercive matings are a common phenomenon in ladybirds under laboratory conditions. It has also been observed that the success of mating attempts is determined by the male’s capability to force mating and female’s ability to show resistance. This in conjunction with the fact that females have been observed showing non-random size based matings led us to question as to whether females would show less resistance to suitable males than to less suitable ones. Also would this resistance be reflected just in their behaviour or also in their reproductive output? Small and large sized females (18 hours old) were paired with large or small sized 20-day-old unmated males (high mating urge) and observed for mating behaviour and reproductive output. Large males took lesser time to establish mating than smaller males. Males grabbed and drummed female elytra, probably as a means of appeasement. This behaviour was not observed in normal matings. Females in general showed resistance (running, kicking and shrinking and bending of abdomen) and were not willing to mate. However, once mating was established, the females become less resistive. Longer mating duration was displayed by small sized males suggesting their size compensatory behaviour. While the overall fecundity and percent egg viability was higher in females that were coerced into matings by larger males, it was observed that egg laying was refrained from till up to 4 days post mating. Thus the mating strategies that maximize the fitness of one sex may have adverse effects on the other sex. These findings raise important questions about the selection forces working on the co-evolution of male sexual coercion and female resistance in this beetle.

Key words: forced copulation, ladybird, female resistance, male appeasement
Intraguild predation between two lady beetle predators of pistachio psyllid: A test of its sensitivity to identity and density of extraguild prey

Ranjbar, Fateme; Michaud, J.P.; Jalali, Amin and Ziaaddini, Mahdi
1 Department of Crop Protection, College of Agriculture, Vali-e-Asr University of Rafsanjan, Rafsanjan, IRAN

The common pistachio psyllid, *Agonoscaena pistaciae*, is a key pest of cultivated pistachio trees. *Oenopia conglobata contaminata* and *Menochilus sexmaculatus* are two predatory lady beetles important as biological control agents of *A. pistaciae* in Rafsanjan, southern Iran. In terms of abundance, *O. c. contaminata* has historically been the dominant coccinellid in pistachio orchards of Rafsanjan. Recently, *M. sexmaculatus* has become increasingly abundant, while the abundance of *O. c. contaminata* has declined, raising questions about the potential for intraguild interaction predation (IGP) between them. We designed a series of experiments to (1) evaluate the potential for IGP between these two species, (2) determine whether there were any asymmetries evident in IGP interactions between them, and (3) characterize the sensitivity of IGP to varying densities of extraguild prey. To this end, we measured rates of IGP by fourth instar larvae and female adults on vulnerable immature life stages of the other species. Because the identity of the extraguild prey can potentially influence outcomes, the experiments were conducted using both the pistacio psyllid and an alternative prey, *Aphis gossypii* Glover. All experiments were conducted under laboratory conditions of 26 ± 1 °C, 16:8 (L:D) photoperiod, and 65 ± 5% RH. In order to standardize hunger levels, both adults and larvae were starved for 12 h prior to use in experiments. All intra- and extraguild prey consumption was tallied after 12 hours. There was an inverse relationship between extraguild prey density and IGP, which decreased parabolically with increasing prey densities. There was a slightly steeper decline in IGP with increasing psyllid density compared to aphid density, but the overall patterns of decline were very similar. Consumption of *A. pistaciae* was higher than *A. gossypii* in all treatments, which may reflect lower food value per prey item, as handling times were similar for both extraguild prey species.

Key words: *Oenopia conglobata contaminata*, prey density, *Menochilus sexmaculatus*, *Agonoscaena pistaciae*

Short and long term parasitoid-mediated indirect interactions between unsuitable and suitable hosts

Monticelli, Lucie S.; Desneux, Nicolas and Heimpel, George E.
1 INRA (French National Institute for Agricultural Research), Université Côte d'Azur, CNRS, UMR 1355-7254, Institut Sophia Agrobiotech, 06903, Sophia Antipolis, France; 2 Department of Entomology, University of Minnesota, Saint Paul, MN, USA

Parasitoids used as biocontrol agents parasitize hosts that vary in suitability for offspring development from highly suitable to completely unsuitable. The unsuitable hosts may indirectly affect populations of suitable hosts e.g. owing to egg and/or time sinks suffered by foraging parasitoids. Under laboratory conditions, we assessed parasitoid-mediated indirect interactions between a suitable (*Aphis glycines*) and unsuitable (*A. nerii*) hosts, sharing the aphid parasitoid *Aphelinus certus*. We observed that *A. certus* females laid eggs in the unsuitable hosts in presence of the suitable host, inducing a 45% decrease in overall parasitoid offspring production. Modeling analyses were used to document potential impact on aphid and parasitoid population dynamics. We identified apparent parasitism between *Aphis glycines* and *A. nerii*. The later acted as egg sink for the parasitoid, benefiting *A. glycines* population. The parasitoid benefited as well in the long term through stabilization of suitable host population. By contrast, the presence of *A. glycines* had a negative impact on *A. nerii* population size because it sustained parasitoid activity (parasitoid stinging induced *A. nerii* death). We demonstrated that presence of...
unsuitable hosts can benefit populations of suitable ones (and decrease the strength of biocontrol) through parasitoid egg sink.

