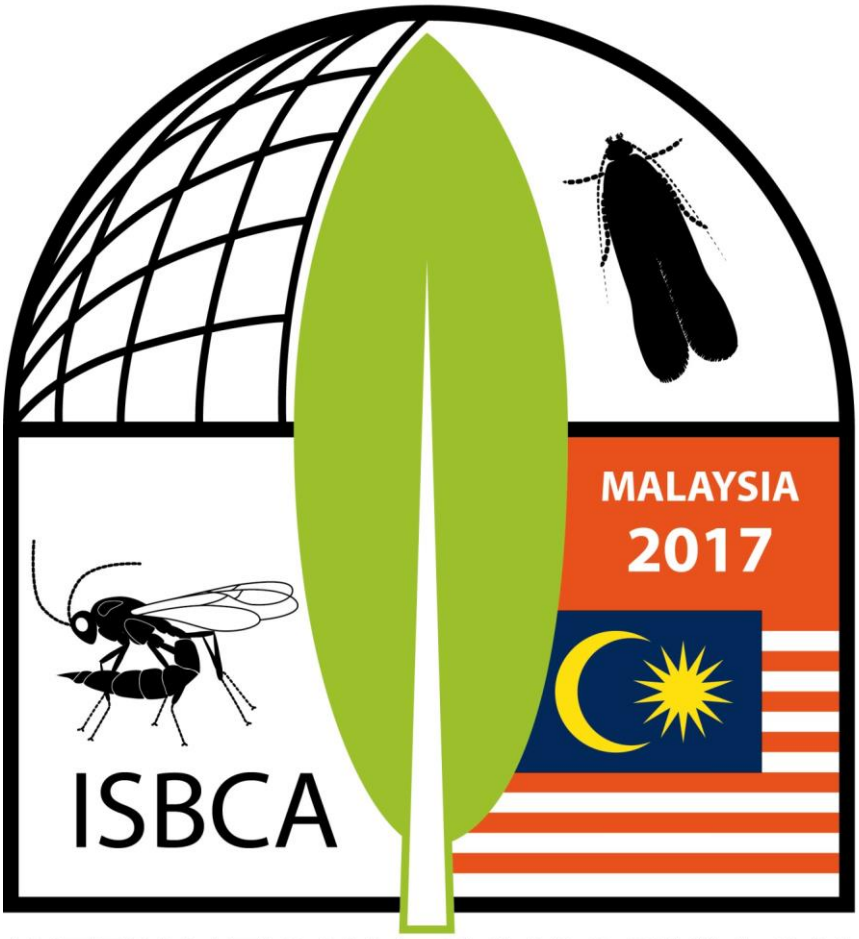


# INTERNATIONAL SYMPOSIUM ON BIOLOGICAL CONTROL OF ARTHROPODS

# LANGKAWI

## September 11-15, 2017

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## Scientific Programme

**including short abstracts and participant list**

**Conference Venue - Meritus Pelangi Hotel, Langkawi, Malaysia**

# Preface

The Fifth International Symposium on Biological Control of Arthropods, held in Langkawi – Malaysia, continues the series of international symposia on the biological control of arthropods organized every four years. The first meeting was in Hawaii – USA during January 2002, followed by the Davos - Switzerland meeting during September 2005, the Christchurch – New Zealand meeting during February 2009, and the Pucón – Chile meeting during March 2013. The goal of these symposia is to create a forum where biological control researchers and practitioners can meet and exchange information, to promote discussions of up to date issues affecting biological control, particularly pertaining the use of parasitoids and predators as biological control agents. This includes all approaches to biological control: conservation, augmentation, and importation of natural enemy species for the control of arthropod targets, as well as other transversal issues related to its implementation.

To this end, 14 sessions have been organized in order to address the most relevant and current topics in the field of biological control of arthropods, delivered by invited speakers, contributed talks and poster presentations. Some of these topics have remained as important issues since the first meeting, for example, the understanding of non-target impacts in arthropod biological control and biological control as the cornerstone of successful integrated pest management programmes, underlined by an understanding of the compatability of biological control with pesticide applications. Since the beginning we have also talked about the importance of regulation and risk assessment methodology. This still remains an important topic, but today biological control practioners also need to be better prepared for implementing access and benefit sharing policies relevant for classical biological control practices. But also, as new tools and environmental concerns arise, some fresh interdisciplinary topics have emerged. These days the importance of ensuring that baseline data are in place is far better recognised in order to be able to assess the impact of biological control programmes. This is not only a cost-benefit anaylsis, it also looks at the socio-economic impact of biological control and the effect on livelihoods. In this context, it is also rather important to understand the uptake of existing biological control solutions in low and lower middle income countries in order to be able to formulate strategies to replace the use of highly hazardous pesticides through the use of biological control agents. Ecological questions also remain at the forefront of biological control research. Topics that are currently high on the agenda include understanding the role of native and exotic natural enemies, as well as the importance of pre- and post-genetics in biological control.

Another important goal of these meetings has been to be truly international, and this is why every conference so far has been organized in a different continent. This year we are holding the meeting in Asia for the first time ever and again we have around 130 participants from around the world. As a result, this meeting represents an opportunity for creating and expanding networks between researchers worldwide, in particular researchers from South-East Asia who have not been in the position to attend the preceding meetings.

Thus we expect that the 5th International Symposium on Biological Control of Arthropods will be an important milestone in maintaining forward momentum with arthropod biological control research and practice. In doing so, this will contribute towards improving the sustainability of managed systems and protecting biodiversity on the planet, thus contributing towards the Sustainable Development Goals (Transforming our world: the 2030 Agenda for Sustainable Development).

# Acknowledgements

We are very grateful to the following individuals for their help in organizing the 5th International Symposium on Biological Control of Arthropods:

Scientific Committee:
Ulrich Kuhlmann (CABI, Switzerland), Barbara Barratt (AgResearch Ltd., New Zealand), Jacques Brodeur (University of Montreal, Canada), Mark Hoddle (University of California – Riverside, USA), Nick Mills (University of California – Berkeley, USA), Tania Zaviezo (Universidad Católica, Chile) and Matthew Cock (CABI, UK).

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Proceedings Editors:
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# Sunday, 10 September 2017

| | |
|---|---|
| **17:00** | **Registration at Meritus Pelangi Hotel** |

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| **19:00** | **Welcome Reception at Meritus Pelangi Hotel** |

# Monday, 11 September 2017

Session 1

Don Weber, USA

Tim Haye, Switzerland

## Accidental introductions of biocontrol agents: positive and negative aspects

**08:00**

### Introduction & Accidental introductions of natural enemies: causes and implications

Don Weber

Accidental introductions of natural enemies, including parasitoid and predatory groups, may exceed species introduced intentionally. Several factors favor this: a general surge in international trade; lack of surveillance for species that are not associated with live plants or animals; inability to intercept tiny organisms such as scelionid parasitoids; huge invasive host populations in source and/or receiving areas that allow rapid establishment; and lack of aggressive screening for pests already established. Recent frequent and surprisingly rapid accidental natural enemy introductions call into question the regulatory emphasis on a rigorous and protracted process for classical biocontrol introductions, when adventives have a high probability to displace or disrupt this planned process.

**08:20**

### Risks and benefits of accidental introductions of biological control agents in Canada

Peter G. Mason

Introduction of natural enemies associated with invasive alien species occurs more frequently than thought. Such introductions are usually detected well after the host has invaded and established in new regions, sometimes even during or after host range studies have been initiated. In Canada, accidental introductions of natural enemies have resulted in unforeseen benefits to manage invasive alien species as well as potential risks to biodiversity. *Macroglenes penetrans* is a key parasitoid in reducing populations of wheat midge in western Canada and conservation of this species has had economic and environmental benefits due to reduced pesticide use. *Trichomalus perfectus* is a key parasitoid of the cabbage seedpod weevil but its host range includes native weevils as well as weed biological control agents. These case studies demonstrate the importance of understanding host range of key natural enemies of invasive alien species and of monitoring exotic natural enemies once present in the invaded region.

**08:40**

### Adventive vs. planned introductions of *Trissolcus japonicus* against brown marmorated stink bug: an emerging case study in real-time

Kim Hoelmer

The scelionid egg parasitoid, *Trissolcus japonicus*, is a key natural enemy of brown marmorated stink bug, *Halyomorpha halys,* in its native Asian range. It has been studied as a candidate biocontrol agent for introduction into North America, where *H. halys* is a damaging invasive pest. Besides *H. halys*, the wasp attacks several other pentatomid hosts in Asia, and no-choice laboratory tests show that it is also capable of attacking some, though not all, native American hosts, with varying degrees of successful development. Behavioral cues result in additional host selectivity. Adventive populations were recent;y discovered in North America, which give opportunities to contrast their actual impact on invasive *H. halys* and native non-target species with the laboratory predictions.

## 09:00 Can native parasitoids benefit from accidental introductions of exotic biological control agents?

Tim Haye

In recent years the unintended introductionof exotic parasitoids associated with invasive pest insects has been observed more frequently. Competitive displacement (or even exclusion) of other parasitoids, both endemic and introduced, is one possible outcome. A previously unexplored possibility is that interspecific facilitation by introduced parasitoids could benefit native parasitoids. In a case study, we demonstrate that the accidental introduction of *Trissolcus japonicus* could facilitate the use of a primary invader (*Halyomorpha halys*) as host by native Trissolcus species, which would otherwise be an evolutionary trap.

## 09:20 Accidental introduction into Italy and establishment of *Aprostocetus fukutai* (Hym.: Eulophidae) in citrus longhorned beetle infestations

Franck Herard

*Anoplophora chinensis* (CLB) was accidentally introduced from Asia into 11 European countries, putting at risk a wide range of broadleaf trees. It was eradicated in 9 countries, but Italy still has residual populations. The gregarious egg parasitoid *Aprostocetus fukutai*, which is native to Asia was discovered in CLB infestations near Parabiago, Italy in 2002. Biomolecular data shows Japan as the country of origin. We present data on the geographical distribution in Italy, development cycle, impact on host in the field, and tests of host specificity. *A. fukutai* has features of good biocontrol agent, but moderate dispersal ability that led us to develop a release technique to artificially spread the parasitoid to isolated pest populations.

## 09:40 Inadvertent reconstruction of exotic food webs: biological control harms and benefits

Joe M. Kaser

As the rate of spread of invasive species continues to increase, exotic species are frequently re-connected with accidentally introduced natural enemies from their native range. These introduced natural enemies are often polyphagous and have the potential to suppress the invasive resource population as well as interact with native species through a variety of direct and indirect pathways. Using a combination of mathematical modeling and experimental work in the lab and field, we examined the introduced aphid parasitoid *Aphelinus certus* which attacks the invasive soybean aphid in North America. Findings are contrasted with other natural enemy-invasive species interactions, and are discussed in the context of biological control risk-benefit assessment.

## 10:00 Coffee Break

## 10:15 Opening Ceremony of the 5th ISBCA, Malaysia, 2017

- **Welcome Address from the Vice-Minister of Agriculture**

# Monday, 11 September 2017
Session 2


Stephen Goldson, New Zealand


Richard Stouthamer, USA

## The importance of pre and post release genetics in biological control

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**10:45**

### Practical management of the genetics of classical biocontrol introductions


Richard Stouthamer

The management of the genetics natural enemies in classical biological control introductions has been a topic of numerous papers that have laid out the problems that may occur during the process of their introduction. Many of these papers suggest approaches to avoid these problems, however in very few, if any, classical biological control projects much attention has been paid to applying these approaches to maintain the genetic quality of the introduced natural enemies. It is thought that despite the theoretical importance of managing the genetics, in "the real world" it is merely a nuisance. Here I will present arguments why it is important and show that taking the steps to maintain the genetic quality of the introduced natural enemies is not complicated nor expensive.

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**11:05**

### Genetic diversity of field and laboratory populations of *Mastrus ridens* and consequences of inbreeding during laboratory culture


Tania Zaviezo

*Mastrus ridens*is a parasitoid of codling moth, imported to USA and moved from laboratory to laboratory for the next 20 years. Is a good model to document the importance of genetics in biological control. We compared genetic diversity of laboratory and field populations, evaluate their genetic differentiation and consequences of inbreeding. Genetic diversity and differentiation were congruent with historical data. Genotyping and flow cytometry revealed occurrence of diploid males, suggesting complementary sex determination (CSD). Females under inbreeding produced less daughters and a more male biased sex ratio. Higher proportion of diploid males were produced under inbreeding, they were fertile but produced less daughters. This research highlight the importance of maintaining genetic diversity while rearing and that molecular tools should be implemented more frequently in biological control programs.

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**11:25**

### Effects of genetic diversity, inbreeding and outbreeding investigated in six reared or released biocontrol agents


Thibaut Malausa

Genetics are expected to impact phenotypic traits of biocontrol agents, and as a consequence our capacity to produce them or establish them in the field. Here, we report the main results of studies that investigated the effects of population characteristics (genetic diversity) or genetic processes (inbreeding, outbreeding) on phenotypic traits or population establishment in six biocontrol agents (*Allotropa burrelli*, *Chrysoperla comanche*, *Cryptolaemus montrouzieri*, *Macrolophus pygmaeus*, *Psyttalia lounsburyi*, *Trichogramma brassicae*) under laboratory or field conditions. Although the results varied among species, they revealed positive or negative effects of the studied factors and motivated the start of several projects aiming at managing genetics in biocontrol agent production settings.

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## 11:45 Rapid biocontrol evolution in New Zealand's species-sparse pasturelands

Stephen Goldson

This contribution highlights the uniqueness of New Zealand's pasture environment which is in effect a partial transplant of the Palearctic grasslands found in NW Europe and is far from an evolved ecosystem. The associated lack of biocontrol biodiversity in these pastures has serious implications particularly relating to their spectacularly low biotic resistance to invasive species. Ironically however, this same lack of biotic resistance has also led to outstandingly high parasitoid biocontrol success, including the useful suppression of the severe grass pest the Argentine stem weevil (ASW). However, since 2011, researchers have noticed a resurgence in ASW numbers indicating a serious loss of parasitoid efficacy. Arguably the simplified ecological environment combined with clonal parasitoid reproduction versus sexual weevil reproduction has led to a lopsided evolutionary arms-race. This very rare occurrence is now the subject of intensive ecological and genetic research that is discussed in this contribution.

