EURAACnewsletter 7/12

EURopeanAssociationofACarologists http://euraac.boku.ac.at

ISSN 1650-5557

IN THIS ISSUE:

- Maurice W. Sabelis spotlights three recent mite articles
- Maria Navajas comments on the decrypted genome of *T. urticae*
- PhD and MSc students introduce their recently defended theses

EURAACCOMMITEESCHAUSBERGERFERRAGUTCASTAGNOLISCHATZBRUINDABER
TGERECKEKREITERNAVAJASRAGUSASABELISWITALINSKIEURAACCOMMITEES
CHAUSBERGERFERRAGUTCASTAGNOLISCHATZBRUINDABERTGERECKEKREITERN
AVAJASRAGUSASABELISWITALINSKIEURAACOMMITTEESCHAUSBERGERFERRAGUT

Editors: Peter Schausberger + Stefan Peneder euraacnews@boku.ac.at

DEAR ACAROLOGISTS

We are pleased to present you the 7th volume of the EURAAC Newsletter. This volume highlights an important step forward in acarology and beyond, particularly the use of mites as research model animals: the recently sequenced whole genome of the two-spotted spider mite *Tetranychus urticae*, published in *Nature*. In the Spotlight section, Maurice W. Sabelis (University of Amsterdam, Netherlands) presents his selection of recent mite papers deserving special attention. In the Forum section, Maria Navajas (INRA-CBPG, Montferriez-sur-Lez, France) comments on one of these three papers, the spider mite genome paper. The Theses section contains the abstracts of recently finished PhD and MSc theses from the Netherlands and Austria. In the Media section, we introduce several mite books, two of which written by Hany Elkawas and dealing with plant-inhabiting mites and mites used as biocontrol agents, respectively.

Thanks to all contributors for sharing their news with us. Please keep on informing us, the Newsletter lives from your contributions. Deadline for news to be included in the 7th issue (November 2012) is end of October 2012.

Looking forward to welcoming you at the 7th EURAAC Symposium, taking place in Vienna, Austria from July 9-13, 2012 (http://euraac.boku.ac.at/SympVienna).

The Editors (euraacnews@boku.ac.at)
Peter Schausberger + Stefan Peneder

CONTENTS

Maurice W. Sabelis (Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Netherlands) selected three recent mite papers deserving special attention
M.W.Sabelis@uva.nl

November 2011

M. Grbić*, T. Van Leeuwen, R.M. Clark, S. Rombauts, P. Rouze, V. Grbić, E.J. Osborne, W. Dermauw, P. Cao Thi Ngoc, F. Ortego, P. Hernandez-Crespo, I. Diaz, M. Martinez, M. Navajas, E. Sucena, S. Magalhães, L. Nagy, R.M. Pace, S. Djuranović, G. Smagghe, M. Iga, O. Christiaens, J.A. Veenstra, J. Ewer, R. Mancilla Villalobos, J.L. Hutter, S.D. Hudson, M. Velez, S.V. Yi, J. Zeng, A. Pires-daSilva, F. Roch, M. Cazaux, M. Navarro, V. Zhurov, G. Acevedo, A. Bjelica, J.A. Fawcett, E. Bonnet, C. Martens, G. Baele, L. Wissler, A. Sanchez-Rodriguez, L. Tirry, C. Blais, K. Demeestere, S.R. Henz, T.R. Gregory, J. Mathieu, L. Verdon, L. Farinelli, J. Schmutz, E. Lindquist, R. Feyereisen & Y. Van de Peer** (2011). *Nature* 479: 487–492.
*mgrbic@uwo.ca
**yves.vandepeer@psb.ugent.be

THE GENOME OF *TETRANYCHUS URTICAE* REVEALS HERBIVOROUS PEST ADAPTATIONS

The spider mite *Tetranychus urticae* is a cosmopolitan agricultural pest with an extensive host plant range and an extreme record of pesticide resistance. Here we present the completely sequenced and annotated spider mite genome, representing the first complete chelicerate genome. At 90 megabases *T. urticae* has the smallest sequenced arthropod genome. Compared with other arthropods, the spider mite genome shows unique changes in the hormonal environment and organization of the Hox complex, and also reveals evolutionary innovation of silk production. We find strong signatures of polyphagy and detoxification in gene families associated with feeding on different hosts and in new gene families acquired by lateral gene transfer. Deep transcriptome analysis of mites feeding on different plants shows how this pest responds to a changing host environment. The *T. urticae* genome thus offers new insights into arthropod evolution and plant–herbivore interactions, and provides unique opportunities for developing novel plant protection strategies.

November 2011

E. Macke*, S. Magalhães, F. Bach & I. Olivieri***** (2011). *Science* 334: 1127-1129.
*emilie.macke@univ-montp2.fr
**snmagalhaes@fc.ul.pt
***isabelle.olivieri@univ-montp2.fr

EXPERIMENTAL EVOLUTION OF REDUCED SEX RATIO ADJUSTMENT UNDER LOCAL MATE COMPETITION

Theory predicts that local mate competition (LMC) favors the evolution of female-biased sex ratios. Empirical support of this prediction is indirect and comes from comparative studies or from studies showing that individuals can adjust their offspring sex ratio in response to varying LMC intensities. Replicate lines from a population of the spider mite *Tetranychus urticae* were selected under three LMC intensities for up to 54 generations. Within each selection regime, the final sex ratio matched theoretical predictions. Further-more, the ability of individuals to adjust their offspring sex ratio diminished in females evolving under strict LMC, but not in females evolving under relaxed LMC levels. These results provide direct experimental evidence for the evolutionary process by which LMC modifies sex-allocation strategies and suggest that evolution under strict and constant LMC may lead to a loss of phenotypic plasticity.