Key words: apparent parasitism, egg sink, evolutionary trap, biological control

**FRI 11:40 am | Parental diets affect selective intraguild predation of ladybirds’ eggs**

Pervez, Ahmad
Biocontrol Laboratory, Department of Zoology, R. H. Govt. P.G. College, Kashipur, Uttarakhand, India.
*ahmadpervez@yahoo.com

Parental diet has a major impact on the evolution of food choice of the progeny. Laboratory experiment was designed to study the impact of parental diet in the form of conspecific eggs/ heterospecific eggs on the food choice of the developing larvae in prey scarcity. Adult male ladybird, *Propylea dissecta* [Pd] reared on conspecific eggs (from egg-hatch to adult emergence) consumed more conspecific eggs than *Coccinella septempunctata* [C7] eggs. Adult male *Pd* consumed greater number of *Menochilus sexmaculatus* [Ms] eggs and C7 eggs rather than *Pd* eggs when raised on *Ms* eggs and C7 eggs, respectively. It is inferred that the diet on which the ladybirds are raised play a crucial role in cannibalism and intraguild predation, as the ones eaten during immature stage is preferred during adulthood.Adult male *Ms* reared on conspecific eggs preferred egg-cannibalism than intraguild predation. Similarly, adult male *Ms* reared on *Pd* eggs preferred to consume *Pd* eggs than *Ms* eggs. This further supports the above inference that ladybirds prefer to consume eggs on which they were raised during instar-stage. However, this pattern was not found in *C7* adults as they preferably consumed *Ms* and *Pd* eggs over their conspecific eggs. It is inferred that *C7* refrains to consume its own eggs regardless its dietary history. This clearly explains why it is more involved in intraguild predation rather than cannibalism, whereas the other two ladybird species used to consume the eggs on which it has been raised during its larval stage. It is also noticeable that *Pd* and *Ms* were least interested in eating *C7* regardless their dietary history. *C7* consumes heterospecific eggs more readily, which may be the reason for the dominance of this species in agricultural ecosystems.

Key words: aphids, *Propylea dissecta, Menochilus sexmaculatus, Coccinella septempunctata*
POSTERS

01 | Understanding the impact of phylloplane biocontrol agents on insects

Grenz, Kristina J1*; Johnson, Louise J1; Mauchline, Alice L2; Key, Georgina3 and Jackson, Rob W1.

1 School of Biological Sciences, University of Reading, Whiteknights, Reading, RG6 6AS, UK; 2 School of Agriculture, Policy and Development, University of Reading, Whiteknights, Reading, RG6 6AR, UK; 3 Agriculture and Horticulture Development Board, Stoneleigh Park, Kenilworth, Warwickshire, CV8 2TL

Aphids are a major pest to the agricultural and horticultural industry, causing significant yield losses by directly feeding on the crop and acting as vectors for plant diseases. Concern for the environment, human health and species evolving resistance to numerous insecticides, has put growers under increasing pressure to find alternative methods of aphid control to the current use of pesticide sprays. *Pseudomonas poae* is a Gram-negative bacterium originally found on cabbage roots that has proven to be naturally virulent against aphids. Previous research found *P. poae* to be highly specific to aphids at no detrimental effect to the host plant. It possesses two toxicity genes that may explain its virulence to aphids and there is also evidence to suggest it deter aphids from colonizing a crop plant. These traits make it a promising potential biocontrol agent for use in glasshouse systems. We used experimental evolution to improve *P. poae*'s effectiveness as a biological control by selecting for survival on the phylloplane and efficacy at killing aphids. We also investigated whether the bacteria is capable of forming biofilms which may increase survival on the phylloplane and contribute to microbial protection of the crop. Our research was successful in evolving biofilm forming isolates of *P. poae*. However, there were clear ecological trade offs. The biofilm-passaged isolates had dramatically reduced virulence and loss of motility, whereas the aphid-passaged isolates increased in virulence but failed to form biofilms.

Key words: *Pseudomonas poae*, *Myzus persicae*, biological control

02 | Is *Scymnus nubilus* (Coleoptera: Coccinellidae) a good candidate as biological control agent of *Aphis frangulae* (Hemiptera: Aphididae)?

Borges, Isabel1*; Arruda, Patrícia2; Meseguer, Roberto2; Vieira, Virgílio1; Pons, Gemma1 and Soares, António O.1

1 Centre for Ecology, Evolution and Environmental Changes, and Azorean Biodiversity Group (cE3c-GBA), University of the Azores, Ponta Delgada, Portugal; 2 Department of Biology, Faculty of Sciences and Technology, University of the Azores, Ponta Delgada, Portugal. *isabel.mm.borges@uac.pt