## 12:05 Food webs, mutliple enemies and biological control

Jason Tylianakis

The number of control agents attacking a target pest may significantly influence both the level and stability of biological control. However, when these agents also attack other (target or non-target) prey, there is potential for indirect effects among prey species, which may strengthen or weaken both biological control and non-target impacts. Knowledge of the use of different prey species by enemies can be used to generate quantitative food webs, and I will discuss examples of parasitoid-host food webs being used to successfully predict attack rates and their stability, as well as indirect effects among host species. Successful predictions of indirect effects can even be made across different habitats when parasitoids use hosts in different crops. Finally, both genetic diversity of a single parasitoid species and the diversity of parasitoids attacking a host may affect the ability of the host to evolve resistance to parasitism, thereby providing stability of control over evolutionary timescales. Thus, enemy diversity may be key to achieving effective and sustainable classical and conservation biological control.

## 12:25 Benefits of pre-release population genetics: a case study using *Psyttalia lounsburyi*, a biocontrol agent of the olive fruit fly in California

Marie-Claude Bon

Incorporating population genetics into research on biological control agents can help improve identification of the best strains for release. The genetic makeup of two geographic strains of the African endoparasitoid *Psyttalia lounsburyi* (Hymenoptera: Braconidae), a biocontrol agent for the olive fruit fly, *Bactrocera oleae*, in California, was evaluated at the onset of the biocontrol program. Since 2006, the parasitoid was released at many sites in California each year, and was first recovered in 2011. Results from a molecular genetic analysis showed that while parasitoids of Kenyan origin were released in higher numbers, those from South Africa were the most frequently recovered, suggesting that they are better adapted and hence should be prioritized for future releases.

## 12:45 Lunch Break

# Monday, 11 September 2017
Session 3


Roy van Driesche, USA


Mark Hoddle, USA

## How well do we understand non-target impacts in arthropod biological control?

**13:45**

### Introduction & Nontarget effects of insect biological control: concepts, examples and trends


Roy van Driesche

We discuss a recent review of nontarget effects of insect biocontrol, noting emerging trends. Nontarget effects discussed include direct attacks; negative foodweb effects such as competition for prey, apparent competition or displacement; positive foodweb effects; hybridization with native species; and attacks on weed biocontrol agents. For the reviewed period of 1985–2015, covering 158 species of introduced parasitoids, there was a shift in the third decade towards agents with an index of genus or species level specificity compared with the first and second decades when nearly half of introductions had family level or above specificity.

**14:05**

### Displacement of native natural enemies by introduced biological control agents in agro-ecosystems: a serious non-target effect or not?


Steve Naranjo

Invasive pest species that colonize new crop habitats are frequently attacked by a suite of native natural enemies that opportunistically take advantage of a new and abundant resource. As more specific exotic natural enemies are introduced to effect pest control, these native enemies are sometimes displaced. This can be interpreted as a negative non-target effect of the introduction, but could also mean that the native natural enemies now continue attacking the native hosts or prey as they did before the invasion. These natives may now exist at their lower natural population densities because their large temporary resource base has either declined (through effective biological control) or are less available because of a superior exotic competitor. Data bearing on this issue are scant, particularly when the native enemies are naturally found in non-crop habitats. This presentation will outline the issues, present and interpret the available data and suggest avenues for increasing our knowledge of the potentially affected non-target species.

**14:25**

### Assessing host use and population level impacts on non-target species by introduced enemies: can host range testing provide insight?


Mark Wright

Assessing population level impacts attributable to introduced natural enemies is a complex challenge. Host range testing is a standard step prior to introduction; but it is typically used to assess physiological host range only. Predictions of non-target impacts made following host range testing showing narrow host range have proven to be very reliable, with very few resulting non-target impacts. But what of species that appear to be ologiphagous in host range testing? Exploring previous records of host use and impacts in places origin of prospective new introductions as biocontrol agents may offer some opportunities for predicting non-target impact in some potential biological control agents.

## 14:45 Parasitoid host ranges: comparing studies from the laboratory and field

George Heimpel

Laboratory assays are used to assess the host-specificity of parasitoids being considered for use as importation biological control agents. The extent to which results from these assays predict the host specificity expressed in the field is often not assessed however. We provide a summary of comparison between laboratory and field host ranges of parasitoid species and report on two case studies from our work. The first involves the aphid parasitoid *Aphelinus certus* (Hymenoptera: Aphelinidae) which attacks a broader range of aphid species in the laboratory than in the field and attacks mainly the soybean aphid in its adventive range in North America. The second is the parasitoid *Conura annulifera* (Hymenoptera: Chalcididae), which was found to be a specialist on flies in the genus *Philornis* in quarantine specificity studies. This conclusion was confirmed in field studies done in its native range of mainland Ecuador.

## 15:05 Can predictive models help to identify the most appropriate non-target species for host specificity testing?

Jacqui Todd

The PRONTI (priority ranking of non-target invertebrates) model was developed to aid the selection of non-target species (NTS) for testing with entomophagous biocontrol agents proposed for release in New Zealand. The model is able to rank hundreds of NTS simultaneously using five criteria: (1) the hazard posed by the agent, (2) the potential exposure of the NTS to the agent, (3) the possible ecological impact resulting from that exposure, (4) the anthropocentric value of the NTS, and (5) the testability of the NTS. We will describe the tool and the results of tests we have conducted using two agents previously released in New Zealand: *Microctonus aethiopoides* (released in 1982 to control *Sitona discoideus*) and *Cotesia urabae* (released in 2011 to control *Uraba lugens*).

## 15:25 What olfactometer tests were able to tell us about non-target risk that no-choice and choice tests could not

Gonzalo Avila

The larval parasitoid *Cotesia urabae* were tested in both Y-tube and four-arm olfactometers to investigate attraction to three non-target lepidoptera species. In a Y-tube olfactometer, female wasps were attracted to the odours of two of the non-target species when larvae were tested on their own and when feeding on their host plants, but not to their non-target host plants alone. The multiple-comparison bioassay conducted in a four-arm olfactometer indicates that target plant-host complex odours consistently produced the strongest attraction compared with any other of the non-target plant-host complex odours tested. The results from this study support the findings of a retrospective risk assessment with *C. urabae* which was conducted using a field cage test under semi-natural conditions, where a significantly stronger preference for the target host was also observed. Olfactory response bioassays could be a useful addition to conventional host-specificity testing methods conducted prior to the release of a candidate parasitoid biocontrol agents.

## 15:45 Coffee Break

# Monday, 11 September 2017
Session 4


Barbara Barratt, New Zealand


Peter Mason, Canada

## Regulation and access and benefit sharing policies relevant for classical biological control

**16:15** **Introduction**

**16:20** **The New Zealand system to assess the environmental benefits and risks of releasing new biocontrol agents of arthropods**


Clark Ehlers

The Environmental Protection Authority (EPA) is the government agency responsible for giving effect to specific environmental management legislation in New Zealand. The EPA is responsible for assessing and managing the risks associated with the importation, development and release of exotic BCA organisms. This paper will present an overview of the regulatory process and discusses the EPA's approach to assessing the risks and benefits of BCA release applications. The EPA works collaboratively with applicants and various interested parties including the scientific community, other government departments, Māori and the public to obtain information that will inform comprehensive qualitative risk assessments. Specific adverse and positive effects include effects on the environment, market economy and Māori are considered. Examples from past BCA release applications will be discussed to demonstrate the effective New Zealand system.

**16:40** **Practical and implementable mechanisms for compliance with the Nagoya Protocol: access and benefit sharing**


David Smith

Live cultures for use in the development of basic and applied science must be collected and utilised in compliance with the regulatory environment. In October 2014 the Nagoya Protocol on Access and Benefit Sharing (ABS) came into force and its implementation is the responsibility of all countries that are signatory to the Protocol. In its work, CABI accesses biological and genetic resources and undertakes sampling and collection of biological materials, among other uses, for developing biological control agents for the management of invasive species. CABI is working with its partners to establish best practices to comply with ABS requirements. During development of the CABI policy several member countries have provided useful feedback. An outline of how CABI has responded to the above will be presented.

**17:00** **Access and benefit sharing: best practices for the use and exchange of invertebrate biological control agents**


Barbara Barratt

The Nagoya Protocol provides a framework for the effective implementation of the fair and equitable sharing of benefits arising out of the utilization of genetic resources. The biological control community needs to demonstrate due diligence in responding to these requirements and to reassure the international community that biological control is a successful and environmentally safe pest management method based on the use of biological diversity. The International Organisation for Biological Control recommends that best practice should include: collaborations to exchange knowledge about what invertebrate biological control agents are available and where they may be obtained; information sharing through freely available databases that document successes; collaborative research to develop capacity in source countries; and technology transfer to provide opportunities for small-scale economic activity

**17:20** **Facilitated discussion**

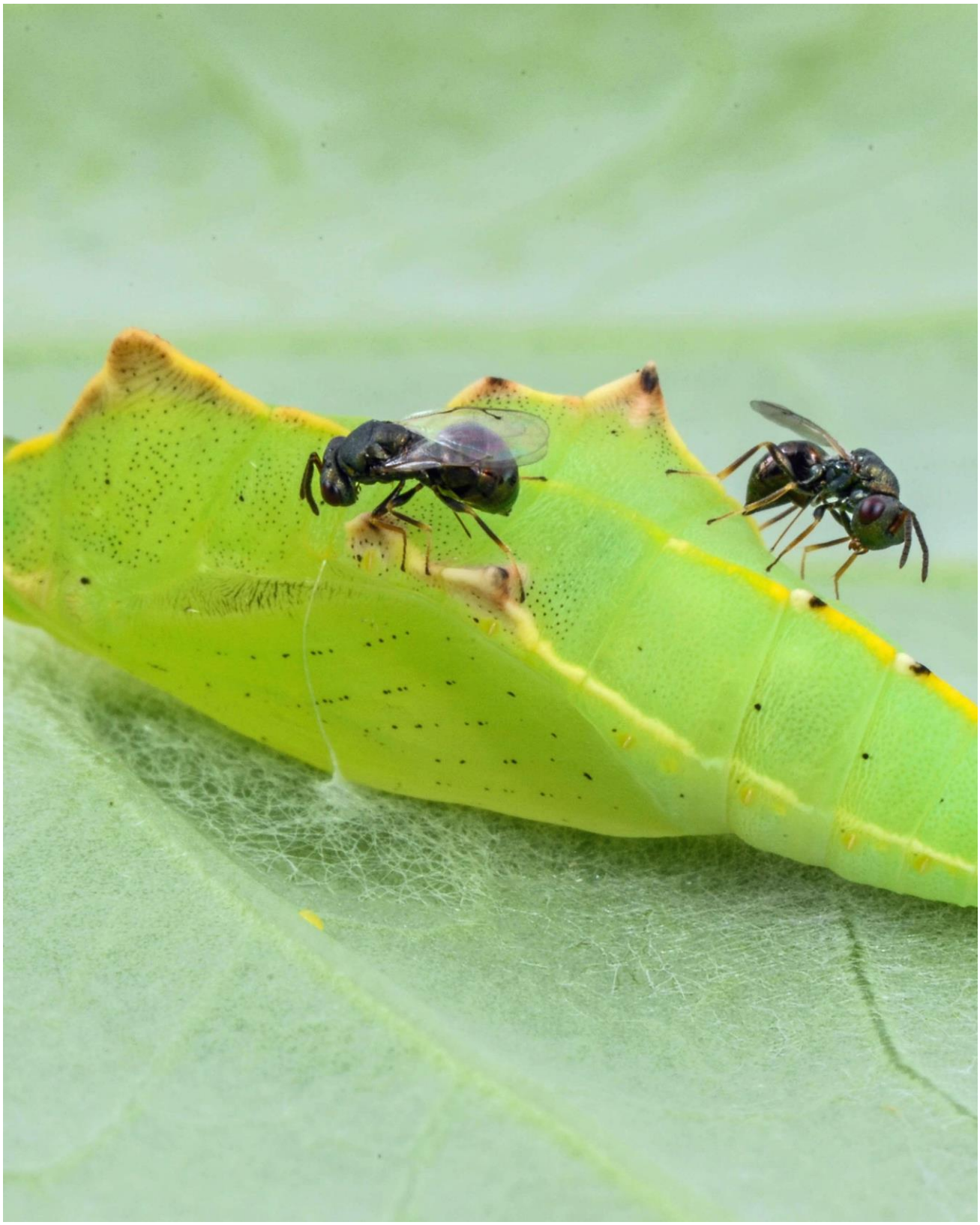


**Photo: Tim Haye, CABI**

# Tuesday, 12 September 2017
Session 5


Tania Zaviezo, Chile


Audrey Grez, Chile

## The role of native and alien natural enemy diversity in biological control

**08:15**

### Native coccinellids and biological control: a positive partnership that can be threatened by the invasion of an alien specie


Audrey Grez

Native natural enemies may play an important role in pest control although this has been scarcely explored in the literature. Agricultural intensification may threaten their populations through habitat homogenization and biological invasions. In alfalfa fields in Chile coccinellids are important predators of aphids. They used to be very diverse and mostly dominated by native species, especially *Eriopis chilensis*, which accounted for most of aphid predation. After the invasion of *Harmonia axyridis* these assemblages have declined in diversity and in the abundance of native coccinellids. In regions where native coccinellids are very scarce and *H. axyridis* and other exotics are relatively very abundant there is no relation between coccinellids and biological control. On the other hand, where natives, especially *E. chilensis*, have higher abundance they are positively associated with biological control. Therefore, the arrival of *H. axyridis* could be disrupting this important ecological service provided by native coccinellids. FONDECYT 1140662.

**08:35**

### Predator invasion disrupts the conservation of natural enemy biodiversity


William Snyder

Agroecologists have long suggested that restoring biodiversity to farms is a critical first step to minimizing pest problems. For example, diverse cropping systems might provide more food and shelter to natural enemies of crop pests, indirectly improving biological control. We have been conducting systems-level examinations of natural pest control with the help of cooperating growers on 100+ working mixed-vegetable farms located all down the western US coast. Across a wide range of climates and landscape contexts, we have uncovered wide variation in biodiversity-biocontrol relationships, sometimes positive but other times negative. For example, we found a strongly positive relationship between biodiversity among dung beetles and the removal of animal feces; this likely reduces the risk that fresh produce will be contaminated with feces-borne human pathogens (e.g., *E. coli* O157:H7). In contrast, diversity among herbivores of *Brassica* crops appears to complicate volatile-chemical profiles of the plants, making it more difficult for parasitoids to locate their hosts and disrupting biological control. For wild songbirds, providing hedgerows or other bird-friendly habitats has the potential to increase bird predation of herbivorous agricultural pests, improving natural pest control. However, larger wild bird populations also might facilitate transmission of bird-vectored pathogens and parasites harmful to humans and livestock. In summary, our work suggests that increasing on-farm biodiversity is not a panacea for all pest problems. Rather, a fairly sophisticated knowledge of systems-level ecology is needed to manage farmland to capture biodiversity's benefits, while reducing potential harms.

