XIV International Symposium on Scale Insect Studies ISSIS

Abstract Book

13th - 16th June 2016
Catania (Italy)

XIV International Symposium on Scale Insect Studies

Dipartimento di Agricoltura, Alimentazione e Ambiente (Di3A)

University of Catania

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WITH THE SUPPORT OF

Monday, 13th June

8.30 Registration

10.30 Opening ceremony - Welcome speech

A. Systematic, Morphology and Genetics
CHAIRPERSON: Penny Gullan

11.00 **An overview on Italian coccidologists**
Giuseppina Pellizzari

11.15 **An overview of the new version of ScaleNet**
Mayrolin García Morales, Barbara D. Denno, Douglass R. Miller, Gary L. Miller, Yair Ben-Dov, Nate B. Hardy

11.30 **Molecular and morphological characterization of armored scale insects (Hemiptera: Diaspididae) and soft scale insects (Hemiptera: Coccidae) in Chile**
Amouroux P., Correa M., Ampuero J., Molina P., Germain J-F., Bout G., Kreiter P., Crochard D., Malausa T., Zaviezo T.

11.45 **Epigenetic mechanisms underlying Paternal Genome Elimination in *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae)**
Stevie Anne Bain

12.00 **PGE in the citrus mealybug, *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae) is the maternal victory complete?**
Andrés G. de la Filia, Laura Ross

12.15 **Endosymbiosis in Putoidae (Hemiptera: Coccomorpha): the continuing story**
Matthew E. Gruwell, Haley Flick, Alex Campbell

12.30 **Geographic and phylogenetic patterns of scale insect diversity and diet breadth**
Nate B. Hardy, Daniel A. Peterson, Benjamin B. Normark

12.45 DISCUSSION

13.15 Lunch

A. Systematic, Morphology and Genetics
CHAIRPERSON: Giuseppina Pellizzari

14.30 **Towards a natural classification of armored scale insects (Hemiptera: Diaspididae)**
Benjamin B. Normark, Scott A. Schneider, Daniel A. Peterson, Geoffrey E. Morse, Akiko Okusu

14.45 **An interactive identification key to armored scale insects of the tribe Aspidiotini (Hemiptera: Diaspididae)**
Scott A. Schneider, Michael A. Fizdale, Benjamin B. Normark

15.00 **Evolution of sensory antennal structures in the ensign scale insects (Hemiptera: Coccomorpha: Ortheziidae)**
Mehmet Bora Kaydan, Isabelle M. Vea, Éva Szita

15.15 **Preliminary morphological studies on immature stages of the Pseudococcidae (Hemiptera: Coccomorpha)**
Małgorzata Kalandyk-Kołodziejczyk

15.30 **New single-copy nuclear loci for scale insect (Hemiptera: Coccoidea) systematics**
Katelyn M. Mullen, Scott A. Schneider, Benjamin B. Normark

15.45 **Diagnostic morphological features of the neotropical species of the genus *Rhizoecus* (Hemiptera: Rhizoecidae), new contributions**
Andrea Amalia Ramos-Portilla

16.00 **Revision of hypogeic mealybugs *Rhizoecus* (Hemiptera: Rhizoecidae) from the Neotropical region**
Andrea Amalia Ramos-Portilla, Alejandro Caballero

16.15 DISCUSSION

16.45 Coffee break

17.15 Poster session A

New insights on Scale insect (Hemiptera: Coccomorpha) sperm: an ultrastructural point of view
Paoli Francesco, Roversi Pio Federico, Gounari Sofia, Mercati David, Dallai Romano

A taxonomic revision of the family Cerococcidae (Hemiptera: Coccomorpha)
Chris Hodgson, Douglas Williams

Diagnosis of the tribe Paralecaniini Williams (Hemiptera: Coccomorpha: Coccidae)
Chris J. Hodgson, Bożena Łagowska

Cryo-SEM observations and imaging of minute lesser sclerotized insects
R. Roberto, V. Russo, L. Diana, M. Kalandyk-Kołodziejczyk, G. Pellizzari, F. Porcelli

Wirjati's historic collection of Indonesian mealybugs (Hemiptera: Pseudococcidae)
Dewi Sartiami, Gillian W. Watson, Mohamad Roff M. N., Idris A. B.