*Aphis frangulae* is a major phytosanitary problem for *Frangula azorica* (Rosales: Rhamnaceae), an endemic plant from the Macaronesia region that is mass produced in nursery conditions by the Azorean Forestry Services in order to be used on conservation programs. The suitability of *A. frangulae* for the development and reproduction of *Scymnus nubilus* was assessed under laboratorial conditions (25±1° C, 75±5% relative humidity, 16L:8D light regime). Consumption tests were also performed. These results were used to design field experimental trials to assess the impact of *S. nubilus* larvae on aphid colonies in both closed and open systems. *Scymnus nubilus* 4th instar larvae and pupae successfully completed development on *A. frangulae* in 9.0±0.2 days and female adults were heavier than males (1.29±0.06 mg vs. 1.06±0.03 mg). Consumption tests showed that 4th instar larvae can ingest 15.1 aphids per day which corresponds to 1.52 mg of biomass ingested. In 24 hours, the larvae increased their weight by 48.4% with a conversion efficiency of 40.3%. On *A. frangulae*, *S. nubilus* females took 5.5±0.3 days to start oviposition and an average of 135±12 eggs were laid per female over the first 15 days, at the rate of 9
eggs/day, with most of the eggs being fertile (84.7%). Field tests showed that S. nubilus 4th instar larvae are more efficient in controlling the pest in closed systems where the effect is more pronounced at high predator densities and at a short term. In open systems, the reduction in the aphid colony size was higher than initially expected. This highlights the role of the natural enemy vast community present in the forestry nurseries which includes *Aphidius colemani*, *Binodoxys*, *Aphidolletes aphidimyza* and syrphids. The results of this study show that *A. frangulae* is an essential prey for *S. nubilus* and therefore the predator can be used in pest management programs against this pest. However further studies focusing on different biological control tactics (innundative or inoculative) and long-term studies are required to assess more accurately the potential role of *S. nubilus* as a biological control agent against *A. frangulae*.

Key words: biological control, ladybird, aphid

03 | Factors of variation in frequency of colour morphs in invasive populations of *Harmonia axyridis*

Honek, Alois1; Brown, Peter M.J.2; Martinkova, Zdenka1; Skuhrovec, Jiri*1; Brabec, Marek3; Burgio, Giovanni4; Evans, Edward W.5; Fournier, Marc6; Grez, Audrey A.7; Kulfan Jan8; Lami, Francesco9; Lucas, Eric10; Lumbeires, Belén11; Masetti, Antonio12; Mogilevich, Timofej13; Orlova-BienkowskiA, Marina11; Phillips, William M.12; Pons, Xavier10; Stroback, Jan1; Viglasova, Sandra8; Zach, Peter8 and Zaviezo, Tania13

1Crop Research Institute, Drnovska 507 CZ 16106 Praha 6 – Ruzyně, Czech Republic; 2Applied Ecology Research Group, School of Life Sciences, Anglia Ruskin University, East Road, Cambridge, CB1 1PT, UK; 3Department of Statistical Modeling, Institute of Computer Sciences ASCR, Prague, Czech Republic; 4Department of Agricultural and Food Science - University of Bologna, Viale G. Fanin 42, 40127 Bologna, Italy; 5Department of Biology, Utah State University, Logan, UT 84322-5305, USA; 6Département des Sciences biologiques, Université du Québec à Montréal, CP 8888, Succ. Centre-ville, Montréal (Qc) H3C 3P8, Canada; 7Facultad de Ciencias Veterinarias y Pecuarias, Universidad de Chile, Chile; 8Institute of Forest Ecology, Slovak Academy of Sciences, Zvolen, Slovakia; 9DAFNAE, University of Padova, Viale dell'Università 16, 35020 Legnaro (PD), Italy; 10University of Lleida, Department of Crop & Forest Sciences – Agrotecnio Centre. Av. Rovira Roure 191. 25198 Lleida, Spain; 11A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 33 Leninskiy Prospect, Moscow, Russia 119071; 124 Archer Close, Loughborough, LE115FF Leicestershire, UK; 13Facultad de Agronomía e Ingeniería Forestal, Pontificia Universidad Católica de Chile, Chile. * jirislavskuhrovec@gmail.com

The Harlequin ladybird *Harmonia axyridis* Pallas, native to eastern Asia, is an invasive non-native species that recently achieved an almost worldwide distribution. A conspicuous feature of this species is colour polymorphism of elytrae. In its native area, the populations consist of a recessive light morph, several dominant dark morphs and a minority of rare morphs. The morph proportions in native populations were intensively studied and vary with geographic area, climate and in time. In contrast, colour polymorphism in invaded region has been little studied. We examine morph frequencies across different invaded regions, and their likely causes. In America, monomorphic populations consist of the *sucinea* morph while European populations contain a fraction of dark morphs. In particular geographic areas of Europe, the average percentage of the *sucinea* morph varied between 78–99%. It was highest in lowlands of northern Italy and central and northern Europe and decreased in Alps and western (Spain, UK) and eastern (southeast Russia) margins of the recently invaded area. In Central Europe, frequency of the *sucinea* morph decreased with the course of the season and increased through years, between 2010–2018. The local differences thus might arise through gradual change of original morph composition of founder invasive non-native populations. However, the variation in *sucinea* morph frequency was not correlated with climatic characteristics that might affect coccinellid polymorphism. The observed rate of change in morph proportions was too small to explain diversification of a supposedly initially uniform invasive non-native population within 15 years elapsed from its establishment in western Europe.