**08:55**

### Impacts of North American native and introduced natural enemies on population dynamics of the emerald ash borer


Jian Duan

The emerald ash borer (EAB) *Agrilus planipennis*Fairmaire is an invasive phloem-feeding beetle that has killed tens of millions of ash (*Fraxinus*) trees in North America since first detected in 2002. We constructed life tables of EAB and analyzed the impact of both North American native and introduced natural enemies on the populations of immature EAB life stages over an eight year period (2008 – 2015) in six stands of eastern deciduous forest in southern Michigan.Our findings indicate that successful biocontrol of EAB may involve suppression of EAB abundance both by North American native, generalist natural enemies (such as *Atanycolus* spp.) and by introduced specialist parasitoids (such as *T. planipennisi*). Biological control programs against EAB in the aftermath of invasion should focus on establishing stable populations of *T. planipennisi* and other introduced specialist parasitoids for sustained suppression of low density EAB populations.

## 09:15

### Relationships between diversity of natural enemy communities and pest predation levels in different farming and landscape contexts in hedgerow network landscapes

Stéphanie Avirona

Biological control of pests by their natural enemies is considered as a key ecological process to reduce pesticide use in modern agricultural systems. A problematic issue in actual researches on biological control is the absence of consensus regarding the relationships between the diversity of natural enemies and levels of pest control. Whilst some studies have shown the importance of predator abundances or species richness, others have highlighted the role of predator species identity in pest predation levels. Another crucial issue is to determine the environmental factors that drive the key components of predator diversity involved in pest control. Existing literature reports positive influences of low input farming practices (especially organic farming) at the field or farm scale, and of spatial landscape heterogeneity related to the amount of semi-natural habitats. More recently, some studies have also explored the role of farming system heterogeneity at the landscape scale, but led to contradictory results. In the present study, we investigate the relationships between predator diversity and pest predation levels, considering different contexts in terms of field farming systems (organic *vs*. conventional farming) and landscape heterogeneity related to both semi-natural habitats and farming systems. We use data from a pluriannual survey of predatory carabid beetles and predation levels of sentinel preys (aphids and weed seeds) in 20 cereal fields located in hedgerow network landscapes, in western France.

## 09:35

### Establishment of *Mastrus ridens* (Hymenoptera: Ichneumonidae), an ecto-parasitoid of codling moth, in New Zealand

Manoharie Sandanayaka

*Mastrus ridens* (Horstmann) (Hymenoptera: Ichneumonidae) was collected from Kazakhstan (as *M. ridibundus*) in the 1990s and released in the USA (California), Argentina and Chile to control codling moth *Cydia pomonella* (Lepidoptera: Tortricidae). Individuals from a laboratory population in Argentina were imported into quarantine in New Zealand in 2009 and approved for release in 2012. More than 200,000 adult parasitoids have since been released into the main apple-growing regions throughout the country. We report on the early establishment of *M. ridens* and evidence of its seasonal activity in different regions. The diversity of existing codling moth parasitoids in different regions is also noted and the potential for both complementary biocontrol and competition within the codling moth parasitoid guild are discussed.

## 09:55

### Exotic or native? Interspecific competition in the parasitization of the fruit fly *Ceratitis cosyra*

Miriam Frida Karlsson

Tephritidae flies are parasitized by Braconidae wasps of which some are used in Biological Control programs. We studied interspecific competition between egg parasitoids; native African *Fopius caudatus* and exotic Asian *F. arisanus* (Hymenoptera: Braconidae) in African native *Ceratitis cosyra* (Diptera: Tephritidae). We compared the wasps' behavior on infested fruit, preference for egg developmental stage, effect of pre-parasitism and parasitism rates. While *F. arisanus* outcompeted *F. caudatus* in parasitization of relatively younger eggs, chasing away *F. caudatus*, and oviposited more, *F. caudatus* survived in younger eggs than *F. arisanus*. More oviposition by *F. caudatus* was found in fruits previously parasitized by *F. arisanus*, coinciding with presence of more developed (and preferred) host eggs while such difference was not observed for . We discuss if and how parasitoid co-occurrence will be affected.

## 10:15 Coffee Break

# Tuesday, 12 September 2017
Session 6

Brett Hurley,
South Africa

Simon Lawson,
Australia

## Frontiers in forest insect control

**10:45**

### Investigating the complex gall community of *Leptocybe invasa*

Brett Hurley

The gall wasp *Leptocybe invasa* is a serious invasive insect pest of *Eucalyptus* trees worldwide. In South Africa, the parasitoid wasp *Selitrichodes neseri* was introduced as a biological control agent, but other native and non-native wasps have also been found associated with the galls. In addition, sequence data has revealed the presence of two distinct *Leptocybe* lineages in South Africa. We collected galled material to investigate the distribution and interactions of the various wasps associated with this complex gall community. Sequence data and specific primers were used to identify minute larvae co-occurring in galls, and to distinguish between the two *Leptocybe* lineages. *Selitrichodes neseri* is well established throughout the country, but interestingly in some sites the galls were dominated by *Megastigmus* species, potential parasitoids and / or inquilines within the galls.

**11:05**

### Larval parasitoids for biocontrol of invasive Paropsine defoliators

Toni Withers

New Zealand has recieved a number of invasive paropsines (Col.: Chrysomelidae) from Australia. All species are defoliating pests of hardwood trees. Of the many established species, *Paropsis charybdis* has been the most damaging pest, defoliating numerous species of valued eucalypts, especially ground durable Symphyomyrtus species such as *E. globulus* and *E. nitens*. We investigated the natural enemies attacking *P. charybdis* in Tasmania, and from these selected a larval parasitoid, *Eadya* sp. (Hym.: Braconidae). The most common field host of this parasitoid in Tasmania is *Paropsisterna agricola*. Field studies of host parasitoid relationships suggest this parasitoid is host specific to a limited number of species within the genera *Paropsisterna* and *Paropsis*. Host range testing within quarantine in New Zealand has now occurred against seven non-target leaf-feeding Chrysomelinae. Data suggests only larvae of eucalypt-feeding non-target species provide cues that stimulate search and attack behaviour in female *Eadya*.

**11:25**

### Biological control of the *Gonipterus scutellatus* species complex: testing the species, climatic and phenological mismatch hypotheses

Michelle Schröder

The egg parasitoid, *Anaphes nitens* (Hymenoptera: Mymaridae) has been released in many parts of the world to control invasive *Gonipterus* (Coleoptera: Curculionidae) species, that defoliate *Eucalyptus* trees. The pest, once treated as a single species, is now known to include at least three species that have spread from their native range in Australia. In each case, the same *A. nites* population was released. In this study, we tested the hypothesis that species mismatch and / or climatic and phenological mismatch drive variable parasitism rates. *Gonipterus* species and their natural enemies were collected in the native range and identified using morphology and molecular tools. Thermal thresholds and climate matching of the pest and parasitoids were used to identify conditions where *Gonipterus* populations will be favoured.

**11:45**

### A successful case of classical biological control of a gall wasp

Fernanda Colombardi

The Asian Chestnut Gall Wasp (ACGW, *Dryocosmus kuriphilus*) represents a noticeable exception to the rule that gallers are of relatively little economic importance as, in the invaded countries, it poses a serious threat to chestnut species and their hybrids. In northeastern Italy, after the first record in 2007, the pest rapidly colonized all the chestnut stands with high infestation levels leading to an almost total reduction in nut and wood as well as, indirectly, in honey yield. As native natural enemies were not able to contain the population (parasitism < 2%), a classical biological control program was implemented in 2010 using the non-native parasitoid *Torymus sinensis*, which successfully established at all release sites. Moreover, in 3 to 5 years it spread via stratified dispersal to non-release sites and increased parasitism to 82%, resulting in enhancing yield to about 50% of the values observed before the arrival of the ACGW.

## 12:05

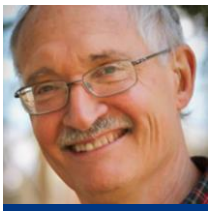
### Biological control of *Thaumastocoris peregrinus* (Hemiptera: Thaumastocoridae) in Eucalyptus plantations in Brazil: an update

Carlos Wilcken

The bronze bug *Thaumastocoris peregrinus* (Hemiptera: Thaumastocoridae) is an invasive pest in Brazil and infested 245,000 ha of eucalyptus plantations in 2012, and it has caused reduction of 10-15 % in wood production. The introduced egg parasitoid, *Cleruchoides noackae* (Hymenoptera: Mymaridae), has been reared in laboratory and released in all country. Bioassays and field evaluations have showed parasitism rate of 50-60% by *C. noackae*. Native predators have been studied as *Chrysoperla externa* and predatory bugs *Supputius cincticeps* and *Atopozelus opsimus*. Considering microbial control the entomopathogenic fungi, as *Beauveria bassiana,* have been used in aerial spraying and natural epizooties of *Fusarium proliferatum, F. equiseti* and*Zoophtora radicans* have caused expressive mortality of the pest. After 3 years of first releases of *C. noackae* the infested area has been reduced to 18.8 % in compare to 2012 data.

## 12:25

### Ecology and biological control of outbreak populations of winter moth in the northeastern United States



Joseph Elkinton

Winter moth, *Operophtera brumata* L. has recently invaded the northeastern United States and caused widespread defoliation. We collected and analyzed life table data for ten years at multiple research plots. We showed that outbreak populations are regulated by density dependent mortality, primarily in the larval stage. This mortality constitutes direct and overcompensating density dependence, resulting in distinct two year cycles of density. The dynamics contrast strongly with classic analyses of low-density populations of this insect. We have also introduced the tachinid parasitoid, *Cyzenis albicans*, which has controlled winter moth at other locations in North America. Our introductions of this fly have resulted in successful establishment at widespread locations and caused sharp reductions in winter moth density in at least one location so far.

## 12:45 Lunch Break

# Tuesday, 12 September 2017
Session 7

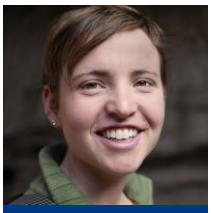
Yelitza Colmenarez, Brazil

Srinivasan Ramasamy, Taiwan

## Biocontrol marketplace – free topics

**13:45** Introduction

**13:50** Friend or foe: the role of native, nature enemies in the biological control of winter moth



Hannah Broadley

Natural enemies that cross over from related native species to inasive species mediate invasions in complex ways. In the northeastern United States, the winter moth (*Operophtera brumata*) is an invasive, forest pest. While biocontrol show promising results, success likely depends on additional mortality from native, natural enemies. However, little is known about the identity or impact of these native species. Our data suggest that in its introduced range, winter moth is not affected by pathogens from native species. However, pupal predators and two native parasitic wasps *(Agrypon* sp. and *Pimpla* sp.) cause high levels of mortality, which in concert with the biocontrol agent, may manage winter moth populations. Concurrently, hyperparasites may hinder efforts. This research improves our understanding of the relationship between introduced and native natural enemies and their relative contribution to successful biocontrol.

**14:10** BiCEP: progress in a global collaboration for the biological control of Australian-origin eucalypt pests

Simon Lawson

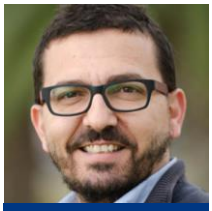
Australian-origin pests of eucalypts have been moving around the world since the 1860's. From the 1990's, the invasion and spread of new eucalypt pests has increased almost exponentially, correlated with huge increases in global trade and movement of people. This has necessitated new approaches to implementing biological control programs, with countries less able to cope with multiple new invasive pests arriving in rapid succession. BiCEP (Biological Control of Insect Pests Alliance), a globally collaborative project was established in 2013 and has been developing targeted research to improve the biological control of key eucalypt pests prioritized by industry partners. Results of this BiCEP research on key pests will be presented, and future directions for this work discussed.

**14:30** Introduction of *Tachardiaephagus somervilli*, an encyrtid parasitoid, for the indirect biological control of an invasive ant on Christmas Island

S.P. Ong

On Christmas Island, the invasive yellow crazy ant (*Anoplolepis gracilipes*) threatens rainforest biodiversity and ecosystem function through direct predation of the endemic red land crab *Gecarcoidea natalis*, a keystone species. Suppression of this ant and its impacts may be achieved indirectly through biocontrol of its primary honeydew source, the introduced lac scale *Tachardina aurantiaca*. Here we describe the rearing and export of a host-specific parasitoid (*Tachardiaephagus somervilli*) from its native range in Malaysia to Christmas Island. Rearing of *T. somervilli* and its host *T. aurantiaca* from August through November 2016 yielded 356 F1 adults of *T. somervilli* for export to Christmas Island. Following introduction, F1 wasps produced a total of 1248 F2 adults and have now been reared to F3+ generation for field release of about 1000 females at each of four rainforest sites.

## 14:50 *Orius laevigatus* induces plant defences in sweet pepper



Alberto Urbaneja

Despite being a zoophytophagous predator, the phytophagy behavior of *Orius laevigatus* and its impact on plant has not been explored in depth. In this study, we demonstrated that plant feeding by *O. laeviagtus* can trigger defensive plant responses. *O. laevigatus*-punctured sweet pepper plants induced repellency for the whitefly *Bemisia tabaci* and the thrips *F. occidentalis.* Contrarily, the whitefly parasitoid *Encarsia formosa*, was significantly attracted to *O. laevigatus* punctured plants. These defensive responses could be attributed to the upregulation of the jasmonate acid and the salicylic acid signalling pathways which triggered a different blend of volatiles. Our results show that the importance of *O. laevigatus* is not only due to its role as predator but also to its capability to induce defensive responses in sweet pepper plants.