A taxonomic revision of *Hypogeococcus* Rau species (Hemiptera: Pseudococcidae) from Argentina
Lucía E. Claps, Nicolás A. Melchert, María Andrea Saracho Bottero, Guillermo Logarzo, María Belén Aguirre

Tuesday, 14th June

A. Systematic, Morphology and Genetics
CHAIRPERSON: Chris Hodgson

8.45 **Investigations on the immature stages of some Eulecaniinae species (Hemiptera: Coccomorpha: Coccidae)**
Gordana Đurović, Selma Ülgentürk

9.00 **Repeated replacement of an intrabacterial symbiont in the tripartite nested mealybug symbiosis**
Filip Husnik, John P. McCutcheon

B. Zoogeography, Faunistics and Alien Species
CHAIRPERSON: Chris Hodgson

9.15 **Known distribution and pest status of fluted scale insects (Hemiptera: Monophlebidae: Iceryini) in South America**
Takumasa Kondo, Andrea Amalia Ramos-Portilla, Ana Lucia B.G. Peronti, Penny Gullan

9.30 **The scale insects (Hemiptera: Coccomorpha) present on *Leptospermum scoparium* (mānuka) in New Zealand**
J. Bohorquez, A. Robertson, J. Millner, J. Stephens, R. Archer

9.45 **Scale insects (Hemiptera: Coccomorpha) of coffee roots from Colombia and Mexico**
Alejandro Caballero, Andrea Amalia Ramos-Portilla

10.00 **Mealybugs (Hemiptera: Pseudococcidae) associated with persimmon *Diospyros kaki* L. (Ebenaceae) in Southern Brazil**
Vitor C. Pacheco da Silva, Thibaut Malausa, Jean-François Germain, Marcos Botton, Mehmet Bora Kaydan

10.15 DISCUSSION

10.35 Coffee break

B. Zoogeography, Faunistics and Alien Species
CHAIRPERSON: Jan Giliomee

11.00 **The armored scale insects (Hemiptera: Diaspididae) of Alabama, USA**
Krystal G. Waltman, Charles H. Ray Jr., Michael L. Williams

11.15 **Scale insects (Hemiptera: Coccomorpha) on sugarcane from Colombia**
Alejandro Caballero, Andrea Amalia Ramos-Portilla, Takumasa Kondo

11.30 **An upgrade of scale insect fauna of some Sicilian endemic plants**
Gaetana Mazzeo, Salvatore Nucifora, Agatino Russo, Pompeo Suma, Santi Longo

C. Biology, Ecology and Population Dynamics
CHAIRPERSON: Jan Giliomee

11.45 **Bio-ecology of cedar scale insect *Torosaspis cedricola* (Balachowsky & Alkan)** (Hemiptera: Diaspididae) in Ankara, Turkey
Özlem Dostbil, Selma Ülgentürk

12.00 **Effect of temperature on bioecological characteristics of *Chrysomphalus dictyospermi* Morgan (Hemiptera: Diaspididae)**
Alime Bayındır, Ali Kemal Birgücü

12.15 **Life history of *Parthenolecanium* spp. (Hemiptera: Coccidae) in urban landscapes of southern United States**
Ernesto Robayo-Camacho, Juang-Horng "JC" Chong

12.30 **Biology, ecology and potential impact of *Ceroplastes sinensis* Del Guercio (Hemiptera: Coccidae) on the invasive *Baccharis halimifolia* L. (Asteraceae) in France**
René FH Sforza, Jonathan Lovet, Clémence Dieudonné, Nicolas Croce

12.45 **Does *Unaspis euonymi* (Comstock) (Hemiptera: Diaspididae) host *Serratia symbiotica* Moran (Bacteria: Enterobacteriaceae)?**
M. Scrascia, C. Pazzani, M. Oliva, V. Russo, R. Roberto, F. Porcelli

13.00 DISCUSSION

13.30 Lunch

15.00 Awards

CHAIRPERSON: Mehmet Bora Kaydan

16.45 Coffee break

17.15 Poster session B+C

Zoogeography, faunistics and alien species

A checklist of the scale insects (Hemiptera: Coccomorpha) in Luxemburg
Carl-Axel Gertsson

Current situation of *Eurhizococcus brasiliensis* (Hemiptera: Margarodidae) in Brazil
Aline Nondillo, Simone Andzeiewski, Aline Nobre Guindani, Vitor C. Pacheco da Silva, Odair Correa Bueno, Marcos Botton

Scale insects (Hemiptera: Coccomorpha) on mulberry trees in Turkey
Selma Ülgentürk, Ehab M.A. Mahmood Mohammed