March 2012

T. Van Leeuwen*, P. Demaeght, E.J. Osborne, W. Dermauw, S. Gohlke, R. Nauen, M. Grbić, L. Tirry, H. Merzendorfer & R.M. Clark** (2012) *Proceedings of the National Academy of Sciences of the United States of America* 109: 4407-4412.
*thomas.vanleeuwen@ugent.be
**clark@biology.utah.edu

POPULATION BULK SEGREGANT MAPPING UNCOVERS RESISTANCE MUTATIONS AND THE MODE OF ACTION OF A CHITIN SYNTHESIS INHIBITOR IN ARTHROPODS

Because of its importance to the arthropod exoskeleton, chitin biogenesis is an attractive target for pest control. This point is demonstrated by the economically important benzoylurea compounds that are in wide use as highly specific agents to control insect populations. Nevertheless, the target sites of compounds that inhibit chitin biogenesis have remained elusive, likely preventing the full exploitation of the underlying mode of action in pest management. Here, we show that the acaricide etoxazole inhibits chitin biogenesis in *Tetranychus urticae* (the two-spotted spider mite), an economically important pest. We then developed a population-level bulk segregant mapping method, based on high-throughput genome sequencing, to identify a locus for monogenic, recessive resistance to etoxazole in a field-collected population. As supported by additional genetic studies, including sequencing across multiple resistant strains and genetic complementation tests, we associated a nonsynonymous mutation in the major *T. urticae* chitin synthase (*CHS1*) with resistance. The change is in a C-terminal transmembrane domain of CHS1 in a highly conserved region that may serve a noncatalytic but essential function. Our finding of a target-site resistance mutation in *CHS1* shows that at least one highly specific chitin biosynthesis inhibitor acts directly to inhibit chitin synthase. Our work also raises the possibility that other chitin biogenesis inhibitors, such as the benzoylurea compounds, may also act by inhibition of chitin synthases. More generally, our genetic mapping approach should be powerful for high-resolution mapping of simple traits (resistance or otherwise) in arthropods.

THE WHOLE-GENOME SEQUENCE OF *TETRANYCHUS URTICAE* DECRYPTED

Maria Navajas
INRA, UMR CBGP, Campus International de Baillarguet, CS 30016, 34988 Montferrier-sur-Lez Cedex, France.
navajas@supagro.inra.fr

The *Tetranychus urticae* whole-genome sequence project

In 2006 an international collaborative effort of arthropod researchers constituted by 5 teams launched the project for sequencing the whole genome of the two spotted spider mite *Tetranychus urticae*. The project was granted by the DOE Joint Genome Institute (JGI), Walnut Creek, CA, USA http://www.jgi.doe.gov/sequencing/why/50028.html). The genome sequence was completed and fully annotated by a consortium of 33 laboratories, and the study was published on November 24th 2011 edition of the Nature magazine [1]. *Tetranychus urticae* has then become the first Acari to benefit from the completion of a whole-genome sequence.

Tetranychus urticae ©INRA/Alain Migeon

The genome of *T. urticae* reveals unique characteristics

Tetranychus urticae has the smallest genome of any arthropod determined so far (90 mega base pairs, e.g. 70% of the size of the Drosophila genome). The complete sequence however revealed that it contains unique genes currently unknown in other arthropods. Some of these genes are the result of lateral gene transfer from fungi and bacteria. The study also revealed several genes involved in detoxification and digestion which help explain the mite's unequaled resistance to the toxic compounds produced by certain plants as a form of defense.

Why sequencing a new genome?

The two spotted spider mite is a cosmopolitan and extremely polyphagous species. It feeds on more than 1,100 plant species (http://www1.montpellier.inra.fr/CBGP/spmweb/), among which over 100 are crops. Extensive outbreaks caused by *T. urticae* are reported, particularly in temperate zones. Regarded as a crop pest of high economic relevance, the mite has raised much interest. In addition, the species undergoes rapid development and is easy to rear in the laboratory, which has motivated its use as a laboratory model for a variety of fundamental studies. A remarkably abundant literature attests of the interest this species has attracted among the active scientific community of Acarologists. A search (1975-2012) in the Web of Science (keyword *Tetranychus urticae)* detected 2083 studies. Likewise, a search in the CAB abstracts database yielded 5568 hits, among which 2169 and 1227 cross-matched with the keywords BioControl and Pesticides, respectively. Many areas of research on this highly studied species will now benefit from the powerful resources created by the genome sequence and new research lines will allow deeper understanding the biology of *T. urticae* but also of spider mites in general. In addition, being the first Arachnid to be sequenced, *T. urticae* is a significant key link in the study of the Chelicerates, the second largest group of animals on Earth with considerable importance for fundamental and applied science.

A large community to use the new resource created

Tetranychus urticae has been and will certainly remain one of the most intensely studied mite species in Acarology. The scientific community has now access to the genetic material of *T. urticae*, including those working in fundamental scientific disciplines as well as in applied science. The genome sequence should be a valuable database for laboratories that study pesticide resistance, host-vectors interactions and the agricultural community, including researcher in pesticide resistance. An essential challenge for scientists is to transfer the information provided by the new resource into research favouring pest control strategies.

The resources created, the questions and challenges raised will be the focus of the sub-symposium on "TSSM Genomics" to be held during the 7th Symposium of the EURAAC, Vienna, Austria, 9-13 July, 2012.

Reference

[1] The genome of *Tetranychus urticae* reveals herbivorous pest adaptations – Nature 479, 487-492 (24 November 2011; doi:10.1038/nature10640)

WIM HELLE DECEASED

M.W. Sabelis informed (via the acarology list, acarology@nhm.ac.uk) about the death of a great acarologist.

On Thursday morning, February 8 2012, our colleague acarologist, Wim Helle, is deceased. He was a full professor in Applied Entomology and Acarology at the University of Amsterdam (1962-1991). He was the founding editor of the journal Experimental and Applied Acarology (1985), initiated Elsevier's series on World Crop Pests (including several volumes on plant-inhabiting mites) and was among those who founded the European Association of Acarologists in 1987.

We lost a scientist who created a basis for the genetics of plant-inhabiting mites. His findings on the genetics of diapause, pesticide resistance and genetic incompatibilities in spider mites, as well as on the phylogenetic distribution of haplo-diploidy, arrhenotokous parthenogenesis and pseudo-arrhenotoky in mites, have inspired a generation of acarologists.

THE CLINICAL SYMPTOMS OF ACARIASES

R. Zhaxylykova
Private Clinic, Astana City, Republic of Kazakhstan.
zhax-rd@mail.ru

About presence the pandemic of Acariasis, caused by house dust mites, we informed the community since 1981. Acariasis is the primary chronic infection. The absence of struggle against this illness as absence of the struggle against any infection conducts to different complications. These complications are the clinical masks of Acariasis. Nowadays the physicians of different parts of medicine work with this clinical masks of Acariasis. The given fact is confirmed by statistics of morbidity of people so-called "noninfection diseases".

In this row are a skin's allergic illnesses. According to our data the 70-95% of skin's allergic diseases is complications of Acariasis. At present time there are many facts in official medicine, which indirectly testify to presence of the pandemic of Acariasis. But we will tell about the facts which conducted us to so responsible conclusion.