## 15:10 The role of tomato plant volatiles mediated by zoophytophagous mirid bugs

Meritxell Pérez-Hedo

Over the past decade, the success of pest management in tomato crops has been possible thanks to the use of zoophytophagous plant bugs (Hemiptera: Miridae). By their phytophagy, mirid predators may activate plant defense mechanisms which release volatiles through diverse pathways triggered by phytohormones. The plant response may be different depending on the species of mirid used. In this work, we studied whether puncturing tomato plants by two different mirid species (*Nesidiocoris tenuis* and *Macrolophus pygmaeus*) induces different plant volatile emissions, one of the important defensive responses of tomato plants. Once we identifiedthe volatiles differentially released by punctured tomato plants, these volatiles were subsequently examined as individual pure standards in a Y-tube olfactometer, to study their effect on two important herbivore tomato pests and on a parasitoid.

**15:30 Coffee Break**

## 16:00 Poster Session I

**17:30 End**

## Wednesday, 13 September 2017
Session 8

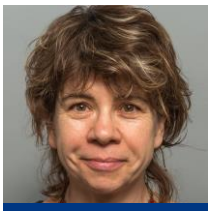

Hariet Hinz, Switzerland


George Heimpel, USA

# Weed and arthropod biological control: mutual benefits and challenges

**08:15** **Introduction**

**08:20** **Keynote Address: weed and arthropod biological control: mutual benfits and challenges**


Hariet Hinz

Classical biological control of arthropods and weeds are based on similar principles and span similar time periods, but their history, implementation and particularly integration with other control measures differ considerably. In contrast, augmentative biological control continues to be dominated by arthropod biological control, despite the fact that there is increasing pressure worldwide to develop environmentally sustainable weed management strategies. We will compare different aspects of these approaches and highlight differences and similarities. We will consider common challenges, but most important identify potential mutual benefits between these disciplines.

**08:50** **Facilitated discussion**

| | |
|---|---|
| **09:30** | **Coffee Break** |
| **10:00** | **Departure from Meritus Pelangi Hotel** |
| **10:30** | **Field Excursion (Group A and B)** |
| **17:00** | **End and Arrival at Meritus Pelangi Hotel** |
| **19:00** | **Conference Dinner at Meritus Pelangi Hotel (access by ticket only)** |

**Photo: Tim Haye, CABI**

# Thursday, 14 September 2017
Session 9

Kris Wyckhuys, Vietnam

Yanhui Lu, China

## Maximizing opportunities for biological control in Asia's rapidly changing agro-environments

**8:30** **Introduction**

**08:35** **From molecule to landscape - integrating molecular biology and landscape ecology to open new opportunities for biological control in East Asia**

Geoff Gurr

At the time of the 2017 ISBCA, biological control has never been at a more exciting stage of development, and the need for biological control has never been greater. This proposed keynote will explore how the recent advances in two particular fields open great opportunities to both understand fundamental aspects of biology that underpin our discipline as well as to deliver more effective solutions to end-users. First, the rapidly falling cost of DNA sequencing and capacity for bioinformatic analyses mean that genomic data-rich studies of agents and functionally related species are increasingly feasible and powerful. Second, theoretical advances in spatial ecology are complemented by unmanned aerial vehicles as platforms for advanced remote, hyperspectral imaging. These high-tech approaches will allow biological control to more consistently achieve end-user benefits such as in recent work in Asian rice.

**08:55** **Phytopathogens and soil nutrients jointly shape biological control of invasive mealybugs in Asia's cassava crops**

Kris Wyckhuys

Biological control practitioners face major challenges to make reliable, context-specific inferences on invader success, natural enemy performance and efficacy of biological control, particularly in highly-heterogeneous farming systems of the tropics. In this study, we assess to what extent soil parameters and phyto-pathogen infection determine success of three globally-important mealybug species (Hemiptera: Pseudococcidae) in Asia's cassava crops. Although microcosm assays reveal strong bottom-up effects, observational studies show that abundance of different mealybug species, and associated parasitic hymenopterans, is related to aggregative measures of soil fertility, soil texture and incidence of a systemic plant disease. Hence, cross-disciplinary research is essential to fully grasp the drivers and impediaments of insect biological control and to successfully implement (invasive) pest management programs.

**09:15** **Recent change of biocontrol services in cotton agro-ecosystem of northern China**

Yanhui Lu

Based on data from 1990 to 2010 at 36 sites in northern China, we show a marked increase in abundance of generalist predators (ladybirds, lacewings, and spiders) and decreased abundance of aphid pests associated with *Bt* cotton adoption and reduced insecticide sprays in this crop. We also found that the predators might provide additional biocontrol services spilling over from *Bt* cotton fields onto neighboring crops. Our work demonstrates that Bt cotton can promote biocontrol services in agricultural landscapes. During 2013-2015, we assessed the effects of landscape composition on predator abundances in 41 study sites. Landscape with a high proportion of some small crops other than major crops (cotton and maize) supported high abundance of predators in cotton field. It indicates that predator abundances and their associated biocontrol services may be decreasing with great increase of maize planting in northern China.

## 09:35

### Know your enemies: suppression of *Plutella xylostella* and *Crocidolomia pavonana* by different predators in West Java, Indonesia

Michael Furlong

The diamondback moth (DBM), *Plutella xylostella* L., and *Crocidolomia pavonana* F., are serious insect pests of *Brassica* vegetable crops in Southeast Asia. Several DBM parasitoids have been established in the region through classical biological control programs; these are effective in the absence of widespread insecticide use. *Crocidolomia pavonana* is difficult to manage without insecticides and growers typically revert to them, thereby disrupting DBM biological control and exacerbating the pest problem. We combined lifetable studies and molecular gut contents analysis to investigate the impact of different natural enemies on the pests in West Java, Indonesia. Both pests were suppressed by the combined action of endemic natural enemies, but the important predators differed markedly between the two species. The implications and possible approaches to an improved IPM strategy for the pest complex are discussed.

## 09:55

### Biological control in vegetable *Brassica* pest management in tropical Asia: where do we currently stand?

Srinivasan Ramasamy

Production of vegetable brassicas is constrained by a plethora of insect pests in tropical Asia. However, *Plutella xylostella* can be controlled by *Diadegma semiclausum, Cotesia plutellae* and *Diadromus collaris*. Absence of effective natural enemies for the secondary lepidopterans triggers the brassica producers to rely more on chemical pesticides, which disrupts the biological control of *P. xylostella*. Absence of effective pupal parasitoids in lowlands also leads to pesticide overuse. Identification of a heat tolerant *D. semiclausum* in Syrian lowlands has opened up new avenues. Identification of a *Trichogramma chilonis* strain parasitizing *Crocidolomia pavonana* in Samoa enhances the potential for its biological control elsewhere. Occurrence of *Cotesia glomerata* and *Pteromalus puparum* on *Pieris rapae*, and *Diaeretiella rapae* on aphids in Southeast Asia increases the scope of brassica bio-control programs.

## 10:15 Coffee Break

# Thursday, 14 September 2017
Session 10


Mohamad Roff, Malaysia


Fang-Hao Wan, China

## Biological control based Integrated Pest Management: does it work?

**10:45** **Introduction**

**10:50** **Successful integrated pest management with biological control: case of the diamondback moth in Malaysia**


Sivapragasam Annamalai

The diamondback moth, *Plutella xylostella* (L.) is an important pest of brassicas with a cosmopolitan distribution. In Malaysia, since 1980, it became resistant to all major groups of pesticides, including *Bacillus thuringiensis*. Studies were initiated on an Integrated Pest Management (IPM) program to manage the pest. The key component was biological control using parasitoids with the indigenous *Cotesia plutellae* complemented by introduced parasitoids *Diadegma semiclausum* and a pupal parasitoid, *Diadromus collaris*. The biological control component assessment was ecologically intensive and included information on life table analysis, competition due to multiple parasitism, impact assessments of host-parasitoid interactions and parasitoid food sources.

**11:10** **A practice of *Trichogramma*-based IPM of rice insect pests**


Maolin Hou

Insect pests are most consistent constraining factor in rice production. Potential *Trichogramma* strains were collected from targeting regions and tested for their tolerance to high temperature and rain, suitability for mass production using rice moth eggs as the substitute host, and field performance against targeting pests, and then a *Trichogramma* release strategy was developed through large-scale field tests. To secure compatibility of released *Trichogramma* with indispensable insecticide application for non-targeting pests of *Trichogramma*, toxicity and window application phase of these insecticides were evaluated. On the base of these laboratory and field tests, a *Trichogramma*-based IPM was established and demonstrated, which showed substantial control of rice insect pests while reduced pesticide use and costs for plant protection.

**11:30** **Conservation biological control and IPM practices in *Brassica* vegetable crops in China: a step further**


Yin-Quan Liu

Brassicas are major vegetable crops in China. During the last 30 years, the area of vegetable crops has increased steadily, however, the control of insect pests on brassica vegetables has largely relied on the heavy use of chemical insecticides. Meanwhile, efforts to develop parctical and sustainable integrated pest management (IPM) strategies for brassica vegetable have been implemented. Here we introduce one successful example of conservation biological control based IPM practice in China. Developted in 2000s, this IPM strategy is based on the cropping system level and the major components include insect monitoring, a composite and dynamic action threshold and selective insecticides. However, the lack of trained farmers and small farms constrained the implementation of IPM practice. Recently, sex pheromone trap, habitat manipulation and plant-mediated support system for natural enemines are explored for conservation biolgical control. We report the potential of the new components for a better IPM practice.

## 11:50

### Biological control of olive fruit fly in California - release, establishment and impact of *Psyttalia lounsburyi* and *Psyttalia humilis*

Kent Daane

Geographic strains of the African endoparasitoids *Psyttalia lounsburyi* and *Psyttalia humilis* (Hymenoptera: Braconidae) were released to suppress the olive fruit fly, *Bactrocera oleae,* in California from 2006 – 2016. Both parasitoid species were recovered post-release within the same fruit season; however, only *P. lounsburyi* was recovered post-release in the following fruit seasons. *P. lounsburyi* was recovered at numerous sites, >2 years after a release, and >50 km from a release location. *P. lounsburyi* is now established in California coastal regions, but not inland, and is found in ornamental trees but has not yet been found in insecticide-treated commercial orchards. We discuss aspects of parasitoid biology that could impede parasitoid establishment and control levels.

## 12:10

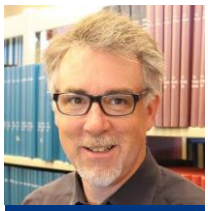
### Biological control ausing predators and parasitoids in Vietnam: from successful participartory approaches to potential challenges

Arnaud Costa

Since first attempts for biological control against the white stem borer *Xylotrechus quadripes* in coffee (1920s), microbial agents have been mostly used by Vietnamese farmers. Major pests have been targeted by introduction of exotic enemies or by safe-guarding natural ones. In coconut, *Asecodes hispinarum* and *Tetrastichus brontispae* parasitoids have been released against the coconut hispine beetle *Brontispa longissima*. Recent participatory trainings have used farmers-reared earwigs *Chelisoches variegatus*. In rice, landscape manipulation using ecological engineering has increased farmers' awareness and foster conservation biological control. We discuss the potential challenges (misuse of pesticides, reduction of landscape diversity) for future development of natural enemies. Concerns for food security and higher food standards (VietGap, Organic Farming, PGS) will promote the use of natural enemies.

## 12:30 Lunch Break

# Thursday, 14 September 2017
Session 11


John Banks, USA


John Stark, USA

## Exploring the compability of arthropod biological control and pesticides: models and data

**13:45**

### How differential stage susceptibility to pesticides affects the success of biocontrol agents


John Stark

Pesticides may be more toxic to certain life stages than others. If certain life stages of a biocontrol agent are more suceptible than others, what does this mean to population viability of the biocontrol agent and the potential success of IPM? In this study, we addressed this question using the aphid parasitoid Diaeretiella rapae and the labdybeetle, Coccinella septempuncata exposed to pesticides. We used a population modleing approach to evaluate long-term impacts on populations of these two biocontrols. Results indicated that differential susceptibility of life stages to pesticides are important determinants to the successful integration of biocontrols and pesticides in IPM programs.

**14:05**

### Orchard pesticides and natural enemies: lessons from the lab and field


Nick Mills

Insecticides are commonly used in apple, pear and walnut orchards in the western U.S.A. for control of codling moth (*Cydia pomonella*) and these products may disrupt biological control of secondary pests in these crops. A comparative analysis was made from a series of laboratory bioassays of acute mortality and sublethal effects of orchard insecticides on seven natural enemy species through use of stage-structured population models. In a parallel set of field studies in which the same insecticides were applied in replicated plots in commercial orchards we examined the hypothesis that laboratory bioassays predict reductions in natural enemy impacts in the field. We discuss the unavoidable difficulties associated with field trials and recommended the use of carefully designed laboratory bioassays that measure population-level effects are for more rapid screening of the selectivity of a broad range of insecticides.

**14:25**

### Pesticide use and floral resources differentially affect communities of predators, parasitoids, and pests in a regional survey


Carmen Blubaugh

Floral resource provisions in agroecosystems may improve compatibility of biocontrol and pesticides by providing untreated refuge space for natural enemies. They may also provide exploitable resources for pests and hyper-parasitoids, which can compromise biological control. In a survey of brassica crops on more than 50 farms in the northwestern United States, we examined farm-scale impacts of both floral resources and pesticide use on densities of pest insects, generalist predators, specialist parasitoids, and hyper-parasitoids. We found fewer generalist predators on farms that employ insecticides, but no impacts on pests, parasitoids, or hyper-parasitoids. Floral resources increased densities of primary parasitoids, generalist predators, and hyper-parasitoids, and did not affect pests. This regional-scale survey suggests that floral resources may promote biocontrol even in intensely managed agroecosytems.

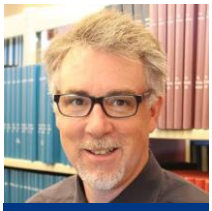
**14:45**

### Integration of biopesticides with natural enemies for control of tropical fruit flies (Diptera: Tephritidae)


Roger Vargas

Fruit flies (Diptera: Tephritidae) are among the most economically important pests attacking tropical fruits and vegetables worldwide. The Hawaii Fruit Fly Area-Wide Pest Management (AWPM) Program developed and integrated biologically-based pest control technologies into a comprehensive management package against such serious agricultural pests as oriental fruit fly, melon fly and Mediterranean fruit fly that was economically viable, environmentally sensitive and sustainable. This program serves as a model for management of not only fruit flies but also other pest species. The role of integration of environmentally friendlly insecticides with natural enemies will be discussed in this presentation.