Eriococcidae (Hemiptera: Coccomorpha) infesting Fabaceae in Argentina
González Patricia, Lucía E. Claps, Andrea Juárez, Diego Moreno

Distribution of scale insects (Hemiptera: Sternorrhyncha: Coccomorpha) on citrus plants in Croatia
Vjekoslav Markotić, Tatjana Masten Milek, Mladen Šimala, Maja Pintar

Scale Insects (Hemiptera: Sternorrhyncha: Coccomorpha) on host plants from family Ericaceae in Croatia
Tatjana Masten Milek, Mladen Šimala, Vjekoslav Markotić

A review of alien scale insects (Hemiptera: Coccomorpha) in Bulgaria
Katia Trencheva

The history of *Dactylopius coccus* (Modeer) (Hemiptera: Dactylopiidae) in the Mediterranean basin: the Sicilian episode
Gaetana Mazzeo, Agatino Russo, Pompeo Suma, Santi Longo

Biology, ecology and population dinamycs

***Parthenolecanium corni* (Bouché) (Hemiptera: Coccidae) associated to vineyards in Portugal: morphology, life cycle, bioecology and type of reproduction**
Elsa Borges da Silva, Marta Maia, Maria Santos, Amândio Cruz, Manuel Botelho, José Carlos Franco, Henrique Ribeiro, António Mexia

The influence of host plant species on *Coccus hesperidum* L. (Hemiptera: Coccidae) honeydew amino acids composition
Katarzyna Golan, Bożena Łagowska, Edyta Górska-Drabik, Izabela Kot, Katarzyna Kmieć

Impact of mealybug (Hemiptera: Pseudococcidae) infestation on metabolism of amino acids and phenolic compounds within orchid leaves
Katarzyna Golan, Edyta Górska-Drabik, Cezary Sempruch, Paweł Czerniewicz, Bożena Łagowska, Katarzyna Kmieć, Izabela Kot, Klaudia Magierowicz

Symbiotic microorganisms in *Acanthococcus aceris* Signoret and *Gossyparia spuria* (Modeer) (Hemiptera: Coccomorpha: Eriococcidae)
Małgorzata Kalandyk-Kołodziejczyk, Anna Michalik, Katarzyna Michalik and Teresa Szklarzewicz

***Nidularia pulvinata* (Planchon) (Hemiptera: Kermesidae) gall-inducing attitude**
R. Roberto, V. Russo, F. Porcelli, G. Pellizzari

***Kermes vermilio* Planchon and *Nidularia pulvinata* (Planchon) (Hemiptera Kermesidae) outbreaks off urban *Quercus ilex* L. (Fagaceae)**
R. Roberto, L. Diana, V. Russo, F. Porcelli, G. Pellizzari

Density, structure and natural enemies of *Delottococcus aberiae* (De Lotto) (Hemiptera: Pseudococcidae) populations on Spanish citrus groves
V. Martínez-Blay, J. Pérez-Rodríguez, A. Tena, A. Soto

Biological observations of *Matsucoccus josephi* Bodenheimer & Harpaz (Hemiptera: Matsucoccidae) in Turkey
Selma Ülgentürk, Hasan Sungur Civelek, Meral Fent

Biology, natural enemies and distribution *Physokermes hellenicus* Kozar & Gounari (Hemiptera: Coccidae) in Turkey
Selma Ülgentürk

20.00 Social dinner

Wednesday, 15th June

07.30–19.30 Field trip

Thursday, 16th June

D. Scale Insect Pest Control
CHAIRPERSON: Agatino Russo

9.00 **Enhancing biological control of pest mealybugs using semiochemicals: a case study**
José Carlos Franco, Elsa Borges da Silva, Manuela Branco, Pompeo Suma, Alessandra La Pergola, Alex Protasov, Zvi Mendel

9.15 ***Rhizaspidiotus donacis* (Hemiptera: Diaspididae), an effective biological control agent of *Arundo donax* (Poaceae) in the United States**
M. Cristofaro, F. Di Cristina, D. De Simone, J. Kashefi, A. Kirk, A. Vacek, P. Moran, J. Goolsby

9.30 **Determination of releasing dosage of *Aphytis melinus* DeBach (Hymenoptera: Aphelinidae) for the biological control of California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) in Turkey**
Lerzan Bakırcıoğlu Erkiliç, Halil Demirbas, Bülent Güven