The prerequisite for our so serious investigations was the casual detection fact about 100% infection of sick persons with Demodectic Discoid Lupus Erythematosus (contrary to categorical back opinion of dermatologists). Therefore, we dilated our main research work by more scrutinizing the coverlets of patients. Involuntarily we began to visually estimate the condition of skin on open parts of body of surrounding people. In 1979 we received the strong conviction about the presence of the non-registered Demodecosis epidemic among the population. The following two years were dedicated to intensive studying of all parameters of any scientific discovery. In results we haven't any doubt about the veracity of our observational data. In the following years we continued more deeply to study this problem, and concurrently informed the corresponding organs about the appearance detection. As a result we learnt about widespread Dermatophagoidic, latent and subclinical variants of Sarcoptic, and others Acariases.

Nowadays we purposefully examined the coverlets of more than 450.000 people, an open part of body on more than 2 million representatives of all continents. During our observations with every year increased the quantity of people who were infected by mites on their skin. Since the August of 1981 we did not meet people with healthy skin. The laboratory examinations revealed mites on 99.8% from 7817 people who had been infected by mites on their skin. Etiopathogenetic treatments allowed complete recovery of more than 8670 sick people with different symptoms of Acariasis. Among them were 178 kids with Atopic Dermatitis, 785 persons with Food and Drug Allergy, 762 with Pollinoses, 213 with Allergy on decoration, 243 with Photodermatosis, 13 with Vulval Leukoplakia, 16 Vulval Kraurosis, 172 with Discoid Lupus Erythematosus, 926 with Acne, 69 with Alopecia, 359 with Neurodermatitis, 9 with Skin Cancer, and others. Necessarily to say that during every following year Acariasis became more severe and complex even with babies. For example, if in the 1970s among infected people 85% did not have subjective complaints, then in 2009 the infection level was only 27%. If in the beginning of the 1980s for full recovery the sick people from skin's allergic symptoms of Acariasis demanded nearly one month, then nowadays it demands from six months to two years depending on clinical case.

Dear colleagues! Please compare these data with epidemiological data in your part of clinical medicine. Owing to information provided at various congresses, everybody of you can inculcate the given knowledge in every days practice and, accordingly, can help full recovery to patients from acariatic variants of illness. Unfortunately, nowadays Acariasis is present among all people. Pleasantly, the technologies at the beginning of the 21st century allow specialists from different parts of our planet to engage in long distance teamwork. The extirpation of widespread clinical symptoms of Acariases is our common task.

For more detailed information about Acariases see www.allergy.kz.

THE COCONUT MITE, *ACERIA GUERRERONIS*, A PLAGUE IN AFRICA: PATHWAYS TO ITS MITIGATION THROUGH BIOLOGICAL CONTROL

Koffi Negloh, PhD 2012
Group of Arthropod Ecology and Behavior, Division of Plant Protection, Department of Crop Sciences, University of Natural Resources and Life Sciences, Vienna, Austria.
k.negloh@cgiar.org

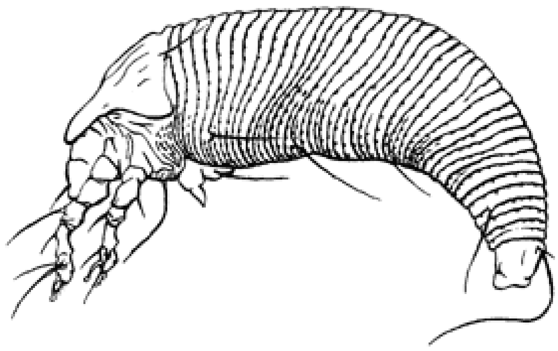
Supervisors: P. Schausberger & R. Hanna

Coconut, *Cocos nucifera* L., a perennial tree crop, is the third most produced tree crop of the world, and widespread through the sub-tropical regions of America, Asia and Africa. It constitutes an important food and income source for hundreds of thousands people around the world. For decades in America and Africa, and more recently in Asia, one of the major biotic constraints to coconut production has been and continues to be a tiny worm-like mite of the family Eriophyidae, the coconut mite, *Aceria guerreronis* Keifer. *A. guerreronis* leaves beneath the perianth of coconut fruits and causes there heavy damage to the developing tissues. To mitigate the damaging effects of the pest on growth of coconut fruits many control attempts have been made in Africa and America from the 1960s until the 1980s, without substantial success. The scientific researches, however, provided valuable insights in the intractable nature and importance of the pest. Several control strategies have been tested, among which biological control became and remains the most promising to date.

The overall objective of the present thesis, as a part of a larger program initiated in 2004, was to help to develop and possibly implement sound and sustainable biocontrol strategies against the coconut mite in Africa and elsewhere in the world through studies on its occurrence, ecology and natural enemies.

The five core studies of the thesis first included surveys in major coconut growing areas of Benin and Tanzania to ascertain the nature and pest status of the coconut mite and its distribution in Africa, with emphasis on its abundance, the severity of damages induced, potential natural enemies and other associated acarine fauna. In both countries not a single coconut plantation was free of damage. The damage incidence was more than 80% at the palm level and the severity of damage increased with fruit age. The density of coconut mites was the highest on 3 to 4 months old fruits. The phytoseiid predatory mites *Neoseiulus paspalivorus, N. baraki* and *N. neobaraki* were the most often associated with the pest in both countries, though they showed reverse patterns of occurrence in these countries. *N. paspalivorus* was the most abundant in Benin, in contrast to Tanzania where the most abundant was *N. neobaraki.* Additionally, several other herbivorous, fungivorus and predatory mites of different taxonomic groups were found on the coconut fruit.

To characterize the interactions between



the pest and its most common predators, the population dynamics of *A. guerreronis* and *N. paspalivorus* were studied in four coconut plantations of two areas, coastal and inland, in Southern Benin. The seasonal and fruit age dependent fluctuations of both mite populations were assessed and the within-plant and within-bunch distribution of both organisms were examined in terms of their population density and proportions of infested fruits. *N. paspalivorus* was only occasionally able to follow the fluctuations of its prey but with a time lag that allowed the pest to thrive. In addition, the predatory mites arrived on the fruits and started to colonize them with almost one month delay after the first arrival of the pest.