## 15:05 Protecting assemblages of biocontrol species: modeling a surrogate species approach



John Banks

Parasitoid wasps are important control agents for a suite of economically important arthropod pests, but because of their vulnerability to chemical pesticides they also represent an opportunity to better understand the compatibility of biological and chemical control of pests. Closely related species are often used interchangeably in risk assessment when assessing the risk of pesticides on biocontrol agents. Here, using a simple mathematical model parameterized with life history data, we simulate reductions in fecundity and survivorship for a suite of economically important braconid species in order to explore potential differences in their vulnerability to lethal and sublethal effects at the population level. We find that even closely related species are not suitable surrogates for one another, and highlight the limitations of a surrogate approach in assessing risk of pesticide exposure to different biocontrol species.

## 15:25 Disruption of biological control due to non-target effects of pesticides in Australian grains

Matt Hill

Grains production in Australia covers an area of 22 million hectares, represents 24% of total agricultural exports, and is heavily reliant on pesticides for controlling pest outbreaks. Non-target effects of pesticides on beneficial invertebrates are not well understood. Using community-based modelling we describe how broad spectrum organophosphates may reduce predatory beetle abundance and lead to secondary outbreaks of other pests. As non-target effects are widely variable, we collated datasets from multiple studies in Australian grains and conducted a meta-analysis in an attempt to synthesis key impacts, including secondary outbreaks, and discuss how understanding potential non-target effects may be used to further Intergrated Pest Management approaches.

**15:45 Coffee Break**

## 16:15 Poster Session II

**17:30 End**

# Friday, 15 September 2017
Session 12


Ulli Kuhlmann, Switzerland


Matthew Cock, United Kingdom

## Successes and uptake of biological control in developing countries

**08:30** **Introduction**

**08:35** **Classical biological control of insects in developed and developing countries: a comparison using the BIOCAT database**


Ulli Kuhlmann

The BIOCAT database of insects used for classical biological control of insects is used to summarize information segregated by developed / developing countries on the number of introductions of biological control agents, the number of biological control agent species used, the numbers of targets for introductions, rates of establishment and success, the number of countries implementing classical biological of insects, where successes first occurred, and how these have varied over time. Patterns and trends will be identified and discussed, including the relative importance of using biological control agents that have already been successfully used elsewhere.

**08:55** **Plantwise developing country data on extension and the uptake of augmentative biological control using arthropods**


Julien Dougoud

The uptake of augmentative biological control agents (BCAs, for this presentation limited to insect parasitoids and predators) is still limited, particularly in many developing countries. This study focuses on factors that affect the uptake of BCAs for arthropod pests by extension services in developing countries, using data generated by the agricultural development programme Plantwise. BCA recommendations for arthropod pests in extension material and by extension workers in six developing countries, Ghana, Kenya, Zambia, India, Nepal and Pakistan, were analysed. The inclusion of BCA recommendations in extension materials and recommendations by extension workers varied greatly between the study countries. The uptake of microbial BCAs is compared with that of invertebrate BCAS using the same dataset. Knowledge, availability and price were identified as the main factors affecting the uptake of BCA by extension services and suggestions are made to address them. The study gives novel insight into the potential of extension services to facilitate the use of BCAs in developing countries and constitutes a baseline for further studies.

**09:15** **The importance of local production to foster the uptake of augmentative biological control in developing countries**


Feng Zhang

Augmentative biological control is applied on a relatively small acreage, even though it has been considered an environmentally and economically sound alternative to chemical pest control. The limited use of augmentative biological control is not only attributed to social and economic factors but also due to technical problems associated with the production and distribution of biological control agents. Here we showcase a field story of establishing local biological control agent production facilities at the grassroot level in Myanmar, Laos and Yunnan - southwestern China, and scaling up the uptake of augmentative biological control with *Trichogramma* to control the Asian corn borer, *Ostrinia furnacalis* (Guenée), the most devastating insect pest of maize crops in the region. With a grassroot approach, eight smallholder communities (3 in Myanmar, 4 in Yunnan - China, 1 in Laos) covering approx. 8,000 smallholder maize farmers were mobilized, and eight biological control agent production facilities were established to produce *Trichogramma* egg cards according to a business plan. Substantial efforts were made to increase sustainablility of these production facilities, and key factors to remove the barrier of the uptake of augmentative biological control were identified.

## 09:35

## Understanding the ecology and impact of parasitoids of whitefly (*Bemisia tabaci* complex, Aleyrodidae) in cassava landscapes in East Africa

Sarina Macfayden

Over the last 20 years, there has been an increase in outbreaks of the *Bemisia tabaci* species complex (family: Aleyrodidae), in East Africa. This species complex vectors viruses that cause widespread damage to cassava, a staple food in many households. Whilst significant effort has gone into developing virus-resistant cassava cultivars, less attention has been paid to the management of natural enemies of *B. tabaci* that may provide biocontrol services. We outline what is known about parasitoid wasps that attack *B. tabaci* species in East Africa, using data on the identity and spatial patterns of activity of parasitoids from Uganda, Tanzania, and Malawi. We discuss the information needed to assess impact in terms of potential for biocontrol of *B. tabaci* complex populations. Developing biocontrol options for farmers will be an important element of future management strategies that address the whitefly problem in East Africa.

## 09:55

## Success and failures in IPM in Africa and Asia: the significance of biocontrol

Julien Lamontagne-Godwin

A meta-analysis of published literature was made to identify validated evidence of smallholder IPM implementation in African and Asia, factors contributing to success or failure, and the significance of biocontrol in outcomes. Most IPM papers cover research only; 140 papers included implementation; 25% had sufficient data to assess success/failure with 90% reporting success. The majority covered IPM in Asia with little on Africa. Rice and cotton IPM predominate in the data. The use of biocontrol is not explicitly mentioned in all IPM papers but implicit in many: the biocontrol reported is largely conservation or augmentation of native natural enemies although a few IPM projects in Africa have reported success because of biocontrol introductions. Biocontrol concepts have been easier to pass to farmers than concepts such as economic thresholds. The constraints to the wider use of biocontrol are reviewed and discussed.

## 10:15 Coffee Break

# Friday, 15 September 2017
Session 13


Steve Naranjo, USA


Jörg Romeis, Switzerland

## Socio-economic impacts of biological control

**10:45** **Introduction**

**10:50** **Success and impact in classical biological control: some examples from developing countries**


Roger Day

Classical biological control programmes ultimately are intended to have social and economic impact which may improve livelihoods, reduce poverty, improve food security, preserve natural ecosystems and ecosystem services, improve human health, boost the local economy, preserve natural ecosystems, etc. Successfully controlling the target pest is the mechanism by which these benefits are delivered, but is not the benefit itself. The degree of pest management achieved is a step towards delivering the ultimate benefits which justifies the intervention using classical biological control. We review selected examples of successful classical biological control programmes in developing countries to illustrate this.

**11:10** **Cost of biological control of invasive arthropods**


Karen Jetter

California is the largest producer of perennial tree crops in the U.S. It has also been subject to the establishment of invasive arthropods that affect the costs to produce fruit. This study will describe the establishment of invasive arthropods in California's commercial perennial tree fruit crops. It will track how changes in conventional and biological pest controls have occurred from 2000 through 2015 based on pesticide use reporting and classical biological control programs. It will estimate the net costs to producers and consumers of the use of conventional and biological pest controls using market models. Finally, it will estimate the potential savings to pest control costs due to successful classical biological control programs.

**11:30** **Assessment of the economic and poverty impacts of biological control of cereal stemborers in Kenya using the economic surplus modeling approach**


Beatrice Muriithi

In response to the severe stemborers invasion in cereal farming regions of Kenya, a biological control (BC) program was initiated by *icipe* scientists. This program has released four natural enemies: *C.flavipes*, *C.sesamiae*, *T.isis* and *X.stemmator* to suppress economically important stemborer pests; *B.fusca*, *C.partelus* and *S.calamistis.* An economic surplus model was developed based on time-series data on production, market and GIS to evaluate the economic impact of the BC program in Kenya. Findings show that the BC intervention has contributed to an aggregate monetary surplus of $US 0.74 billion to the economy of Kenya. The net present benefit of $US 236 million, the Internal Rate of Return of 46% and the Benefit Cost Ratio of 276:1 justify that the program was worthwhile. An estimated average of 80,030 persons was yearly lifted out of poverty due to the BC program. Wide promotion and up-scaling of the BC program should thus be considered.

## 11:50 Socio-economic impacts and extension process of conservation biological control in mango orchards in Réunion Island

Enric Frago

In Réunion, mango cultivation is confronted to a wide range of pests and diseases. To replace long-standing agrochemical protection, conservation biological control experiment was conducted from 2012 to 2014 in 12 pilot orchards. The farmers involved appreciated the efficacy of practices, including vegetal cover on the ground, and quickly adopted them. Insecticide and herbicide treatments were eliminated and production costs reduced by 35%. After the experimental phase, the diffusion of this innovation among the other mango producers was carried out by the extension services and by the public authorities. This pioneering experience shows that it is possible to adopt a conservation biological control approach while improving socio-economic and environmental performances.

## 12:10 Chronicling the socio-economic impact of integrating biological control, technology, and knowledge over 25 years of IPM in Arizona

Peter Ellsworth

IPM in Arizona cotton over the last 25 years has depended on the successful integration of biological and chemical controls along with other insect management knowledge and technologies. Contemporaneous measurement systems enabled economic evaluations with long-term datasets to examine economic outcomes and impacts, as well as durability of adopted technology. After devastating outbreaks of pink bollworm and an invasive whitefly in the early 1990s, major economic losses to the plant bug, *Lygus hesperus*, in the late 1990s, and continuing pest threats throughout the last two decades, cotton growers in Arizona have saved >$500 ($US million) through uptake and adoption of technology and knowledge to implement developed IPM plans that include conservation biological control.

## 12:30 Lunch Break

# Friday, 15 September 2017
Session 14


Sunday Ekesi, Kenya


Wai Hong Loke, Malaysia

## Biocontrol marketplace: free topics

**13:45** **Introduction**

**13:50** **Do GM plants with stacked insecticidal traits pose an increased risk to biological control**


Jörg Romeis

Genetically engineered crops with stacked insecticidal traits expose arthropods to multiple Cry proteins from *Bacillus thuringiensis* (Bt). One concern is that the different Cry proteins may interact and lead to unexpected adverse effects on non-target species. Bi- and tri-trophic experiments with SmartStax maize, herbivorous spider mites (*Tetranychus urticae*) and aphids (*Rhopalosiphum padi*), and predatory spiders (*Phylloneta impressa*), ladybeetles (*Harmonia axyridis*), and lacewings (*Chrysoperla carnea*) were conducted. ELISA analyses were used to quantify the flow of the various Cry proteins from the plants via herbivores to the predators. Acute lethal or sublethal effects of SmartStax maize on the predators were not observed. The study thus provides evidence that the different Cry proteins do not interact in a way that poses a risk to the investigated non-target species under controlled laboratory conditions.

**14:10** **Initial evaluation of two native egg parasitoids for the control of *Bagrada hilaris*, an invasive stink bug in western USA**


René Sforza

First reported in California in 2008, *Bagrada hilaris* (Hem.: Pentatomidae), a major pest of Brassicaceae, has now spread to several U.S. states and Mexico. We studied host phylogeography by sequencing CO1 from 20 bagrada populations and determined that Pakistan is the likely origin for invasive US populations. Sentinel host eggs were used to collect 2 species of parasitoids: *Trissolcus hyalinipennis* and *Gryon* sp. (Hym.: Platygastridae) in Pakistan. Laboratory studies showed that 1 to 4-day old bagrada eggs were equally suitable for parasitization and that fresh eggs were more suitable than frozen eggs. Both species successfully attacked host eggs from California and South Africa. Longevity, development time, and fecundity were measured at room temperature to support future studies.

**14:30** **Old and new host-parasitoid associations: parasitism of the invasive fruit fly *Bactrocera* species and five African fruit fly species**


Samira Mohamed

Laboratory experiments were conducted to assess the performance of three African native parasitoid species. *Psyttalia concolor*, *P. cosyrae* and *Tetrastichus giffardii* and two exotic introduced pasitoids, *Fopius arisanus* and *Diachasmimorpha longicaudata* against five native tephritids fruit flies, *Ceratitis capitata*, *C. cosyra*, *C. rosa*, *C. fasciventris* and *C. anonae* and two alien invasive species *Bactrocera zeugodacus* and *B. dorsalis*. In general parasitoids performed better on their respective co-evolved host species. The introduced parasitoid were able to establish new association with some of the African native fruit fly species, but the reverse was not true, whereby the native parasitoid species were unable to parasitize the alien fruit fly species as their eggs were encapsulated in these host species. Implications of the findings of this study is discussed within the framework of system approach management strategy for fruit flies suppression.

## 14:50 Harnessing of floral and faunal biodiversity of rice ecosystems for pest management

Chitra Shanker

Rice paddies have a complexity of fauna which interact with each other and provide ample scope for natural biological control. Some simple techniques of IPM can help to conserve them and enhance pest control. Field cum laboratory studies carried out at ICAR - Indian Institute of Rice Research (IIRR) showed an increase in longevity and fecundity of hopper egg parasitoids by the provision of nectar bearing flower plants on bunds in rice fields and had significant impact on biodiversity and parasitisation rates. Theparasitisation increased 100 fold while the longevity of parasitoids was enhanced 200 times and many parasitoids such as *Apanteles* sp. *Mymar taprobanicum*, *Anagrus* sp., *Tetrastichus schoenobii and Bracon sp* etc. were observed near the flowering border. Harnessing of floral and faunal biodiversity provides a novel eco-friendly opportunity of managing rice pests with additional economic benefits particularly for resource poor Asian farmers along with safety to human health and environment.

## 15:10 Seasonal abundance of *Plutella xylostella* (Lepidoptera: Plutellidae) and diversity of its parasitoids along altitudinal gradients of the Eastern Afromontane

Sevgan Subramanian

Monthly surveys of diamondback moth (DBM), *Plutella xylostella* (L.) and its parasitoids were undertaken across altitudinal transects of Mt. Kilimanjaro and Taita hills. DBM population per plant was highest during the short rains and in medium zones among the seasons and altitudinal zones, respectively. Eight parasitoid species were recorded from the Eastern Afromontanes. *Cotesia vestalis* and *Oomyzus sokolowskii* were dominant in the low zones, while *Diadegma semiclausum* was dominant in the medium and high zones. During the long rains, both parasitism and DBM population were low. With increasing altitude, diversity of parasitoids reduced, while the diversity of wild crucifers increased. Wild crucifers were three times more diverse in Mt. Kilimanjaro than in Taita hills. The ecological complexity of the cropping system with diverse wild crucifers was a major contributor to increased parasitoid diversity in the region.