Key words: polymorphism, alien species, distribution, variation, climate, selection
04 | Location and plant variety influences endosymbiont communities in banana aphid from Abaca (*Musa textilis* Nee) in the Philippines, but does genotype?

Galambao, Marciana B.*1; Griffiths, Sarah M.1; Preziosi, Richard F.2; Zytynska, Sharon E.2 and Rowntree, Jennifer K.1

1Ecology and Environment Research Centre, Department of Natural Resources, Manchester Metropolitan University, Manchester, United Kingdom; 2Department for Ecology and Ecosystem Management, Technical University of Munich, Munich, Germany. *galambao@stu.mmu.ac.uk

Abaca (*Musa textilis* Nee) is a fibre crop indigenous to the Philippines. It is one of the major sources of foreign exchange earnings and employment generation in the country. However, the abaca industry is threatened by destructive viral diseases such as bunchy top virus, mosaic and bract mosaic virus that significantly lower the yield of abaca fibre. The banana aphid (*Pentalonia nigronervosa* Coquerel) is the vector that transmits bunchy top disease, the most destructive disease affecting abaca. Knowledge of the bunchy top vector and an understanding of how it interacts with the host plants, the virus, and symbionts are important for disease management. Endosymbionts (usually bacteria) are commonly present in aphids and are believed to confer resistance and susceptibility to diseases, modify the phenotypes and host plant preference of insects, and provide protection against natural enemies. In this study, banana aphids were collected in 55 Abaca plant varieties from three abaca germplasm collections in the Philippines and their endosymbionts communities were identified. Four endosymbiotic bacteria were found to infect banana aphids living on Abaca plants in the Philippines: *Regiella insecticola*; *Serratia symbiotica; Rickettsia* sp. and *Wolbachia*. The identification of *Serratia symbiotica* is the first report of this endosymbiont in banana aphids from the Philippines. Endosymbiont community varied across location and plant variety and within aphid colonies. Host genotype also potentially influences endosymbiont infection and genetic analyses are underway to test this. Results of these analyses will be presented along side the endosymbiont data. We anticipate that this information will provide us an insight for the development of efficient control strategies against bunchy top disease for abaca.

Key words: endosymbiotic bacteria, bunchy top virus, fibre crop, *Pentalonia nigronervosa*

05 | Low-risk insecticides to alternate with pyrethroids for conservation of the pyrethroid-resistant ladybug *Eriopis connexa* (Coleoptera: Coccinellidae)

Torres, Jorge B.1*; Nascimento, Deividy V.1; Lira, R.1; Barbosa, Paulo R.2; and Barros, Eduardo M.3

1Departamento de Agronomia- Entomologia, Universidade Federal Rural de Pernambuco, Rua Dom Manoel de Medeiros s/n, Dois Irmãos, 52171-900, Recife - PE, Brazil; 2Instituto Federal Goiano – Campus Posse, Brazil; 3Instituto Goiano de Agricultura, Goiás, Brazil. *jorge.torres@ufrpe.br

Spinetoram, spinosad, and chlorantraniliprole are insecticides from spinosyn and diamide classes recommended against lepidopteran larvae and other defoliating species. Therefore, they do not share the target of Coccinellinae ladybug that preys primarily upon aphids, a group with various key pest species. Previous data have categorized spinosad and chlorantraniliprole as low risk for *Eriopis connexa* and other ladybugs. In this work, we evaluated the interaction of spinetoram using the field rates 0.08, 0.12, and two-fold the highest field rate (ca., 0.24 g i.a./L) with different stages of the neotropical ladybug, *Eriopis connexa* (Germar), regarding two different populations: susceptible (SUS) and resistant (R-SEL) to pyrethroids, which are another class of insecticides also widely recommended against defoliating pest species. Ladybug egg mass might be contaminated through spray; spinetoram applied over the egg masses resulted in similar development and hatching across spinetoram rates and ladybug populations. However, newly hatched larvae from the treated R-SEL population exhibited reduced
survival during the first instar compared to untreated and the lower spinetoram rate. Ladybug larvae forage on treated surface for prey items; 6-day-old larvae confined on treated cotton leaves exhibited similar developmental duration, pupation, and emergence rates. Nonetheless, larvae of similar age caged on treated leaves and infested with aphids that promote dried residue and ingestion of contaminated prey resulted in lower pupation rate at the highest spinetoram field rate for both beetle populations. Adults from both ladybug populations caged on either spinetoram-dried residues or dried residues plus contaminated aphids exhibited similar egg production and survival. Based on these findings, spinetoram seems to be compatible with E. connexa irrespective of resistance trait to pyrethroid. Therefore, spinetoram can be another option for insecticide recommendation against lepidopteran larvae to conserve the ladybug E. connexa.

Key words: nontarget effect, pyerethroid resistance, physiological selectivity, spinosyns

06 | Sub-lethal effects of the insecticide (GF-120 ©) used in organic farming on the oviposition behaviour of a biological control agent, Aphidoletes aphidimyza Rondani (Diptera: Cecidomyiidae)

Bernardo-Santos, Jonathan*1; Sentis, Arnaud2; Vickery, William1 and Lucas, Eric1.