In the laboratory, the life history traits of *N. baraki* originating from Benin and Brazil were compared on five food sources, one of which was *A. guerrreronis*. Individuals of both origins were able to complete development on *A. guerreronis*, the two-spotted spider mite *Tetranychus urticae* and maize pollen. Both origins achieved the most favorable demographic parameters on *A. guerreronis* but the Brazilian population was slightly superior to the Beninese population in its population growth parameters. The Brazilian population was, however, less well able than the Beninese population in utilizing *T. urticae*. The other food sources, coconut pollen and castor bean pollen, were not suitable to sustain growth of any population.

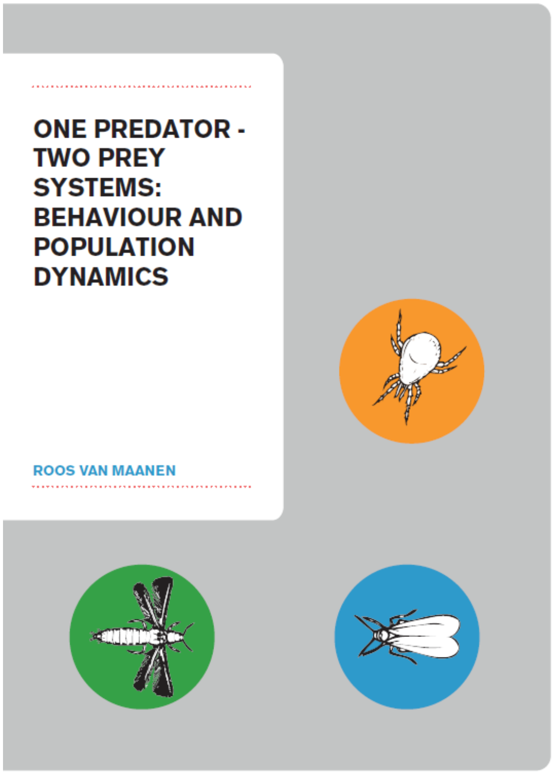
The most commonly found predators occurred sometimes in the same area or on the same palm. Thus, we found it necessary to investigate possible predator-predator interactions and examined cannibalism and intraguild predation of *N. paspalivorus* and *N. neobaraki.* The latter species was previously found to be a far more voracious predator of *A. guerreronis* than the former. In presence of coconut mite prey, both species refrained from cannibalism but *N. neobaraki* continued to engage in intraguild predation. *N. neobaraki* was superior in intraguid predation to *N. paspalivorus* but was less efficient in converting food into offspring, compared to *N. paspalivorus*. In complete absence of food, *N. paspalivorus* survived longer than *N. neobaraki* but none of them produced eggs.

Although morphologically identified as *N. paspalivorus,* three populations of this species originating from Brazil, Ghana and Benin, appeared to have substantial biological differences. Therefore, detailed morphometric characterizations and reproductive compatibility studies were conducted to ascertain the con-specifity of these three allopatric populations. The results of the inter-population crosses showed that the three populations were completely isolated from one another, although morphological measurements showed no differences. The three populations are therefore distinct biological entities despite their morphological similarities.

ONE PREDATOR TWO PREY SYSTEMS: INDIVIDUAL BEHAVIOUR AND POPULATION DYNAMICS

Roos van Maanen, PhD 2012
Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Netherlands.
Vanmaanen.roos@gmail.com

Supervisors: M.W. Sabelis & A. Janssen



In this thesis, I study the interactions among prey that share a predator. In such systems, indirect interactions mediated by the shared predator can occur between pest species, such as apparent competition and apparent mutualism. Theory predicts that adding a population of a new prey species to a system consisting of one predator and one prey results in a lower equilibrium density of the resident prey, even when the two prey species do not compete for resources. This is because the equilibrium density of the shared predator increases with the increased equilibrium density of the added prey species. This interaction can even lead to exclusion of the resident prey species. In the short term, before reaching equilibrium, two prey species that share a predator may also affect each others' densities positively because an increase in the numbers of one species may lead to predator satiation, resulting in decreased predation on the other species (so-called apparent mutualism). In biological control systems, apparent competition is desired because it brings pest levels down; apparent mutualism is not, because it does the opposite. Moreover, biological control systems, especially those in greenhouses, consist of relatively simple food webs that are open to manipulation of the species composition, and therefore offer an ideal opportunity to study interactions among prey species. I used a system consisting of a biological control agent, the generalist predatory mite *Amblyseius swirskii*, and several pest species (greenhouse whitefly, Western flower thrips and two-spotted spider mites) and cucumber plants. I investigated direct interactions between herbivores and indirect interactions via a shared predator to gain insight into the dynamics of the prey species. In particular, I studied whether these dynamics can be characterized as positive or negative indirect interactions among the pest species, i.e. whether shared predation is positive or negative for biological control. I also studied the effects of behaviour of predator and prey on these interactions. For example a generalist predator might have a preference for one prey species and the other prey species may therefore temporarily escape predation, which can lead to apparent mutualism. Another example is that mixed diets are known to have positive effects on reproduction in some predator species and the effect of adding a new species to a system consisting of one prey species and one predator species would then surpass that of simply adding more prey items. A mixed diet can result in higher growth rates of the predator population, resulting in the reduction of the prey species (apparent competition).

In Chapter 2, I report that the densities of a shared predator reach much higher levels in the presence of two prey species than with either prey species alone, and that this occurs within a time span of 8 weeks. This results in lower densities of one of the two prey species, whereas the densities of the other prey were low, independent of the presence of the alternative prey. This predator-mediated interaction can be classified as apparent competition. Hence, the control of whiteflies was improved by the presence of thrips, whereas thrips were adequately controlled in the presence as well as in the absence of whiteflies. Laboratory experiments with *A. swirskii* (Chapter 2) suggested that the higher predator densities observed in the greenhouse were partly due to a higher juvenile survival and developmental rate on a mixed diet. Whereas thrips were a superior food source for *A. swirskii* than whiteflies, a mixture of the two is even better.

In Chapter 3, I show that two prey species that share a predator may also affect each others' densities positively. Such, short-term apparent mutualism is undesired for biological control. In the system studied here, both the predators and prey species went through several generations before positive indirect effects between the pests were overruled by negative effects (apparent competition). In Chapter 4, I studied whether the high predator densities resulting from a mixed diet affected pest populations on which the predators have a small *per capita* effect. Besides the Western flower thrips and greenhouse whitefly, a marginally suitable prey, the two-spotted spider mite (*Tetranychus urticae* Koch) was included in the investigation. Lower levels of spider mite damage were found in the presence of the other two pest species, which probably resulted from a strong numerical response of the predator (up to 50 times higher densities) on thrips and whiteflies. This shows that apparent competition effects can also affect species that are not considered suitable for the predator. It also shows that diversity of pest species can enhance biological control through increased predator densities.