**15:30 Coffee Break**

**16:00 Business Meeting**

- **General issues**
- **Next venue of the 6th ISBCA 2021**

**16:30 End**

## Poster 01

### Discovery of *Phasmarhabditis hermaphrodita* (Nematoda) in the USA and its potential importance in the biological control of invasive gastropods

Rory Mc Donnell

Snails and slugs are among the most serious pests of agriculture. Control measures are focused on chemical molluscicides but their efficacy is very variable. In Europe a commercially available biological control agent is used to help manage slugs in a range of crops. The active agent is a nematode called *Phasmarhabditis hermaphrodita* and its associated bacteria, *Moraxella osloensis*. Multiple past attempts at recovering *Phasmarhabditis* from slugs and snails in the US have been unsuccessful but we recently discovered *P. hermaphrodita* from a range of slug species in California and Oregon. This nematode has only been recovered from European invasive gastropod species in the US and not from native species, suggesting an accidental introduction. Virulence trials with this strain have shown that it is lethal to a range of pest slugs and snails highlighting its potential role as a biological control agent of these pests in the US.

## Poster 02

### Feeding behavior of *Rumina decollata* (Gastropoda) raises questions about its efficacy as a biocontrol agent of the pestiferous brown garden snail *Cornu aspersum* (Gastropoda)

Rory Mc Donnell

The facultative predatory snail, *Rumina decollata*, was accidentally introduced to the US in the early 1800s and it has been used as a biological control agent of *Cornu aspersum* in Californian citrus for almost 50 yrs despite the fact that there is little laboratory and field evidence of its efficacy. We have shown that this snail can only successfully kill *C. aspersum* that are <13mm (diameter) and if given a choice between a known food plant (carrot) and *C. aspersum* within this vulnerable size range, the majority of *R. decollata* (~ 93%) exhibited herbivory. Our research has also shown that *R. decollata* will feed on *C. aspersum* eggs (~ 3 eggs per week) but given the large number of eggs laid by *C aspersum* and their location (i.e. underground) it is unlikely that ovicide is a significant driver of population decline. These experimental results support previous anecdotal suggestions that *R. decollata* may not be an efficacious snail predator.

## Poster 03

### Genetic diversity and origins of *Halyomorpha halys* in the United States and of its potential biocontrol agent unexpectedly recovered from the wild in the U.S.

Marie-Claude Bon

The brown marmorated stink bug (BMSB) (*Halyomorpha halys*) has recently invaded the US from its origin in Asia, posing a serious nuisance to people and threat to agricultural industry. We investigated the mitochondrial phylogeography of BMSB in the US. Results evidenced a predominantly Chinese origin, but that there were different colonization events in eastern and western US. We also investigated the genetic makeup using microsatellites of all colonies of the most promising candidate for biocontrol, the egg parasitoid, *Trissolcus japonicus*, which have been under study in US quarantine facilities since 2007. Our results show that the *T. japonicus* individuals unexpectedly recovered from the wild in the US did not escape from the US quarantine facilities, but came predominantly from China.

## Poster 04

### Variable performance and improvement by crossing in commercial populations of the pirate bug *Orius majusculus*

Kim Jensen

Populations of insect predators used in biological control may have different origins and have typically been maintained under laboratory conditions for many generations. They are therefore likely to differ genetically and may be genetically depauperate, and thus may differ in quality for biological control. We tested three commercial populations of the pirate bug *Orius majusculus*, as well as crosses between the populations, for starvation tolerance, predation rate, basic activity, and tolerance to thermal extremes. The results showed a lower general performance in one of the three commercial populations. Furthermore, the F1 individuals obtained from the crosses on average had higher general performance suggesting heterosis. The study highlights that commercial populations may differ in genetic quality and that crossing populations may be a useful tool for increasing performance of predators used in biological control.

## Poster 05

### Parasitoids of *Drosophila* in Switzerland and their potential for biological control of the invasive *Drosophila suzukii*

Jörg Romeis

In Europe, the invasive vinegar fly *Drosophila suzukii* is causing large economic damage in stone fruit, berry and vine cultivation. Control of this pest remains challenging. To investigate the potential role of hymenopteran parasitoids for *D. suzukii* control, we conducted a field survey in various regions of Switzerland. Using sentinel *D. melanogaster* hosts we collected a total of eight hymenopteran parasitoid species. Capture of particular species varied among regions, time of the growing season, and habitat type. Laboratory no-choice assays with the field-collected species demonstrated that while none of the three larval larval parasitoids collected were able to reproduce on *D. suzukii*, all of the four pupal parasitoids could. Thus, native parasitoids could contribute to the control of *D. suzukii* and information on their phenology and habitat preference is particularly important in this context.

## Poster 06

### Native North American vs. Asian parasitoid natural enemies of invasive brown marmorated stink bug

Kim Hoelmer

The invasion of brown marmorated stink bug, *Halyomorpha halys*, in North America and Europe, has led to efforts to characterize indigenous natural enemies attacking this pest. We reviewed survey datasets spanning a variety of sampling methods, habitats, and geographic areas to consolidate available information, evaluate trends, and identify gaps in research. Research has focused mostly on predators and parasitoids of *H. halys* eggs using sentinel and wild egg masses to characterize composition and impact of enemy communities. Parasitism and predation rates are typically <10% although they may be substantial in certain habitats. This contrasts with the impact of egg parasitism in the native Asian range, which is considerably greater, suggesting the need for classical biocontrol. Studies of natural enemies attacking *H. halys* nymphs and adults are less common to date.

## Poster 07

### Insect natural enemies: review and future application for cocoa pod borer management in cocoa

Navies Maisin

Insect natural enemies of cocoa pod borer (CPB) have been described and reported by since the 80s. Natural enemies attacking the eggs, emerging larva, pupa and the adult stage. A total of 24 different parasitoids have been reported attacking CPB. Only eggs parasitoid was successfully mass produced and augmented. Control usin parasitoid for emerging larva and the pupa never been reported. Control success by predator was limited only to certain locality. Local natural enemies of CPB could be able to reduce the CPB population below economic threshold if the cocoa farm ecosystem able to support these natural enemies survival. Therefore, biodiversity in cocoa farm ecosystem should be encouraged through concepts of landscape agriculture system by introducing other beneficial crop and flowering plant.

## Poster 08

### Do invasive alien species affect diversity of local communities

Pavel Kindlmann

Adding an "alien" species to an established community of "domestic" species initially increases its diversity. This effect decreases with increasing diversity of the community. As the alien species spreads, diversity decreases and vanishes, when the alien species replaces all domestic species. Here we investigate the dynamics of diversity in such system by considering five scenarios differing in (i) availability of uncolonized "free" space within the original community, (ii) mode of interaction between alien and domestic species and (iii) distribution of the domestic species. Distinguishing change in abundance of species of the new community including alien species from changes in diversity of the original community may conceptually clarify discussion about the effect of alien species. A corrolary is that diversity of the new community may decline with little or no effect on diversity of the community of original species. This is very important in cases when domestic species become rare before the arrival of the invasive species and leave "free space" for its spreading.

## Poster 09

### Introduction to FAO guide: Classical biological control of insect pests in forestry: a practical guide

Shiroma Sathyapala

Classical biological control sees the introduction of exotic natural enemies to manage the pests supports sustainable forest management, where appropriate, assisting in reduced reliance on other less environmentally friendly pest control methods such as the use of chemical insecticides. At present, no general guidelines exist for the classical biological control of forest pests, particularly in a format that would benefit economically developing countries that do not have easy access to this information in their own language. To address this gap, FAO is leading a multistakeholder process to develop a guide, *Guide for the classical biological control of insect pests in planted and natural forests. The guide* is being authored by an international panel of expert scientists and it is intended for policy-makers, planners, managers and educators as well as the forest workers who implement peat management activities.

## Poster 10

### Diversity of edible Saturniids (Lepidoptera: Saturniidae) and their parasitoids in Kenya

Sevgan Subramanian

Saturniid caterpillars are key edible insects in the Central and Southern Africa. In East Africa, information on the diversity of Saturniids and their natural enemies is minimal. Surveys in different ecologies of Kenya indicated that the African Emperor moth, *Gonimbrasia zambesina* on *Mangifera indica* in the coast to mid altitudes; Cabbage tree emperor moth, *Bunaea alcinoe* on *Balanites aegyptiaca* and *G. belina* on *Acacia* sp.in the low to mid altitudes and Pine tree emperor moth, *Nudaurelia krucki* on *Schinus molle in the* high altitudes were the widely prevalent edible Saturniids in the region. Dipteran larval-pupal parasitoids belonging to Tachnidae such as, *Carcelia sp.* and *Ceromyia sp.on B. alcinoe, G. zambesina* and *G. belina*; Ichneumonid and braconid larval parasitoids of *G. zambesina* and *B. alcinoe* and egg parasitoids belonging to Euplemidae on *N. krucki* were among the key parasitoids observed in the region.

## Poster 11

### Action of *Bacillus thuringiensis* on Eucalyptus snout beetle *Gonipterus platensis* (Coleoptera: Curculionidae) larvae

Carlos Wilcken

The *Gonipterus* spp. complex is the main group of Coleoptera defoliators of *Eucalyptus* plantations. This pest ressurgence in some countries demand new management strategies to reduce the outbreaks. In Brazil, *Gonipterus platensis* is the main pest species and recent outbreaks in states of São Paulo and Parana have occurred due low parasitism rate of *Anaphes nitens* (Hym.: Mymaridae). One of control alternatives in study is application of *Bacillus thuringiensis*. *G. platensis* 1st. instar larvae were submitted to strains of *B. thuringiensis* var. *israelensis* (*Bti*), *B. thuringiensis* var. *kurstaki* (*Btk*) and *B. thuringiensis* var.*tenebrionis* (*Btt*) in different concentrations in controlled conditions. *Bti* strain caused 97% of larva mortality in highest concentration (3 x 109 spores/ml), while *Btt* strain reached 71% in the same conditions. Further studies are needed to determine the possible toxins are involved in toxicityof *G. platensis* larvae.

## Poster 12

### Host specificity testing of *Psyllaephagus bliteus*, an accepted biocontrol agent of *Glycaspis brimblecombei*, reveals a new host

Brett Hurley

The risk of releasing *Psyllaephagus bliteus* (Hymenoptera: Encyrtidae) in South Africa to control the lerp-forming eucalypt pest, *Glycaspis brimblecombei* (Hemiptera: Psyllidae), was evaluated using no-choice tests. The chosen non-target test insects included the only native lerp-forming psyllid in South Africa, as well as three non-native psyllids that occur on eucalypts, one of which, *Spondyliaspis* cf.*plicatuloides* (Hemiptera: Psyllidae) forms lerps. *Psyllaephagus bliteus* did not show interest in three test species, but it did oviposit and develop in *S*. cf. *plicatuloides*. The risk to native species is thus low. The inclusion of non-native species on the same host as test species provided a better understanding of the host range of this agent.

## Poster 13

### Potential of entomopathogenic *Hyphomycetes* for control of forest and urban Lepidoptera pests in Georgia

Medea Burjanadze

Gypsy moth, *Lymantria dispar* L., Fall webworm, *Hyphantria cunea* Drury, Mottled Umber *Erannis defoliaria* (Clerck, 1759) are economically important forest, orchards and urban pest in Georgia. In regular cycles, they causes large-scale defoliation. Recent investigations suggest that, entomopathogenic *Hyphomycetes*, witch are isolated from different geographical sites and natural environment of Georgia, have been tested for virulence against mentioned pest. Three isolates of entomopathogenic fungi representing three species *Beauveria bassiana*, *Beauveria pseudobassiana*, *Metarhizium anisopliae* were screened as potential biological control agents. In this study the maximum mean mortality of larvae L.*dispar*, H.*cunea*, E.*defoliaria* were marked at 18 days post-inoculation and ranged 80.8%; 84.3;%; 85.9% for *B.basiana*, 78.7%; 82.3%; 85.3% for *B.pseudobassiana*, and 72. 6%; 76.5%; 70.5% for *M. anisopliae.*

## Poster 14

### Diversity of entomopathogenic fungi from forest ecosystem of Georgia

Ketevan Koridze

Entomopathogenic fungi naturally occurring in the soil represent a reservoir of antagonists to insect pest. Local strains may be adapted to their environment by that they cause particular interest for being used in biological control. In order to study diversity of entomopathogenic fungi total 45 soil samples were taken from forest ecosystem of Georgia in 2014-2016. They were collected from different sites and different altitudes (100-1800 m a.s.l). Entomopathogenic fungi were isolated from soil using the Galleria bait method (Zimmerman 1986). The following entomopathogenic fungal taxa were found with following percentage: Beauveria Bassiana 63. 5 %, Metarhizum 15,8%, Leccaniccium sp. 7%-ს, Isaria fumosoroseus 5%-ს, Paecilomyces sp andFusarium sp. 3,5 %.

## Poster 15

### Innate positive chemotaxis to pollen from crops and banker plants in predaceous biological control agents: towards new field lures?

Shu Li

Predator-prey interactions form the core of biological control of arthropod pests. Which tools can be used to monitor and collect carnivorous arthropods in natural habitats and targeted crops? Ecofriendly and effective field lures are urgently needed. In this research, we carried out olfactometer experiments assess innate positive chemotaxis to pollen of seven crop and banker plant by two important predatory biological control agents: the coccinellid *Propylea japonica* and the anthocorid *Orius sauteri.* We compared the attractiveness of pollens from crops and banker plants to that of common prey homogenates (aphids and thrips, respectively). Attractiveness of the tested odor sources was checked via field trapping experiments conducted in organic apple orchards and by release-recapture assays in organic greenhouse tomato crops. Maize and canola pollen were attractive to both them, in laboratory and field assays.