1 Laboratoire de Lutte Biologique, Département des Sciences Biologiques, Université du Québec à Montréal (UQAM), CP 8888, succursale Centre-Ville Montréal (Québec, CANADA) H3C 3P8; 2 UMR RECOVER, IRSTEA, Aix Marseille Univ., 3275 route Cézanne, 13182 Aix-en-Provence, France. *jonathan.bsantos.jbs@gmail.com

Larvae of the aphidophagous Aphidoletes aphidimyza Rondani (Diptera: Cecidomyiidae) are slow-moving, furtive predators that are used to control aphid populations. The oviposition behaviour of A. aphidimyza is of importance for biological control as the females select oviposition sites based mainly on aphid abundance and larvae do not disperse across aphid colonies. Females usually lay individual eggs proportionally to aphid abundance. In the present study, we first released A. aphidimyza females in an apple orchard and we observed an alternative oviposition behaviour, not previously described, consisting in laying eggs in large clutches in both the presence and absence of aphids. The number of eggs in these clutches was not correlated with aphid abundance unlike the “normal” single egg strategy. Moreover, we observed a clutch of 48 eggs without aphids which has never been described before for this species. We suspected that this atypical behaviour has been induced due to female intoxication by an insecticide used in organic farming (GF-120 ©, active component: Spinosad) sprayed close to our experimental site. In the laboratory, tests were conducted on individual potato plants using two treatments, with and without GF-120 ©. The concentration used was 1:100 mL of GF-120© (Spinosad Content: 0.02%) which corresponds to 1/20 of the recommended concentration. Each replicate included a 5-leaf potato plant, 40 green peach aphids (Myzus persicae Sulzer), and two A. aphidimyza adults. The tests lasted 65 hours. The results showed that, even at a supposedly non-lethal concentration, there was still some mortality (about 50%) in adults when in contact with the insecticide. GF-120 © also modified the oviposition behavior of females by generating atypical laying eggs patterns (clutches of eggs in the absence of aphids). We next questioned the adaptive value of this behaviour given that neonate larvae can only disperse approximately 6 cm to find their first prey. These results demonstrate the difficulty in using both GF-120 and A. aphidimyza releases in an integrated pest management program.

Key words: spinosad, egg clutch, furtive predator, mortality, sublethal effects
07 | Life cycle and survival rate of a new potential aphidophagous biocontrol agent *Eupeodes americanus* (Diptera: Syrphidae) and comparison with the commercial *Aphidoletes aphidimyza* (Diptera: Cecidomyiidae)

Ouattara, Téné Yacine *1*; Fournier, Marc 1; Rojo, Santos 2 and Lucas, Éric 1

1Laboratoire de Lutte Biologique, Département des Sciences Biologiques, Université du Québec à Montréal (UQAM), Canada; 2Research Group Bioinsecta Bionomy, Systematic and Applied Research on Insects Research Institute CIBIO, Department of Environmental Sciences and Natural Resources, University of Alicante, Spain. *ouattara.tene_ouattara@courrier.uqam.ca

Aphids (Hemiptera: Aphididae) are a major economic problem in many crops in Quebec. Larvae of *Eupeodes americanus* (Wiedemann, 1830) (Diptera: Syrphidae) are common natural enemies of aphids (Hemiptera: Aphididae) in natural and agro ecosystems. The objective of the study was to characterize the life cycle of *E. americanus*, in order to evaluate its potential as a biocontrol agent. The development, survival and longevity of *E. americanus* were determined and compared with those of the commercial aphid gall midge *Aphidoletes aphidimyza* (Rondani, 1847) (Diptera: Cecidomyiidae) in laboratory conditions using *M. persicae*. The adult longevity of *E. americanus* was four times longer than that of *A. aphidimyza*, while the preimaginal (eggs to adults) developmental time was similar for both species. Larval development was significantly longer in *E. americanus* than that in *A. aphidimyza* (less than one day). Sex ratio was not different from 50%/50% in both species. Egg hatching rate, larval survival rate and pupal emergence rate were similar in both species. For *E. americanus*, several results such as a higher adult longevity or a longer larval developmental time demonstrated its potential as a new aphidophagous biocontrol agent.

Key words: *Eupeodes americanus*, development cycle, survival rate, adult longevity, *Aphidoletes aphidimyza*, *Myzus persicae*

08 | Impact of contrasted spatial and temporal crop richness on spillover of natural enemies and associated biocontrol services against aphids: a case study on *Harmonia axyridis*

Thomine, Eva 1*; Rusch, Adrien 2; Supplisson, Camille 1, Monticelli, Lucie S 1, Amiens-Desneux, Edwige 1, Lavoir, Anne-Violette 1 and Desneux, Nicolas 1*

1Université Côte d’Azur, INRA, CNRS, UMR ISA, 06000 Nice, France; 2INRA, ISVV, Univ. Bordeaux, Bordeaux Sciences Agro, UMR SAVE, F-33883 Villenave d’Ornon, France. *nicolas.desneux@inra.fr and eva.thomine@inra.fr