The increased control reported in Chapters 2, 3 and 4 are thus not only caused by the increased presence of prey for the predators, but also through a positive effect of mixed diets on predator population growth. A slightly different and so far underexposed advantage of a mixed diet for generalist predators is that predators can reach higher predation rates on a superior prey species. This is because many prey species are able to recognize chemical cues associated with the presence of predators and these cues usually induce anti-predator behaviour in the prey, such as counterattacking, hiding, remaining motionless or aggregating. To tune this behaviour to the current danger, prey need to assess predation risk. Many prey species can distinguish chemical cues from predators that fed on conspecific prey from those that fed on heterospecific prey, and react stronger to the first. The explanation for this is that predators that fed on conspecific prey pose a larger threat than predators feeding on other prey. However, the predator side of this story has been underexposed: if diet-related chemical cues enable prey to discriminate between harmless and dangerous predators, predators might be able to 'chemically disguise' themselves by eating different species alternatingly thereby reducing antipredator behaviour and increasing predation rates. In Chapter 6, I studied whether generalist predators indeed have an increased chance to capture a given prey species when they are contaminated with chemical cues from another prey species. I marked predatory mites with cues of either whiteflies or thrips, and subsequently offered the predators the same or the other prey species. Predators marked with thrips cues were found to kill significantly fewer thrips larvae than predators marked with whitefly cues, even though the predator's tendency to attack was the same. In addition, more thrips larvae sought refuge in the presence of a predatory mite marked with thrips cues than when marked with whitefly cues. I suggest that the predator *A. swirskii* can indeed increase her predation rate on the superior prey (thrips) by selecting a mixed diet.

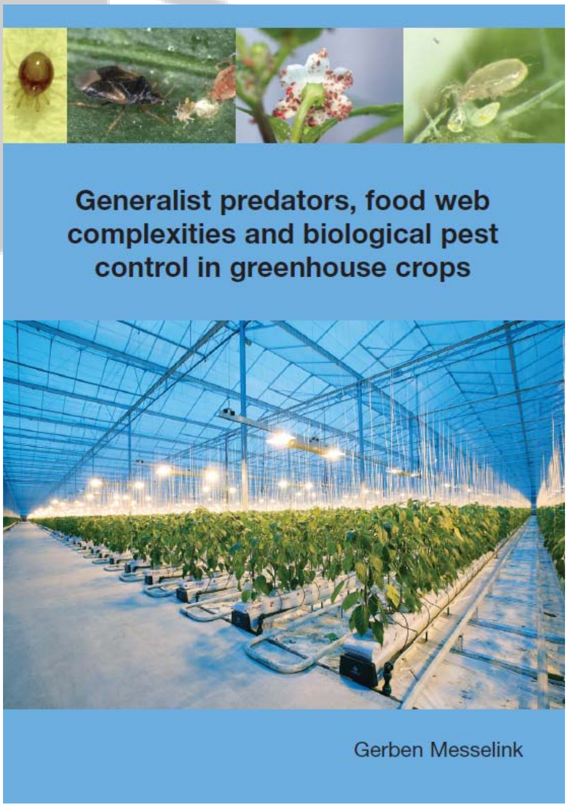
In conclusion, the results show that the densities of a shared predator reached much higher levels in the presence of two prey species than with either prey species alone. This can partly be explained by an increased developmental rate and juvenile survival of the predator on a mixed diet. Another explanation might be that predators can reach higher predation rates on a superior prey species by masking themselves by alternatingly feeding on the inferior and the superior prey species.

With respect to biological control, I show that the use of one species of natural enemy against several pests can result in reduced control in the short-term, but increased control in the long-term. In general, biological control strategies might be improved by using generalist predators that can feed and reproduce on several pest species.

GENERALIST PREDATORS, FOOD WEB COMPLEXITIES AND BIOLOGICAL PEST CONTROL IN GREENHOUSE CROPS

Gerben J. Messelink, PhD 2012
Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Netherlands.
gerben.messelink@wur.nl

Supervisors: M.W. Sabelis & A. Janssen



Plants in agricultural production systems are usually attacked by several species of herbivorous insects and mites. Biological control of these pests can be achieved using specialist and generalist natural enemies. For a long time, biological control was mainly focussed on specialist natural enemies, because they are well adapted to their prey. However, they often cannot persist in a crop when prey are scarce or absent. Repeated introductions are usually needed to control pests, which often involves problems with timing, costs and quality of the natural enemies. In general, generalist predators establish better in crops and can potentially control several pest species. However, they are more involved in various interactions among species than specialists, which can be either detrimental or favourable for pest control.

One of these interactions occurs when generalist predators mediate interactions among pests. These pests can directly influence each other through competition for plant material, but they can also affect each other indirectly by changing the population densities of the generalist natural enemies they share. Theories based on equilibrium dynamics predict that, if a population of a new prey species is added to a system of one predator and one prey species, the equilibrium density of the shared predator will increase and that of the resident prey species will decrease. This is called ‘apparent competition’, because the dynamics of the two species resemble that of species competing for resources, whereas in fact it is the shared predator that mediates this interaction. In the short term, when dynamical equilibria have not been reached, the predator-mediated indirect interaction between prey may cause the opposite effect; the addition of a population of a second prey species to a predator-prey system leads to satiation of the predator population and consequently lower predation on the resident prey population. In that case, one prey species benefits from the addition of another prey species, which can be classified as ‘apparent mutualism’. Such effects may also occur in the long-term in predator-prey systems that show persistent fluctuations. Thus, generalist predators can mediate interactions between pest species that can enhance pest control, but in some cases also can reduce pest control.

Another type of food web complexity occurs when generalist predators consume other natural enemies. This is referred to as ‘intraguild predation’ when the two species of natural enemies also compete for the same pest species. The predator species that kills and eats natural enemies of another species is called the intraguild predator and the other natural enemy is the intraguild prey. Equilibrium theory on intraguild predation predicts that when the intraguild prey is a better competitor for the shared pest than the intraguild predator, this will eventually yield less efficient pest control. Predators can also attack other predators with which they do not share a prey (i.e. each predator feeds on a different prey species). I suggest using the term hyperpredation for this kind of interaction, because of its similarity to hyperparasitism (parasitic wasps that parasitize parasitized prey). Hyperpredation can in fact be classified as apparent competition between the alternative prey and the specialist natural enemy. Predation of specialist natural enemies by hyperpredators will release the pest of the specialist natural enemy from control and this effect might become stronger when alternative prey increase the densities of the hyperpredators.