## Poster 16

### Estimating parasitoid suppression of aphid populations in the field

Jacques Brodeur

We developed and validated a quantitative method to assess the capacity of parasitoids to reduce peak aphid densities under field conditions. Our method was built upon an existing model describing the bell-shaped population dynamics observed in many aphid species and estimates the impact of early parasitoid-induced mortality on forthcoming aphid populations. We validated the model using the soybean aphid, *Aphis glycines*, and its most abundant parasitoid in North America, *Aphelinus certus*. Soybean aphid populations were well described by the model, facilitating the prediction of peak aphid densities and its timing from the date of field colonization onward. The method estimated that *A. certus* reduced peak soybean aphid densities by only 1-6% in 2012 and 2013 because of low levels of parasitism early in the season. The method we propose is simple and could be extended to other natural enemies.

## Poster 17

### Does patch-guarding behaviour in parasitoids deter or attract arthropod egg predators?

Josée Doyon

Host patch defence has been reported in several parasitoid taxa. Typically, a patch-guarding parasitoid female finds a patch, oviposits and patrols the patch for some time. Patch guarding has been shown to reduce competition. We quantified a potential drawback of patch defence, i.e. increased predation on developing parasitoids, using *Telenomus podisi* exploiting eggs of the brown marmorated stink bug, *Halymorpha halys*. We hypothesized that parasitoids either deter predators with aggressive behavior or attract them with their movement. In the laboratory, we recorded the behavior of *T. podisi* protecting their patch against *Chrysoperla carnea* and *Podisus maculiventris*. Patch-guarding increased the residence time of predators on egg masses from 6% to 55% and the number of eggs consumed from 17% to 68%, depending on the predator species. In field experiments, predation rates were 50% higher on egg masses guarded by a parasitoid female.

## Poster 18

### The behavioural type of a top predator drives the short-term dynamic of intraguild predation

Radek Michalko

Variation in foraging aggressiveness and prey choosiness among individual top predators may shape the dynamic of interactions with pests and other predators occurring in an agroecosystem. We studied such dynamic using a top predator spider, a mesopredator spider, and a psyllid pest. The system with an aggressive/nonchoosy top predator, without prey preferences between pest and mesopredator, suppressed the pest more when the top predator to mesopredator abundance ratio was high. In contrast, the system with a timid/choosy top predator that preferred the pest to the mesopredator was more effective when the ratio was low. We show that the behavioral types and abundances of interacting species need to be considered together when studying food-web dynamics in biocontrol.

## Poster 19

### The effect of plant resistance on biological control of insect pests

Daniela Weber

Biological control of insect pests and intrinsic plant resistance are two fundamental parts of integrated pest management. Yet, altering plant quality traits like resistance can affect performance and abundance of biocontrol agents. Using woodland strawberry (*Fragaria vesca*) as model system, the aim of this project is to test how and to what extent biological control is affected by variation in plant resistance. The high within-species genetic variation in resistance of *F. vesca* to the Strawberry Leaf beetle (*Galerucella tenella*) makes it ideal to investigate resistance effects on tritrophic interactions. Current results from experiments with the associated parasitoid *Asecodes parviclava* (Hymenoptera: Eulophidae) show that resistant plant genotypes can facilitate successful biocontrol. Yet, the system appears to be more complex and plant resistance alone seems not to be a good proxy for successful host-parasitoid interaction.

## Poster 20

### Promoting *Cotesia rubecula*, an antagonist of *Pieris rapae*

Shakira Fataar

The loss of natural habitats through monocultures negatively impacts the existence of beneficial insects. Countermeasures include adding food sources and shelter to crop fields through tailored flowering strips and companion plants. To reach the desired effects, flowers should be carefully selected to promote beneficial insects, but not pests. *Pieris rapae* is a pest of cruciferous plants, attacked by the larval parasitoid *Cotesia rubecula*. Laboratory trials were conducted to test the impact of selected flowers on fecundity and longevity of both species. Further, olfactometer experiments were performed to determine the attractiveness of volatiles released by the selected flowers. In the field, parasitation performance of *C. rubecula* was investigated by exposing *P. rapae* larvae in specially composed exposition sets. Differences were found in insect enhancement, as well as in the attractiveness of the tested flowers.

## Poster 21

### Cold acclimation increases cold- and starvation tolerance but reduces predation rate and reproduction in the predatory mite *Geolaelaps aculeifer*

Kim Jensen

Ectotherms acclimate to thermal conditions by adjusting physiological parameters. They may therefore be expected to have higher performance at a given temperature after a period of exposure to this temperature compared to individuals with a recent and abrupt exposure. We investigated thermal acclimation effects on predation and reproduction in the predatory mite Geolaelaps aculeifer. Females were exposed to low (10°C), intermediate (15°C), and standard rearing (20°C) temperatures for 7 days while fed prey ad libitum. Our study shows that predation and reproduction of G. aculeifer are significantly reduced after a period of exposure to low temperature compared to individuals maintained at their standard rearing temperature. These effects were consistent when testing across all 3 temperatures. We therefore recommend keeping cultures at 20°C without cold exposure until release in the field, also under cold field conditions.

## Poster 22

### Mass-rearing optimization of the parasitoid *Psyttalia lounsburyi* for biological control of the olive fruit fly

Florianne Chardonnet

The larval parasitoid *Psyttalia lounsburyi* is a biological control agent of olive fruit fly, *Bactrocera oleae*, which is a pest in the Mediterranean Region and California. However, it has been difficult to rear the parasitoid in the laboratory because the host develops only in fresh olives, which are not available for most of the year. The parasitoid can be reared on the Mediterranean fruit fly, a factitious host but not very efficiently. We improved the efficiency of rearing, including an artificial olive fruit to stimulate oviposition, optimizing host age, the density of adult parasitoids, frequency and duration of exposure for oviposition, conditions for holding adults until release, as well as methods to quickly standardize the number of exposed larvae and to count emerging adult parasitoids.

## Poster 23

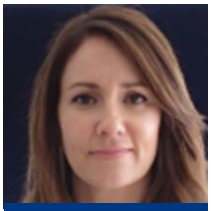
### Evaluation of sixspotted thrips, *Scolothrips sexmaculatus*, for biological control of spider mites in California almonds

David Haviland

Over the past decade there has been a shift in natural enemy complexes for spider mites in California almonds. Recently, sixspotted thrips, *Scolothrips sexmaculatus*, has replaced the phytoseiid *Galendromus occidentalis* as the predominant predator. During 2016 and 2017 we conducted field trials to develop monitoring tools for sixspotted thrips and to evaluate the impact of thrips on populations of Pacific spider mite, *Tetranychus pacificus*. The most effective method for thrips monitoring was determined to be sticky cards, which were then used to document predator-prey ratios during naturally-occurring outbreaks in almond orchards. These data are being converted into management recommendations for growers that can help to maximize conservation biological control.

## Poster 24

### Area-wide integrated pest management incorporating the sterile insect technique: gut microbiota impacts on tephritid fitness and performance



Olivia Reynolds

The sterile insect technique (SIT) uses mass-reared insects that are irradiated before release to render them infertile. Success of SIT relies on sterile releases 'overflooding' the wild population, minimizing wild males and wild females mating to produce viable eggs, under an Area Wide Integrated Pest Management (AWIPM) scenario. It is feasible that irradiation and domestication may impact an insect's gut microbiota and affect the quality of the flies used in SIT programs. To determine the difference in bacterial abundance and diversity of larval *Bactrocera tryoni* (Froggatt), we characterised the bacterial community from individual domesticated and wild larval midguts. Administering bacterial probiotics, we tested performance traits of domesticated, sterile *B. tryoni*. Understanding the microbiome of larval *B. tryoni* could lead to improved diets and increased fly performance in AWIPM programs that incorporate SIT.

## Poster 25

### Non-target impacts of *Isaria fumosorosea* (Hypocreales: Cordycipitaceae) on natural enemies of arthropod pests

Rostilav Zemek

A number of biopesticides based on entomopathogenic fungi have been developed since the 1960s. While the efficacy of these products against target pests has been documented in many studies, less is known about their effects on beneficial organisms. The objective of the present contribution is to assess non-target impacts of*Isaria fumosorosea*, a worldwide distributed species with a relatively wide host range, on parasitic wasps, predatory mites and entomopathogenic nematodes. Our results revealed that this fungus can reduce population of hymenopteran parasitoids overwintering in fallen leaves of horse chestnut by 46%. It also attacks phytoseiid predatory mites *Phytoseiulus persimilis* and *Typhlodromus pyri* and negatively affects development of entomopathogenic nematode *Steinernema feltiae.*

## Poster 26

### Releases of *Trissolcus japonicus* and *Anastatus* sp. for suppression of *Halyomorpha halys* in kiwifruit orchard

Feng Zhang

Kiwifruit is one of the most important cash crop in Shaanxi Province, China, and recently has been plagued by occasional outbreak of *Halyomorpha halys*. In order to avoid using broad-spectrum insecticides, biological control approaches to control *H. halys* are needed. *Trissolcus japonicus* and *Anastatus* sp. are two dominant egg parasitoids of *H. halys* in northern China. Inoculative releases of *T. japonicus* and augmentative releases of *Anastatus* sp. were made twice in 2016 in a kiwifruit orchard at Zhouzhi County. Parasitism by *T. japonicus* and *Anastatus* sp. on sentinel eggs of *H. halys* reached 79% and 77% in release plots after second releases, while parasitism by *T. japonicas* was 76% in no-release plots. The higher parasitism rate in no-release plots might be attributed to dispersal of *T. japonicus* from the first release. Field trials will be repeated in 2017 to further assess the effectiveness of releases of the two parasitoids for suppression of *H. halys* in kiwifruit orchard.

## Poster 27

### Caught on camera: confirmation of natural enemies attacking pest leafrollers in kiwifruit orchards

Jacqui Todd

We identified parasitoids and predators of pest leafroller species (*Ctenopseustis obliquana* and *Cnephasia jactatana*) in the shelterbelts of 12 kiwifruit orchards over 2 years. Parasitoid identity and parasitism rates were determined using larvae placed on the leaves of potted poplar trees, and predators were identified by videoing tethered larvae and egg batches. Predation was measured using the disappearance rate of sentinel larvae and egg batches. We identified 14 predators and four parasitoid species, however, initial results suggest parasitism and predation rates were low - a maximum of 3% and 35%, respectively. Increasing the contribution of these species to the control of these pests may reduce the number of Bt-based insecticides that need to be applied by growers.

## Poster 28

### *Telenomus* sp., a potential biological control agent against the cabbage moth *Mamestra brassicae*

Shakira Fataar

The cabbage moth *Mamestra brassicae* (Linnaeus 1758) (Lepidoptera: Noctuidae) is an insect pest distributed throughout Europe and Asia. Its larvae can cause severe damages to different brassica crops and alternatives to broad-spectrum insecticides are scarce. A candidate to develop an egg parasitoid based biocontrol agent was identified during field trials in Switzerland and was determined as *Telenomus laeviceps* (Foerster, 1861) (Hymenoptera: Scelionidae). Laboratory trials were conducted to build a small scale rearing. Effects on parasitation rates and proportions of female progeny were tested for following aspects: temperature, parasitizing female density and mating time between emergence and parasitation. Based on the presented results a stable rearing of *T. laeviceps* was achieved, potentially allowing the development of a mass rearing for augmentative biocontrol purposes.

## Poster 29

### Alteration of predatory behavior of a generalist predator by exposure to two insecticides

Radek Michalko

Predation pressure exerted by spiders on pests depends on their prey choice and predatory activity. We tested the effect of spinosad and methoxyfenozide, on the predatory activity and prey choice of spider *Philodromus cespitum*. We investigated the prey choice of *P. cespitum* between the pest *Cacopsylla pyri* and spiders *Theridion* sp. We found that the philodromids in control treatment significantly preferred theridiids to psylla while the philodromids in both pesticide treatments did not show any distinct preferences. Both pesticide treatments increased the predatory activity of philodromids. The results show that the application of pesticides can disrupt the natural ecological dynamics of predator-prey interactions due to the altered predatory activity and prey choice.

## Poster 30

### Impact of plant extracts of *Embelia ribes* and two commercial pesticides on mortality and predator activity of a generalist predator *Oxyopes lineatipes*

Ondrej Kosulic

In this study, we evaluated the lethal and sublethal effects of the crude extract from leafs of *Embelia ribes*, biopesticide Azadirachtin, and synthetic acaricide Amitraz on the lynx spider *Oxyopes lineatipes*. The sublethal effect was examined by means of functional response. Embelia, Azadirachtin, and Amitraz had no, slightly negative, and highly negative effect on survival of *Oxyopes*, respectively. Azadirachtin reduced the capture rate of *Oxyopes*, while *Embelia* did not. The extract from *Embelia* appears to be a new suitable biopesticide, due to its high efficiency in mite pest suppression but no adverse effects on natural enemies. In contrast, Azadirachtin that is considered as safe for non-target organisms exerted significantly negative sublethal and slight lethal effect.

## Poster 31

### *Vespula* biocontrol in New Zealand

Ronny Groenteman

European *Vespula* wasps are invasive in several parts of the world, but biological control against them has only been seriously attempted in New Zealand. Parasitoids of the genus *Sphecophaga* were introduced in the late 1980s and shortly thereafter the biocontrol programme was discontinued. *Sphecophaga* established at a limited range and did not bring wasp populations down to an acceptable level. This poster describes the renewed interest in biocontrol against wasps, which has seen the programme revived in 2014, first with examination of the new species of mite, *Pneumolaelaps niutirani*, first discovered on wasps in New Zealand, followed by re-introduction of *Sphecophaga* from a more suitable geographic range. Next we will explore new candidate agents from the wasps' native range – *Volucella inanis, Leopoldius* sp. and *Metoecus paradoxus*.

## Poster 32

### The rich tapestry of biological control targets and agents in sweetpotato production systems of Papua New Guinea

Jian Liu

We introduce our ongoing work in the sweetpotato production systems of Papua New Guinea (PNG) where cash-cropping is developing from subsistence farming. Surveys have shown that arthropods - especially weevils - are the major plant protection concern. Despite growers reporting use of a wide range of plant protection methods including biological control, a large majority use no active intervention. Our work is evaluating the potential for biological control interventions to complement traditional practices such as the use of pigs and poultry to consume pests and crop residues. Field surveys in PNG as well as in Australia are being used to explore the diversity of natural enemies, whilst laboratory and field studies are comparing candidate entomopathogens (e.g. *Metarhizium*sp. and *Pasteuria* sp.) and investigating the influence of volatile and non-volatile plant compounds.