Aphids are pests causing major damages on crops but their population can be reduced by natural enemies. High plant biodiversity is known to have a positive impact on biocontrol services. However, few studies have assessed how differential spatial and temporal crop richness actually impact biocontrol services on aphids. Within this framework, using a four-cage maze system under laboratory conditions, we evaluated the effect of a highly diversified crop system (four crops, namely cotton, tomato, squash and soybean) and low diversified crop systems (one single crop), on the predator *Harmonia axyridis* (Pallas) population and predation capacity on aphids. The system varied food availability both in space, i.e. different cages, and in time, i.e. different dates of resources implementation. In general, the effects observed in the highly diversified crop system resulted from the additive effects of the individual low diversified crop systems; the impact of the predator was highly dependent on the plant. The predator laid more eggs and had a higher survival rate on the squash low diversified crop system. However, it showed a similar biocontrol activity on aphids in the tomato and squash low diversity crop systems as well as in the highly diversified one. Low diversified crop systems actually proved to be either very suitable for the predator development and its biocontrol activity (tomato and squash), or not at all (soybean and cotton). The spillover of the ladybird was strongest in the squash low diversified crop system and lowest in the cotton one, other systems showing intermediate spillover values. In the highly diversified crop system, the ladybird presence
was always closely related to plant presence. Still, the predator was also found in cages lacking plant, as opposed to the low diversified crop systems; it hinted the potential of the highly diversified crop system to promote ladybird dispersal and increase foraging activity. We demonstrate that increasing crop diversity in agroecosystems may help promoting biocontrol services provided by *H. axyridis* and notably through promoting its spillover among crops (e.g. while the plants are senescing and/or when they are harvested).

Key words: polyculture, monoculture, resource diversity, ladybird, generalist predator, aphid

**09 | Phylogenetic relationships of aphid parasitoids from the genus *Lipolexis* Förster (Hymenoptera, Braconidae, Aphidiinae) with recognition of six new species**

Tomanović, Željko*; Petrović, Andjeljko1; Kocić, Korana1; Čkrkić, Jelisaveta1; Aparicio, Yahana2; Arnó, Judit2; Kavallieratos, G. Nickolas3; Hebert, Paul D. N.4; Rakshani, Ehsan5 and Starý, Petr6

1University of Belgrade, Faculty of Biology, Institute of Zoology, Belgrade, Serbia; 2IRTA, Cabrils, Barcelona, Spain; 3Agricultural University of Athens, Department of Crop Science, Laboratory of Agricultural Zoology and Entomology, Athens, Attica, Greece; 4Centre for Biodiversity Genomics, Biodiversity Institute of Ontario, University of Guelph, Canada; 5Department of Plant Protection, College of Agriculture, University of Zabol, Zabol, I.R. Iran; 6Institute of Entomology, Biology Centre, Laboratory of Aphidology, AVCR, České Budějovice, Czech Republic *ztoman@bio.bg.ac.rs

The genus *Lipolexis* Förster is thought to be one of the least diverse genera of Aphidiinae. Both known species, *L. gracilis* and *L. oregmae* Gahan, are thought to have near-global distributions and to attack a very wide range of aphids in orchards, vegetable, forage and wheat crops. Two additional species were described from India (*L. pseudoscutellaris* Pramanik&Raychaudhuri and *L. myzakkaiae* Pramanik&Raychaudhuri) and one from China (*L. wuyiensis* Chen). However, they are sporadically mentioned in literature; some authors treat *L. pseudoscutellaris* as a synonym of *L. oregmae*, while some retain its species status. *Lipolexis myzakkaiae* and *L. wuyiensis* are currently recognized as valid species, but based on their morphological descriptions, all three species are conspecific with *L. oregmae* in our opinion. Despite their importance as biocontrol agents, taxonomic investigations on *L. gracilis* and *L. oregmae* are limited to a few old studies. Our preliminary examination of several *Lipolexis* populations revealed high variability in characters that are typically diagnostic of different species. As a result, we re-examined all available *Lipolexis* specimens, including those from BOLD (boldsystems.org), using both morphology and sequences from the barcode region of the COI gene. Patterns of sequence divergence at COI was congruent with morphological variability, indicating the presence of eight phylogenetic clades with distances ranging from 2.5% to 27.5%. The joint morphological and molecular results enabled recognition of five new species in the “gracilis” group: *Lipolexis* sp.n.1 – Spain (*Myzus persicae* Sulzer), Slovenia (*Aphis fabae* Scopoli), China (*Aphis gossypii* Glover), Japan (*Melanaphis sacchari* Zehntner), *Toxoptera aurantii* (Boyer De Fonscolombe)); *Lipolexis* sp.n.2 – Pakistan (*A. gossypii*), India, Bangladesh; *Lipolexis* sp.n.3 - China, Japan (*A. gossypii*); *Lipolexis* sp.n.4 – Greece (*A. fabae*), Montenegro (*Aphis punicae* Passerini), Bosnia and Herzegovina (*A. fabae, A. hederae* Kaltenbach); *Lipolexis* sp.n.5 – Serbia (*Myzus cerasi* (F.), *A. fabae*), Croatia (*Anoecia corni* F., *Myzus lythri* (Schrank)), Spain (*M. persicae*), Slovenia (*M. cerasi*), Bulgaria, Moldova (*M. cerasi*), and one new species from the “oregmae” group: *Lipolexis* sp.n.6 - Bangladesh. The ecological and biocontrol roles of all *Lipolexis* taxa from various crops should be evaluated in the light of those findings.