This thesis is on the role of generalist predators in the control of multiple pest species in greenhouse vegetable crops. My first goal was to see whether dynamical patterns predicted by theories of apparent competition, apparent mutualism and intraguild predation could be identified from the dynamics of arthropod communities in greenhouse crops, and second, how interactions in these food webs with generalist predators affected pest control. The pest species that I studied are among the most harmful species in greenhouse crops, namely the greenhouse whitefly, western flower thrips, spider mites and aphids. My research started with the selection and evaluation of different species of generalist predatory mites for the control of thrips in cucumber. Several predatory mite species controlled thrips better than the hitherto commonly used species *Neoseiulus cucumeris*. Strikingly, the most effective predators of thrips, *Typhlodromalus limonicus*, *Amblyseius swirskii* and *Euseius ovalis*, were proven to be capable of controlling whiteflies in other studies. A logical next step was thus to determine how pest control is affected by these predators when both thrips and whitefly were present in a crop. In Chapter 3, I show that both the generalists *A. swirskii* and *E. ovalis* control whiteflies better in the presence of thrips. This appeared a straightforward confirmation of the theory of apparent competition, but something more was going on. The densities of predatory mites were remarkably high when both pests were present, higher than could be explained by the availability of prey. I found that the predatory mite *A. swirskii* developed faster on a mixed diet of whitefly eggs and thrips larvae compared to a diet of thrips only or of whiteflies only. Moreover, there was virtually no mortality during the immature mite stages on a mixed diet, whereas up to 40% of the predators died on a diet of whitefly eggs. Hence, the populations of predators increased faster on a mixture of the two pest species, and the effects of apparent competition seem to be strengthened by this effect of a mixed diet.

In chapter 4, I tested the hypothesis that the interaction between two pests that share a predator may lead to increased pest densities (apparent mutualism) in the short term. This was indeed the case: the control of thrips was reduced by the presence of greenhouse whitefly during the first 3 weeks. However, a strong increase in density of the predatory mites eventually led to better control of thrips with whiteflies present. Satiation effects can occur repeatedly when prey populations show persistent fluctuations, resulting in the repeated occurrence of positive indirect interactions between the prey species. Such fluctuations may occur when young, vulnerable stages that escape from predation due to predator satiation become invulnerable and give rise to a new generation of offspring. This, in turn, can again result in predator satiation, thereby releasing thrips and whiteflies from control. In the experiments described in chapter 4, I mimicked such fluctuations through the release of high numbers of pests at once, which resulted in a high density of a second generation of whiteflies, which indeed resulted in a significant delay of the suppression of thrips populations. Until now, there was little empirical evidence for the occurrence of these effects. With these greenhouse experiments, I show that such effects of fluctuating populations may give rise to a substantial delay in the control of multiple pests with a shared predator population.

In chapter 5, I extended the system of generalist predatory mites, thrips and whiteflies with spider mites, another pest species. First of all, I showed that the predatory mite *A. swirskii* was unable to control spider mites when this was the only pest species present. A laboratory experiment showed that *A. swirskii* was hampered by the web of spider mites, which they produce to protect themselves against various predators. It was therefore surprising that the control of spider mites by this predator was improved in the presence of other pests in a greenhouse trial on cucumber plants. The control of spider mites was better in the presence of thrips than in the presence of greenhouse whiteflies, but the best control occurred in the presence of thrips, whiteflies and spider mites. In this experiment too, the improved pest control was probably caused by the strong population growth of the predatory mites on a mixed diet of thrips and whiteflies. Thus, pest diversity can enhance pest control with generalist predators, even when this pest is a less suitable prey species.

In chapter 6, I show a downside to the use of generalist predatory mites. In greenhouse trials, it became clear that they consume the eggs of an important predator of aphids, the gall midge *Aphidoletes aphidimyza*. This interaction can be classified as hyperpredation, because the mites do not prey on aphids. Hyperpredation of gall midge eggs by the predatory mite *A. swirskii* significantly disrupted the control of aphids in a sweet pepper crop. Hence, this study shows that disruption of aphid control by predatory mites is a realistic scenario and therefore needs to be considered when used in biological control.

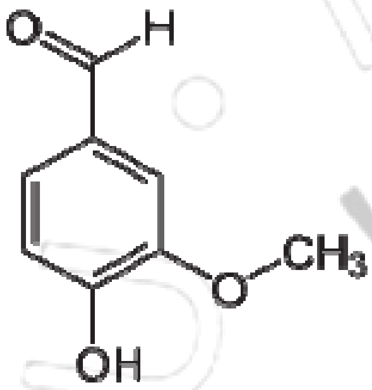
In Chapter 7, I compare the effects of several types of generalist predators on aphid control. Specialist natural enemies of aphids (parasitoids and gall midges) were combined with either generalist predatory mites or generalist predatory bugs in a sweet pepper crop that was attacked by aphids and thrips. The predatory mite *N. cucumeris*, a hyperpredator of gall midges, seemed to release aphids from control: densities of aphids were higher in the presence of this predator than when only specialised enemies of aphids were present. The opposite was found for the predatory bug *Orius majusculus*, an intraguild predator of both parasitoids and gall midges; the control of aphids in the presence of this generalist was significantly enhanced compared to the treatment with only specialised aphid enemies. In the laboratory, I showed that these predatory bugs fed on both aphids and thrips when both pests were present. Thrips are likely to contribute to the establishment of the predatory bugs and thereby strengthen the control of aphids, despite the fact that the predatory bugs also feed on the specialist aphid enemies. Hence, this study shows that intraguild predation between natural enemies does not necessarily result in reduced biological control, and it emphasizes the importance of evaluating the effects of generalist predators within food webs of pests and natural enemies.

I conclude that generalist predators can be very valuable for multiple pest control, but that caution is needed because of potential negative effects of generalists on pest control. Biological control in ecosystems with multiple pests and natural enemies therefore requires a systems approach, taking into account the interactions among organisms. Greenhouse experiments that evaluate multiple pest control with diverse assemblages of natural enemies are not only needed to further develop biological control strategies, but also offer excellent opportunities to test ecological theories on multispecies interactions.