9.45 **The temperature-dependent development and life table parameters of *Rhyzobius lophanthae* Blaisdell (Coleoptera: Coccinellidae) on *Aspidiotus nerii* Bouche (Hemiptera: Diaspididae)**
Ali Kayahan, İsmail Karaca

10.00 DISCUSSION

10.30 Coffee break

D. Scale Insect Pest Control
CHAIRPERSON: Pompeo Suma

11.00 **Host range and suitability of six parasitoid species (Hymenoptera: Encyrtidae) and their implication to biological control of three invasive *Phenacoccus* spp. (Hemiptera: Pseudococcidae) in Israel**
Zvi Mendel, Pompeo Suma, Dani Blumberg, Alex Protasov, Eyal Erel, George Japoshvili, José Carlos Franco

11.15 **Isonet® PF, a new mating disruption product for the control of *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae)**
Andrea Lucchi, Edith Ladurner, Francesco Savino, Luca Gandini, Luisa Mattedi, Mauro Varner, Andrea Iodice

11.30 ***Nidularia pulvinata* (Planchon) (Hemiptera: Kermesidae) urban outbreaks associated with entomopathogenic fungi**
R. Roberto, S. Pollastro, G. Pellizzari, F. Porcelli

11.45 **Development and life table parameters of predator *Rhyzobius lophanthae* Blaisdell (Coleoptera: Coccinellidae) on three armored scale insects (Hemiptera: Diaspididae)**
Betül Şimşek, Ali Kayahan, İsmail Karaka

12.00 **The use of scale insects as biocontrol agents of weeds**
René FH Sforza, Massimo Cristofaro

12.15 DISCUSSION

13.00 Lunch

14.15 Poster session D

Natural enemy associates of *Parthenolecanium* spp. (Hemiptera: Coccidae) in urban landscapes of southern United States
Ernesto Robayo-Camacho, Juang-Horng "JC" Chong

Effects of some entomopathogenic fungi on Citrus Mealybug *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae)
Gürsel Karaca, Ali Kayahan, Betül Şimşek, İsmail Karaka

Biological control of the vine mealybug *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae) on table grape vineyards in Murcia (Spain)
Lucas Espadas Alfonso, Hermosilla Cerón Alfonso, Andrea Lucchi

Synthesis of mealybug sex pheromones and their field mating disruption application
Erina Ohno, Miyoshi Yamashita, Tatsuya Hojo, Takeshi Kinsho

The vine mealybug, *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae) in Emilia Romagna (Italy): state of the art and control strategies
E. Pasqualini, M. Melandri, L. Depalo

Observations on microorganisms infecting *Kermes quercus* (Linnaeus) (Hemiptera: Kermesidae)
Elżbieta Podsiadło, Anna Michalik, Teresa Szklarzewicz

Those strange black matter with armoured scale insects (Hemiptera: Diaspididae) embedded
F. Porcelli, R. Roberto, G. Pellizzari

Potential for management of *Protopulvinaria pyriformis* (Cockerell) (Hemiptera: Coccidae) in organic avocado in eastern Sicily, Italy
Lucia Zappalà, Antonio Biondi, George Japoshvili, Gaetano Siscaro, Agatino Russo, Pompeo Suma

Red scale in Sicily citrus orchard now is under effective biological control
Riccardo Agostino Tumminelli

Isoclast™ active: efficacy against scale insects in citrus
S. Convertini, A. Fenio, L. Bacci, E. Tescari

Isoclast™ active: efficacy against scale insects in stone and pome fruits
S. Convertini, A. Fenio, L. Bacci, E. Tescari

Induced responses of *Bougainvillea glabra* Choisy (Nyctaginaceae) against *Phenacoccus peruvianus* Granara de Willink (Hemiptera: Pseudococcidae)
Abbate C., Toscano S., Arcidiacono R., Romano D., Russo A., Mazzeo G.

15.30 Choice of site for ISSIS XV - Concluding remarks

Friday, 17th June

Post meeting tour

Monday, 13th June

SYSTEMATIC, MORPHOLOGY AND GENETICS

ORAL PRESENTATIONS

An overview on Italian coccidologists

Giuseppina Pellizzari
University of Padova, Department of Agronomy, Food, Natural Resources, Animals and Environment DAFNAE, viale dell'Università 16, 35020, Legnaro, Italy.