Key words: barcoding, taxonomy, phylogeny, aphids, biological control
10 | Possible ways of wing vein reduction in Aphidiinae (Hymenoptera: Braconidae)

Žikić, Vladimir*1; Čkrkić, Jelisaveta2; Petrović, Andjeljko2; Stanković, Saša S1; Milošević, Marijana Ilić1; Klingenberg, Christian Peter3; Tomanović, Željko2 and Ivanović, Ana2

1Department of Biology and Ecology, Faculty of Sciences and Mathematics, University of Niš, Serbia; 2Institute of Zoology, Faculty of Biology, University of Belgrade, Serbia; 3School of Biological Sciences, University of Manchester, UK.

Wing vein reduction occurs in many Braconidae subfamilies, especially in Euphorinae and also Aphidiinae, one of the well investigated groups of parasitic wasps. We explored wing venation patterns of 55 species from 13 genera of Aphidiinae covering almost all types of wing venation within the subfamily Aphidiinae. To explain the phylogenetic background of wing vein reduction we used a landmark-based geometric morphometrics method and a phylogenetic comparative analysis. Thus, we tested whether evolutionary changes in wing shape correlate to the changes in wing venation and whether both changes depend on the size of the wings. With different degrees of vein reduction which can be observed in analyzed Aphidiinae taxa, eight wing venation types are recognized and defined. We found that the Ephedrus wing venation type is basic for Aphidiinae from which three directions of vein reduction can be explained. Generally, wing venation type is largely genus specific, except in the case of much reduced wing venation which could be found across the examined Aphidiinae taxa. The reconstruction of evolutionary changes in wing venation indicates that changes in wing vein distribution, also the whole wing shape are related to the changes in general wing size. We also noted that wings with much reduced wing venation (only radial vein left) and maximally reduced wing venation (no veins in the distal part) affect stigma; shortening its length making it more or less triangular; which can be connected with the theory of miniaturization of the insect body, or some morphological structures. Based on the results, it seems that the reduced wing venation have evolved independently in the subfamily several times.

Key words: parasitoids, comparative analyses, geometric morphometrics, evolution

11 | Aphids out of control – How defensive symbiosis affects parasitoid biocontrol success

*Donner, Helena1;2; Pannebakker, Bart1; Verhulst, Eveline2; Zwaan, Bas1; Dicke, Marcel1

1Laboratory of Genetics, Wageningen University, Wageningen, the Netherlands; 2Laboratory of Entomology, Wageningen University, Wageningen, the Netherlands. *Helena.Donner@wur.nl

Biological control of crop pests is becoming more important with the regulations on pesticide use becoming stricter. While for the biocontrol of aphid pests, parasitoid wasps are considered especially effective, they have been employed with varying degrees of success. Therefore, optimization is still necessary. Since facultative symbionts have been found in almost all pest aphid species studied so far, this could pose an underestimated threat to biocontrol efficiency. Laboratory studies on endosymbiont-conferring resistance in aphids have shown that parasitoid biocontrol can be seriously affected by defensive symbiosis. Studies on endosymbiont-conferring resistance in aphids have been limited to laboratory and field situations. Information on the effects of symbiont-conferring resistance in greenhouses is currently lacking. A greenhouse study is necessary considering the possible consequences of endosymbiont-conferring resistance on parasitoid augmentative biocontrol strategies. We are currently undertaking the first large-scale greenhouse study on the effects of endosymbiont-conferring resistance on parasitoid biocontrol success.

Key words: parasitoids, greenhouse biocontrol, integrated pest management, endosymbionts
12 | Insect netting: effect of mesh size on exclusion of some natural enemies of aphids under laboratory and orchard conditions

Chouinard, Gérald1,*; Pelletier, Francine1; Larose, Mikael1; Tavares, Jason2; Knoch, Simon2 and Dumont, Marie-Josée3
1Institut de recherche et développement en agroenvironnement, St-Bruno-de-Montarville, Canada; 2École Polytechnique de Montréal, Montréal, Canada; 3Université McGill, Montréal, Canada. *gerald.chouinard@irda.qc.ca