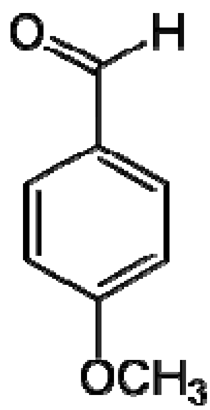
PRENATAL LEARNING IN THE PREDATORY MITE *NEOSEIULUS CALIFORNICUS*

Pablo C. Peralta Quesada, MSc 2011
Group of Arthropod Ecology and Behavior, Division of Plant Protection, Department of Crop Sciences, University of Natural Resources and Life Sciences, Vienna, Austria.
pa_luca@hotmail.com

Supervisor: P. Schausberger



Prenatal learning, behavioral change following experience made before birth, has been demonstrated in a wide variety of animals, including humans, sheep, chickens, fish, toads, and may have important short or long-term consequences on postnatal behaviors. A literature search suggested that there are no reports on prenatal chemosensory learning in arthropods in general. Here, prenatal learning was tested in a mite, the generalist predatory mite *Neoseiulus californicus*, which is an important natural enemy of spider mites and insects used in biological control in diverse agricultural ecosystems around the world. The predators were prenatally, i.e. in the embryonic stage, exposed to two types of phenolic aldehydes (vanillin and anisaldehyde) or not (neutral) by feeding their mothers on spider mites containing these compounds or not. After reaching the protonymphal stage, the postnatal behavior of the predator (residence and feeding preferences, resting and moving) was observed every 20 min during choice tests lasting for 140 min in total, where they were offered spider mites treated as the ones their mothers had fed on (neutral, vanillin or anisaldehyde spider mites) and alternative spider mites. In all choice situations, the predatory mites preferentially resided close to the type of spider mites their mothers had been fed on. There was a slightly stronger preference of the predatory mites pre-experienced with anisaldehyde for anisaldehyde spider mites when the alternative was neutral spider mites than when the alternative was vanillin spider mites. This might be explained by the similarities in chemical structure of both phenolic aldehydes. To exclude that size-assortative predation confounded the outcome of the choice tests, the body size of the predatory mites and their prey was measured. No size differences were found among treatments. Overall, the study documents that prenatal learning also occurs in the phylum Arthropoda. The ability to prenatal learning may be exploited in biological control in order to create more efficient populations of predatory mites able to better or more easily recognize the chemical cues and signatures of their prey.



BOOKS

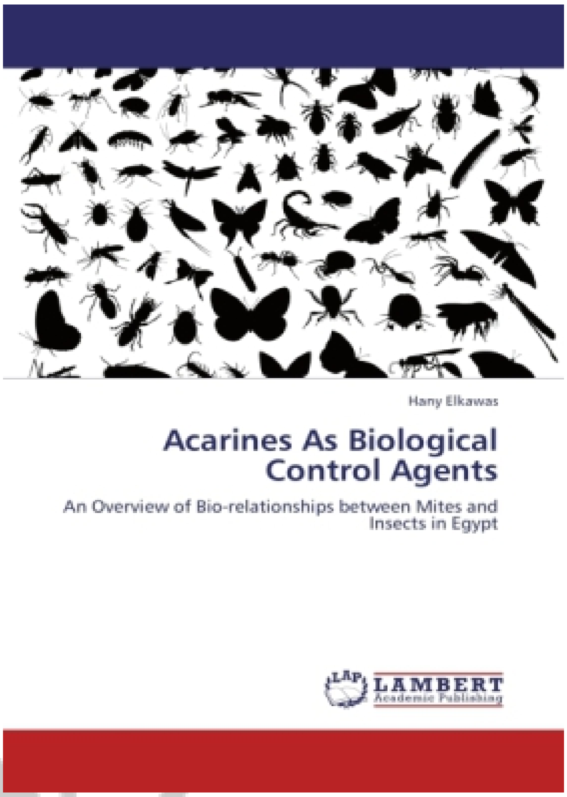
TETRANYCHID MITES – PEST OF THE MEGALOPOLIS GREEN PLANTATIONS

I.A. Akimov & O. V. Zhovnerchuk (2010) Kyiv

If you are interested, send your order to olya@izan.kiev.ua.

ACARINES AS BIOLOGICAL CONTROL AGENTS: AN OVERVIEW OF BIO-RELATIONSHIPS BETWEEN MITES AND INSECTS IN EGYPT

H. Elkawas (2011), LAP LAMBERT Academic Publishing, ISBN: 978-3847327349



Biological control of agricultural pests around the world and especially in Egypt may help to reduce the environment pollution by insecticides in addition to save costs for controlling it. The book aims to clear the important role of mites in suppressing number of harmful insects by survey the bio-relationships between mites and economic insects at six Egyptian governorates during three successive years. These relations classified into six categories. Results revealed eighty-two mite species belonging to fifty-five genera associated with forty two insect species belonging to eight insect orders. Also, taxonomical studies for new mite species and finally, biological studies for two common predacious mites in Egypt to throw light on their efficiency in Integrated Pest Management programmes (IPM).

PLANT MITES COMMUNITY - MITES ASSOCIATED WITH CERTAIN CROPS IN EGYPT

H. Elkawas (2012), LAP LAMBERT Academic Publishing, ISBN: 978-3-8484-0992-1

There are huge numbers of mites belonging to different mite taxa inhabiting in soil under plants and others infesting leaves of fruit trees and field crops. Some of them are harmful for plants while others can be useful in biological control of pests. So, the present work aimed to survey of mite species associated with certain fruit trees and field crops in three distracts at Sharkia Governorate, Egypt. In addition taxonomical studies to the collected mites with identification keys for them. Finally, taxonomical and biological studies on the predatory mite, *Euseius hutu* (P. & B.)

JOURNALS

Persian Journal of Acarology

An information (sent via the acarology list, acarology@nhm.ac.uk) by **A. Saboori** on behalf of the PJA Editorial Board

We are very glad to inform you that the first issue of the Persian Journal of Acarology is published in 15 January 2012. Please visit journal website (http://www.acarology.ir/Online%20issue.htm) and free download papers.

Persian Journal of Acarology (PJA) is a peer-reviewed international journal of the Acarological Society of Iran for publication of high quality papers on any aspect of Acarology including mite and tick behavior, biochemistry, biology, control, ecology, evolution, morphology, physiology, systematics and taxonomy. All manuscripts will be subjected to peer review before acceptance. We would like to increase number of issues from 2 to 4 or more. Now, we have enough paper to publish second issue and if we receive enough papers, we will increase its number this year. We are looking forward to receive your excellent papers.