The most relevant Italian coccidologists and their contributions to studies on scale insects are briefly outlined. **Oronzo Gabriele Costa** (1787-1867) and his son **Achille Costa** (1823-1898), both active in Naples as professors of Zoology at the local University and directors of the Zoological Museum of Naples. The Florentine **Adolfo Targioni Tozzetti** (1823-1902) was the first outstanding Italian Coccidologist. Besides the description of several species, he attempted a systematic revision of the group and was in regular correspondence with the contemporaneous coccidologists (f.i. Signoret in Paris). The famous Entomologist **Antonio Berlese** (1863-1927) was an assistant of Targioni Tozzetti and then professor in Portici (Naples). It is worth mentioning his studies on *Icerya purchasi* Maskell (Hemiptera: Monophlebidiae) and *Pseudaulacaspis pentagona* (Targioni Tozzetti) (Hemiptera: Diaspididae) and the successful introduction to Italy of their specific natural enemies. His assistants were Leonardi and Silvestri. **Gustavo Leonardi** (1869-1918) mostly studied Italian scale insects fauna, becoming in short time a high level specialist but also described species from Argentina and Africa. He died before his time and his well known book on Italian scale insects was published posthumous. **Filippo Silvestri** (1873-1949) is considered the most remarkable entomologist of his generation and his contributions cover pure and applied entomology. He had a deep interest in coccidology and described many new species from Asia, Africa and south America. His collection of scale insects from all over the world is in Portici. **Vincenzo Lupo** (1908-1999) was an assistant of Filippo Silvestri. His favourite subject was the study of Diaspidids. In 1950 moved to the University of Catania and founded the local school of Entomology, still very active in scale insect studies. He revised and illustrated all genera and species of Italian Diaspididae. **Giovanni De Lotto** (1912-1990) started his training in entomology at the local Museum of Natural History of Venice. From 1945 onward he joined the British Department of Agriculture as entomologist, at first in Eritrea, then in Kenya, and later in Pretoria, South Africa. De Lotto was an eminent and internationally recognized coccidologist. He established many new genera and described tens of new species. Moreover his species illustration are excellent. He come back to Italy in 1979 when retired. **Salvatore Marotta** (1958-2001) started studying scale insects under the guidance of the professors E. Tremblay and Antonio Tranfaglia in Portici. He was a passionate student of scale insects, interested in everything concerned this group. For a long period he faced a heavy illness, but in spite of this he went on with firmness and perseverance with his studies. The results of his researches are in 49 high quality papers. His sudden death aged 43 left a great blank.

An overview of the new version of ScaleNet

Mayrolin García Morales[1], Barbara D. Denno[2], Douglass R. Miller[2,4], Gary L. Miller[2], Yair Ben-Dov[3], Nate B. Hardy[1]

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[2] *Systematic Entomology Laboratory, Agricultural Research Service, US Department of Agriculture, Beltsville, MD 20705*
[3] *Agricultural Research Organization, The Volcani Centre, Beit-Dagan, Israel*
[4] *Division of Plant Industry, Gainesville, FL 32608-1201*

ScaleNet was launched in 1995 to provide insect identifiers, pest managers, insect systematists, evolutionary biologists, and ecologists efficient access to information about scale insect biological diversity. It provides comprehensive information on scale insects taken directly from the primary literature. Currently, it draws from 23,477 papers and describes the systematics and biology of 8,194 valid species. For 20 years, ScaleNet ran on the same software platform. That platform is no longer viable. Here, we present a new, open-source implementation of ScaleNet. We have normalized the data model, begun the process of correcting invalid data, upgraded the user interface, and added online administrative tools. These improvements make ScaleNet easier to use and maintain, and make the ScaleNet data more accurate and extendable.

Molecular and morphological characterization of armored scale insects (Hemiptera: Diaspididae) and soft scale insects (Hemiptera: Coccidae) in Chile

Amouroux, P.[1*], Correa M.[2], Ampuero J.[3], Molina P.[3],Germain J-F.[4], Bout G.[2], Kreiter P.[2], Crochard D.[2], Malausa, T.[2], Zaviezo, T.[1]

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[4] ANSES, Laboratoire de la Santé des Végétaux, unité Entomologie et Plantes Invasives, CBGP, 755 avenue du Campus Agropolis, 34988 Montferrier-sur-Lez, France

In Chile, 61 species of Armored Scale Insects (Hemiptera: Diaspididae) and 13 species of Soft Scale Insects (Hemiptera: Coccidae) are recorded up to now and some of them can cause economic impacts on agriculture and ornamental plants. Our objective was to describe the diversity of armored and soft scale insects present in Chile and provide molecular tools for futures researches and to orientate the development of biocontrol methods in Chile.