Exclusion nets can prevent damage caused by the majority of apple pests but can sometimes be accompanied by increased infestations of aphids of various species, possibly related to the exclusion of their natural enemies. To get insights on possible improvements of exclusion systems currently being developed for tree fruits, the permeability of different nets to *Aphidoletes aphidimyza* (Diptera: Cecidomyiidae), *Aphidius matricariae* (Hymenoptera: Braconidae) and *Aphelinus abdominalis* (Hymenoptera: Aphelinidae) was tested in laboratory. Six nets with mesh sizes ranging from 0.4 to 2.8 mm were 3D-printed from strands of polylactic acid (PLA) and compared to two similar-type commercial nets made of polyethylene (HDPE): ProtekNet60 (0.95 x 1,90 mm) and Artes5x4 (2.2 x 3.4 mm), which were also tested in field experiments. The abundance of natural enemies on infested apple shoots was surveyed weekly in netted and unnetted plots. Under laboratory conditions, *A. matricariae* and *A. abdominalis* were able to pass through net aperture only slightly larger than the width of their thorax while for *A. aphidimyza*, the aperture had to be more than twice its thorax width. In the lab, *A. aphidimyza* was almost completely excluded by ProtekNet’s smaller mesh size, while more than 75% of the individuals were able to pass through Artes’ net. In the field, *A. aphidimyza* represented more than 80% of all natural enemies observed in unnetted plots and almost all of those observed under nets. Abundance of cecidomyiids in trees netted with Artes was similar to that observed in unnetted plots, while significantly lower numbers were observed on trees covered with ProtekNet. Permeability of this net to cecidomyiid was however greater than expected in orchards than in laboratory tests, eggs or larvae being observed on more than 40% of infested shoots. Those results suggest that using nets with a mesh size larger than the current “1x2 mm” standard used in recent studies may favor the entrance of beneficials while continuing to provide effective protection against other apple pests. Also, the use of bio-based polymers to replace fossil-fuel-based products may further improve these systems by reducing the use of pesticides without potentially increasing greenhouse gas emissions.

Key words: apple orchard, mesh size, biopolymer, *Aphidoletes aphidimyza*, *Aphidius matricariae*, *Aphelinus abdominalis*

13 | Voracity, functional response and prey preference of *Nabis americoferus* feeding on tarnished plant bugs and aphids

Solà, Mireia1,2,*; Dumont, François2; Labrie, Geneviève; Provost, Caroline2 and Lucas, Éric1
1 Laboratoire de Lutte Biologique, Département des Sciences Biologiques, Université du Québec à Montréal (UQAM), CP 8888, succursale Centre-Ville Montréal (Québec, CANADA) H3C 3P8; 2 Centre de recherche agroalimentaire de Mirabel, 9850, rue de Belle-Rivière, Mirabel (Québec, CANADA) J7N 2X8; *msola@cram-mirabel.com

The damsel bug, *Nabis americoferus* (Carayon) (Hemiptera: Nabidae) is a polyphagous predator commonly found in valuable cultures of North America. *Nabis* species can feed on several important agricultural pests such as the tarnished plant bug (TPB), *Lygus lineolaris* (Palisot de Beauvois) (Hemiptera: Miridae) or aphids such as *Myzus persicae* (Sulzer) and *Aphis gossypii* (Glover) (Hemiptera: Aphididae). Both pest groups can be often found together in strawberry fields and cucumber greenhouses. Understanding functional and numerical responses is important for biological control purposes. However, few information on *N. americoferus* predatory capacity is
available. We tested the level of voracity, the functional response and the prey preference of the predator on these two major agricultural pests under controlled conditions in the laboratory and in the greenhouse. For the laboratory experience, one fastened *N. americoferus* adult was allowed to feed for 24h on a different density of preys (TPB or *M. persicae*) in a small aerated arena containing one strawberry leaf and the number of survival preys were assessed. For the greenhouse experiment, 3 adult *N. americoferus* were introduced in cages with cucumber plants initially infested with: 1) TPB, 2) *Aphis gossypii* or 3) a mixture of both. A control with the mixture of preys but without the predator was also prepared. After six weeks, the three populations were evaluated. Tests are currently on-going. Fresh results will be presented during the conference. With this study, we expect to provide valuable information of the predatory capacity of *N. americoferus* to present this species as a potential control agent against tarnished plant bugs and aphids.

Key words: Biological control, damsel bug, *Ligus lineolaris*, *Myzus persicae*, *Aphis gossypii*, predator.

14 | Evaluation of the predatory behaviour of the hoverfly Eupeodes americanus (Diptera: Syrphidae)

Levi Garcia-Mourão, Alexandre*; Meseguer, Roberto; Pons, Xavier and Lucas, Eric

Universitat de Lleida, Agrotecnio Centre, Lleida, España; Laboratoire de Lutte Biologique, Université du Québec à Montréal (QC) Canada

Predation strategies differ among aphidophagous insect species and critically impact their performance when exploiting aphid colonies. In this study, we aim to determine whether the predation strategy of the third instar larvae of the american hoverfly *Eupeodes americanus* Wiedemann (Diptera: Syrphidae) is active-searching like aphidophagous ladybird beetle larvae (Coleoptera: Coccinellidae) or if, conversely, it shows a furtive predation strategy, like the cecidomyid *Aphidoletes aphidimyza*. The aphid colony disturbance triggered by the third instar larvae of *E. americanus* was evaluated and compared with that of the active-searching ladybird beetle *Harmonia axyridis* Pallas, after inoculation close to a pea aphid, *Acyrthosiphon pisum* (Harris) (Hemiptera: Aphididae) colony. Results indicate that aphids showed significantly fewer defensive acts (walking away, dropping, wriggling, kicking) in the presence of *E. americanus* larvae, than in the presence of ladybird beetle 3rd instar larvae. Furthermore, the impact of *E. americanus* larvae on aphid colony disturbance was similar to that of the control treatment without predators. These results clearly indicate that *E. americanus* larvae use a furtive predation strategy.
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