Systematic & Applied Acarology

An information (sent via the acarology list, acarology@nhm.ac.uk) by **Z.-Q. Zhang,** Editor-in-Chief

I am pleased to inform that Systematic and Applied Acarology 17(1) was published in February. This issue includes 15 papers on a variety of mites from authors in Argentina, Brazil, China, Iran, Japan, Paraguay, Russia, South Africa, Spain, Turkey, USA and Vietnam.

http://www.nhm.ac.uk/hosted_sites/acarology/saas/saa/saa17.html

Systematic & Applied Acarology is covered in ISI Science Citation Index Expanded and Current Contents.

WWW LINKS

Z.-Q. Zhang is pleased to alert you (sent via the acarology list, acarology@nhm.ac.uk) that a series of four new papers on mite classifications were published just before Christmas (all open access): Despite the fact these papers are very short, they provide for the first time a complete list of mite higher taxa at the family levels and above, with taxonomic authority for each name and also diversity estimates for each family. According to these, the most recent count of described valid species of mites and ticks is 54,617.

SUPERORDER PARASITIFORMES REUTER, 1909

F. Beaulieu, A.P.G. Dowling, H. Klompen, G.J. De Moraes & D. Evans Walter

Zootaxa 3148: 123–128. In: Zhang, Z.-Q. (Ed.) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness.
http://www.mapress.com/zootaxa/2011/f/zt03148p128.pdf

ORDER TROMBIDIFORMES REUTER, 1909

Z.-Q. Zhang, Q.-H. Fan, V. Pesic, H. Smit, A.V. Bochkov, A.A. Khaustov, A. Baker, A. Wohltmann, T. Wen, J.W. Amrine, P. Beron, J. Lin, G. Gabrys & R. Husband

Zootaxa 3148: 129–138 in: Zhang, Z.-Q. (Ed.) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness-

http://www.mapress.com/zootaxa/2011/f/zt03148p138.pdf

SUBORDER ENDEOSTIGMATA REUTER, 1909

D. Evans Walter, S. Bolton, M. Uusitalo & Z.-Q. Zhang

Zootaxa 3148: 139–140 in: Zhang, Z.-Q. (Ed.) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness.

http://www.mapress.com/zootaxa/2011/f/zt03148p140.pdf

SUBORDER ORIBATIDA VAN DER HAMMEN, 1968

H. Schatz, V.M. Behan-Pelletier, B.M. OConnor & R.A. Norton

Zootaxa 3148: 141–148. In: Zhang, Z.-Q. (Ed.) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness.

http://www.mapress.com/zootaxa/2011/f/zt03148p148.pdf

MITES OF AUSTRALIA

B. Halliday (http://www.csiro.au/people/Bruce.Halliday.html) announced (via the acarology list, acarology@nhm.ac.uk) the publication of a complete new checklist and bibliography of the mites of Australia.

The checklist includes references to the original descriptions of the 3,512 species, 1,164 genera, and 317 families of mites known to occur in Australia. It gives the correct name and authorship for every taxon, references to subsequent literature for most species, information about taxa that have not yet been fully identified, and a short summary of the systematics and biology of each family. It does not attempt to provide any means of identifying mites. Instead, it provides access to taxonomic works in which more information about particular groups can be found. The bibliography includes more than 4,000 books and papers published up to 31 January 2012. I have used what I consider to be the best modern classification for each group but, as always, the taxonomic arrangement is only a hypothesis, and subject to constant review. The new checklist was published by the Australian Biological Resources Study, with support from Atlas of Living Australia, and can be found at this address: http://www.environment.gov.au/biodiversity/abrs/online-resources/fauna/afd/taxa/ACARI.

It can also be found by searching the internet for *Australian Faunal Directory*, selecting AFD: groups, and then searching for Acari using the internal search engine.

I would welcome your feedback about my errors and omissions, so I can correct them in future editions of the checklist.

PROCEEDINGS PERSIAN CONGRESS OF ACAROLOGY

A. Saboori informed (via the acarology list, acarology@nhm.ac.uk) that the "Abstract and Proceeding Book of the First Persian Congress of Acarology" is now available on the ASI website www.acarology.ir.

PROCEEDINGS of the 24th INTERNATIONAL CONGRESS OF ACAROLOGY (Recife, Brazil 2010)

Z.-Q. Zhang informed (via the acarology list, acarology@nhm.ac.uk) that the Proceedings of the last ICA (Brazil) were published in the book series Zoosymposia (http://www.mapress.com/zoosymposia/content/2011/v6/index.htm). All papers are free for open access. The hard copy version is available for purchase.

MITES BLOG

H. Pinto invited (via the acarology list, acarology@nhm.ac.uk) all acarologists to join his blog:

It's just to inform that I've recently updated/created a blog and a linkedin group both dedicated (specially) to acarologists but also to mite interested people. I don't expect any kind of personal credits/benefit whatsoever. I really think that it would be usefull and, equally important, promote acarology. Feel free to join.

2012

7th SYMPOSIUM OF THE EUROPEAN ASSOCIATION OF ACAROLOGISTS

July 9 to 13, 2012
Vienna, Austria

http://euraac.boku.ac.at/SympVienna

14th INTERNATIONAL BEHAVIORAL ECOLOGY CONGRESS

August 12 to 18, 2012
Lund, Sweden

http://www.isbe2012lund.org/

24th INTERNATIONAL CONGRESS OF ENTOMOLOGY

August 19 to 25, 2012
Daegu, South Korea

http://www.ice2012.org/

EVOLUTION OTTAWA: 1st JOINT CONGRESS ON EVOLUTIONARY BIOLOGY

July 6 to 10, 2012
Ottawa, Ontario, Canada

http://www.confersense.ca/Evolution2012/index.htm

2014

14th INTERNATIONAL CONGRESS OF ACAROLOGY

July 14 to 18, 2014
Kyoto, Japan

http://ica14.acarology-japan.org/

Peter Schausberger + Stefan Peneder

Group of Arthropod Ecology and Behavior, Division of Plant Protection, Department of Crop Sciences, University of Natural Resources and Life Sciences, Vienna.

Peter Jordanstraße 82
1190 Vienna, Austria

Ph + 43 1 47653 3361
Fax +43 1 47654 3359

euraacnews@boku.ac.at
http://euraac.boku.ac.at
http://www.dnw.boku.ac.at/ag27.html?&L=1

Vienna, May 2012