## Poster 33

### *Acerophagus papayae* (Hymenoptera: Encyrtidae) as a biocontrol agent of *Paracoccus marginatus* (Hemiptera: Pseudococcidae) in Barbados

Yelitza Colmenarez

*Paracoccus marginatus* (Hemiptera: Pseudococcidae) is a polyphagous insect that attacks different crops and ornamental plants. *Acerophagus papayae* (Hemiptera: Pseudococcidae) has been reported as an efficient biocontrol agent. The biology of the parasitoid and *P. marginatus* was studied and it was evaluated the influence of 3 host plants (*Papaya*, *Beans* and Cotton) on the development of the pest and parasitoid. It was studied the biology of *A. papayae,* and it was evaluated the nymphal stage preferred by the parasitoid. The most favorable host for the development of *P. marginatus* and *A. papayae* was papaya, followed by beans. Nymphs reared in papaya were the most favorable host. The 3rd instar nymphal was the preferred one, showing 86.1% of parasitism in nymphs reared in Papaya. The results indicate the potential for Biological Control of *P. marginatus* in the Caribbean.

## Poster 34

### Economic impact of biological control of mango-infesting fruit flies: a case study of Kenya

Sunday Ekesi

The impact of the parasitoids (*Fopius arisanus* and *Diachasmimorpha longicaudata*) for fruit fly suppression was evaluated in combination with other management strategy within a frame work of IPM, in comparison to farmers' practices as a control group, in Meru County, Kenya. Our study findings showed that parasitoid release in combination with other strategies had a significant impact on mango wwerevenues compared with the control group. While the average expenditure on pesticides decreased across all mango farmer households, the reduction was comparable between the treated and control farms. Further, significant decrease in mango damage due to fruit fly infestations among all farmers using the different IPM combinations was observed. The use of parasitoid for the invasive fruit fly B. dorsalis with a holistic IPM strategy is discussed in the light of the findings of this study.

## Poster 35

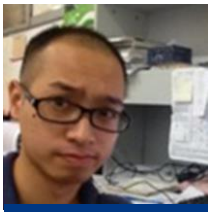
### „Nothing kills insects", or how public and farmer perceptions affect success rates of biological control

Kris Wyckhuys

Over the past decades, anthropologists and sociologists have realized that many of the world's farmers are unaware and un-informed about natural pest control. Although biocontrol is irregularly examined through a 'social science' lens, farmer knowledge, attitudes and beliefs are of paramount importance to its adoption and successful implementation. We critically examine different biological control forms, concepts and technologies through a 'diffusion of innovations' lens, and identify elements that hamper their diffusion and farm-level uptake. Biocontrol technologies do suffer a number of notable shortcomings, but cross-disciplinary science could help bolster adoption rates, counter-act surging insecticide use and restore public trust in one of nature's prime ecosystem services.

## Poster 36

### Evolution and potential non-target effect of the introduced biological control agent *Cryptolaemus montrouzieri*



Hao-Sen Li

*Cryptolaemus montrouzieri* (mealybug destroyer) is a predatory ladybird of Australian origin and has been introduced worldwide to control mealybugs. We first found different performances of this introduced ladybird from different areas. Then, we detected strong genetic differentiation and local adaptation among the worldwide distributed populations by analyses of mitochondrial genomes, microsatellite and reduced-representation genomes. These genetic markers also suggested a history of population admixture, which were further confirmed in a lab-simulated experiment. Finally, the test of diet ranges and analysis of adaptation to diet shifts suggested potential non-target effect of this introduced ladybird.

## Poster 37

### Bioassay and scanning electron microscopic observations reveal high virulence of entomopathogenic fungus on the onion maggot

Zhongren Lei

The susceptibility of onion maggot adults to 12 isolates of the Beauveria bassiana, at a concentration of 1×107 conidia/ml, was tested in laboratory experiments. Eight of the more potent strains caused in excess of 80% adult mortality 8 days post inoculation, while the median lethal time (LT50) of these strains was less than six days. Our conclusion was that many of the B. bassiana strains are highly toxic to D. antiquaadults and should be considered as potential biocontrol agents against the adult flies.

## Poster 38

### Cattle fever tick, *Rhipicephalus annulatus* (Acari: Ixodidae), and the quest for discovery of its natural enemies in the Balkan region

Javid Kashefi

*Rhipicephalusannulatus* is a hard tick native to Mediterranean region with several hosts such as cattle and white tailed deer. It transmits two lethal diseases, piroplasmosis and babesiosis. R. annulatus is an invasive species in US, with significant impact on cattle production especially in Texas. Extensive use of acaricide resulted in resistance. Special attention is given to the Balkan region for discovery of natural enemies since molecular analysis of CFT showed that the Texas population is similar to those of Bulgaria and Romania. Extensive travelling and cooperation with various institutions and small family farms which are not using any acaricidae in Greece, Turkey, Albania and Bulgaria resulted in creation of a wide network of potential tick exposure sites. Classical biological control using specialist parasitoids, predators and nematodes from the native ranges of CFT could complement existing control strategies.

## Poster 39

### Laboratory evaluation for entomopathogenic fungi against the red palm weevil, *Rhynchophorus ferrugineus* Olivier

Laila Alshuraym

The red palm weevil (RPW), *Rhynchophorus ferrugineus* Olivier is the most pests of various palm species. Effects of the entomopathogenic fungi, *M.anisopliae var.acridum* ( Metchinkoff) soroken , *B.bassiana* ( Bals) Vuill on *R.ferrugineus* was studied in laboratory . Two entomopathogenic fungi were tested at three concentrations 1 x 102 , 1x103 and 1x104 spore / ml . ( C1,C2 & C3) . Mortalities were observed daily. The mortality recorded 7.5% by infection the 3rd concentration from *M.anisopliae* after 3rd day but was 2.5% with the same conc. from *B.bassiana a*nd day .The mortality recorded 7.5% by infection the 3rd concentration from *M.anisopliae* after 4th day but was 4% with the same conc. and day from *B.bassiana M.anisopliae* was more virulent to the larvae, pupa and adults of *R.ferrugineus* than *B.bassiana*

## Poster 40

### Effect of release frequency of egg parasitoid as a biological control agent for cocoa pod borer

Meriam Mohd Yusof

Cocoa pod borer (CPB) *Conopomorpha cramerella* (Snellen) discovered attacking the cocoa plantation in Malaysia in early 1980's and considered as a serious pest. This pes can causes heavy losses up to 100 % if the pest is not kept under control. Several method have been practiced to control this pest. Among th emethod, the uses of natural enemies egg paraasitoid *Trichogrammatoidea cojuangcoi* is consider as one of the environmental friendly method to manage this pest. This study was carried out to evaluate the effect of release frequency of the parasitoid as a biological control agent for CPB management on crop loss and Average Damage Severity Index (ADSI) of the cocoa bean. Result from this study showed that double up the release frequency give some positive impact on crop loss and ADSI.

## Poster 41

### New progress in mass production of *Trichogramma* and field application for biological control on agricultural pests in China

Lian-Sheng Zang

Since the 1950s, artificial reproduction of *Trichogramma* and their application technologies have been systemically studied in China. In recent years, we have made some progress in mass production of *Trichogramma* with the large eggs of *Antheraea pernyi*, small eggs of *Corcyracephalonica* and *Sitotroga cerealella*, as well as artificial eggs. Here, we summarized the new progress in mass production of *Trichogramma* with large eggs from the matched production facilities and technologies, with small eggs from breeding device for larvae and collection methods for adult moth, and with artificial eggs from medium and production facility. In addition, we introduced the technologies with mixed-releasing two *Trichogramma* species produced using large eggs and small eggs to control rice striped stem borers. Ever since 2004, the total release area was approximately 17 million hectares.

## Poster 42

### Sublethal effects of *Beauveria bassiana* (Ascomycota: Hypocreales) on life table parameters of *Frankliniella occidentalis* (Thysanoptera: Thripidae)

Hai Hong Wang

We assessed effects of parental exposure to *Beauveria bassiana* on life history traits of subsequent generations of *Frankliniella occidentalis*. Results demonstrate that *B. bassiana* has sublethal effects that reduce the reproductive success of *F. occidentalis*.

## Poster 43

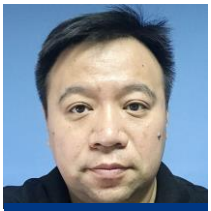
### Efficacy of multicolored lady beetle *Harmonia axyridis* against aphid *Myzus persicae* on vegetables under greenhouse conditions

Fan Zhang

In order to evaluate the control ability and benefit of *Harmonia axyridis* on *Myzus persicae*, releasing *H. axyridis* to control *M. persicae* were investigated as comparing with application of biological insecticide in pimiento and eggplant greenhouse. The results showed that *H. axyridis* could continue to depress population densityof *M. persicae* in pimiento greenhouse. In addition, the yield of pimiento and benefit that releasing *H. axyridis* control *M. persicae* were higher than biological control. In eggplant greenhouse,releasing *H. axyridis* delayed the peak of aphids for one week. These results indicated that monitoring the population dynamics of natural enemies and pests in entire stage should be definitely facilitated the ratio of natural enemy and pest per week after planting 15 days. Releasing *H. axyridis* in early could be cost-effective and sustainable in controlling *M. persicae* in vegetable greenhouses.

## Poster 44

### Conservation biological control in organic orchard



Su Wang

Application of conservation biological control (CBC) techniques, include enhance plant introduction, functional botanic habitat regulation has been utilized as the most efficient solution for suppressing arthropod pest. During past 15 years, we proceeded a series improvement of CBC in an organic apple orchard. From 2004-2006, we did nothing in target orchard. Since 2006, we started to plant specific weeds alternatively under trees for increase the biodiversity. After 3 years, we started provided banker plants (*Vicia faba* seedling carried *Acyrthosiphon pisum*) for supporting predatory natural enemies. Then we established a botanic garden which cultured over 60 different crops as a resource of natural enemy close to the orchard from 2011. After all the procedures, we now achieve that the ecological self-regulation of arthropod complex and do not releasing any natural enemy for pest suppression.

## Poster 45

### The control effect of large-area application of sex pheromone to *Grapholitha molesta* in peach orchard

Xiaojun Guo

In order to evaluate the actual control effect of disrupting mating with sex pheromonesto *Grapholiths molesta* (Busck), the sex pheromone was used in large area peach orchard (approximate 8667 hectare) of Pinggu district in Beijing that. Sex attractants and sugar-vinegar liquid were used to monitor the population dynamics of *G. molesta* as compared with chemical control area. Our results showed that the population number of *G. molesta* in sex pheromone treated area was significantly lower than in the chemical control area. The mating disruption rate of *G. molesta*in three treated area were 99.05%, 98.10% and 99.68%, respectively. The peach fruit-preserving effect was achieved to 100%. Our results demonstrated that the good control effect of disrupting mating with sexattracts to *G. molesta* when it was used in large area in peach orchard.

## Poster 46

### Feeding and search behavior of *Cryptolaemus montrouzieri*: a potential biocontrol agent of *Paracoccus marginatus*

K.S. Hemchandra

*Cryptolaemus montrouzieri* was assessed to use in augmentative release to manage Paracoccus marginatus, papaya mealybug (PMB), an introduced mealybug species to Sri Lanka. Feeding rates of female (#/day) were 86±1.17, 48±0.3, 40±0.95, 38±0.99 and 34±1.23 when on eggs, 1st, 2nd, 3rd instar nymphs and adults of PMB respectively when provided with one type of food. Fourth larval instar consumed the highest number: 2382 ± 10.83, 1288 ± 6.44, 1280 ± 5.68, 1125 ± 13.64, and 968 ± 3.96 when on eggs, 1st, 2nd, 3rd instar nymphs and adults of PMB respectively when on one type of food. The predatory larvae attract towards the mealybug egg masses and 2nd instar larva takes 56.5 minutes to reach the egg mass which was 10 cm away. Food search by larvae significantly varied with morphology of the leaf surface; the second larvae took 9.5±1.9 minutes to reach the eggs on a cassava leaf which was 5 cm away.

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# Map of Langkawi Island

| Time | Sunday<br>10 Sept 2017 | Monday<br>11 Sept 2017 | Tuesday<br>12 Sept 2017 | Wednesday<br>13 Sept 2017 | Thursday<br>14 Sept 2017 | Friday<br>15 Sept 2017 |
|---|---|---|---|---|---|---|
| **08:00** | | **Session 1:** Accidental introductions of biocontrol agents: positive and negative aspects | *House-keeping* | *House-keeping* | **08:15** *House-keeping* | *House-keeping* |
| **08:15** | | | **Session 5:** The role of native and alien natural enemy diversity in biological control | **Session 8:** Weed and arthropod biological control: mutual benefits and challenges | **08:30 Session 9:** Maximizing opportunities for biological control in Asia's rapidly changing agro-environments | **Session 12:** Successes and uptake of arthropod biological control in developing countries |
| **10:15** | | **10:00** *Coffee Break & Opening Ceremony* | *Coffee Break* | **09:30** *Coffee Break* | *Coffee Break* | *Coffee Break* |
| **10:45** | | **Session 2:** The importance of pre and post release genetics in biological control | **Session 6:** Frontiers in forest insect control | **Field Excursion starting at 10:00**: Nature Trip incl. Picnic Lunch and visit to MARDI Station (organized in 2 groups) – entire field excursion **ends approximately at 17:00** | **Session 10:** Biological control based Integrated Pest Management: does it work? | **Session 13:** Socio-economic impacts of biological control |
| **12:45** | | Lunch | Lunch | | **12:30** Lunch | **12:30** Lunch |
| **13:45** | | **Session 3:** How well do we understand non-target impacts in arthropod biological control? | **Session 7:** Biocontrol Marketplace I – Free topics | | **Session 11:** Exploring the compatibility of arthropod biological control and pesticides: models and data | **Session 14:** Marketplace II – Free topics |
| **15:45** | | *Coffee Break* | *Coffee Break* | | *Coffee Break* | **15:30** *Coffee Break* |
| **16:15** | **Registration** starting at 17:00 at Meritus Pelangi Hotel | Session 4: Regulation and access and benefit sharing policies relevant for classical biological control approaches | **Poster Session I: until 17:30** | | **Poster Session II: until 17:45** | **16:00 Business meeting until 16:30** |
| **18:00** | | *End* | *End* | | *End* | *End* |
| **19:00** | **Welcome Reception** at Meritus Pelangi Hotel, Waterfront | | | **Group Dinner** at Meritus Pelangi Hotel – BBQ Waterfront | | |