In this study about 100 sites were we sampled for scale insects on fruit trees (mainly avocados, citrus and olives trees), ornamental and endemic plants from Arica (18°S) to Frutillar (41°S) between January 2015 and February 2016. About 280 individuals of Armored Scales and 240 of Soft Scales were sequenced on parts of the COI mtDNA region and the 28S rDNA region. Selected individuals were then morphologically identified.

The list and the distribution of the species of scale insects in Chile were updated. We identified 20 species of Diaspididae and 11 species of Coccidae. The most relevant pests in the orchards were *Saissetia oleae* (Olivier) (Coccidae), *Aspidiotus nerii* Bouché, *Hemiberlesia rapax* (Comstock), *H. lataniae (*Signoret), *Aonidiella aurantii* (Maskell), *Diaspidiotus perniciosus* (Comstock), *Lepidosaphes beckii* (Newman) and *L. ulmi* (Linnaeus) (Diaspididae). The COI mtDNA revealed three divergent lineages of *A. nerii* which were not confirmed with the 28S rDNA. Two lineages of *H. rapax* were confirmed by the two markers. The black scale, *S. oleae*, was present from the first region (19°S) to the eighth region (36°S) of Chile while the hemispherical scale, *S. coffeae* (Walker), was only observed in the northern regions (18°S to 29°S). The COI mtDNA of the black scale showed haplotype diversity but without relationships with the localisation or the host-plant. In addition *Parasaissetia nigra* (Nietner) is first time recorded in Chile in this study.

Keywords: Diaspididae, Coccidae, genetic diversity, COI, 28S

Epigenetic mechanisms underlying Paternal Genome Elimination in *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae)

Stevie Anne Bain
University of Edinburgh, UK

Paternal genome elimination is a genomic imprinting phenomenon found among several insect species, including the citrus mealybug, *Planococcus citr*i (Risso) (Hemiptera: Pseudococcidae). In sons, the paternally inherited set of chromosomes is silenced and then eliminated from the germline. Since males can only pass on their genetic information through daughters, it is in their interest to female-bias their offspring's sex ratio. However, females have a genetic transmission advantage through sons, as sons can only pass on their maternally inherited chromosomes to any offspring they sire. Thus, a sexual conflict occurs. In an evolutionary context it seems most likely that a maternal factor underlies the process of PGE, since females benefit from a transmission advantage and males suffer a disadvantage. Genomic imprinting in *P. citri* appears to be regulated by the same epigenetic machinery involved in mammalian silencing and imprinting (histone modifications and methylation), but the molecular details remain poorly understood. Here we study the parent-of-origin specific epigenetic modifications involved using whole genome bisulphite sequencing and immuno staining for histone modifications throughout development. DNMT gene expression (genes involved in DNA methylation) was also investigated. These data help to understand how paternal and maternal chromosomes are distinguished in order to allow elimination of only those paternally inherited by sons.

PGE in the citrus mealybug, *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae): is the maternal victory complete?

Andrés G. De la Filia, Laura Ross
School of Biological Sciences, Institute of Evolutionary Biology, University of Edinburgh, Edinburgh, EH9 3JT, UK

Genetic conflict has been invoked to explain diversification of genetic systems. Among these, one of the most unusual is paternal genome elimination (PGE), which is found in several insect species, including the citrus mealybug *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae). In males, the paternally-inherited genome is initially heterochromatinized and subsequently eliminated during spermatogenesis in a process controlled by maternally-inherited genes. PGE is therefore a whole-genome form of meiotic drive, as sperm only contain maternal chromosomes. However, paternal genomes can sometimes escape germ-line elimination and/or silencing. This suggests an evolutionary arms race between maternal and paternal genomes. This study investigates if paternal genomes have evolved adaptations against PGE that could be unveiled by exposing paternal genotypes to different maternal backgrounds. Inheritance and expression of paternal alleles were analyzed in F1 and F2 generations of intraspecific and interspecific crosses with *P. ficus* (Signoret) (Hemiptera: Pseudococcidae). Paternal inheritance was assessed via microsatellite analysis, while transcriptomes for whole F1 males and F1 testis samples were generated to evaluate whether paternal alleles can escape inactivation and if expression patterns differ in testes. Our results provide a solid foundation to study potential PGE suppressors and thus increase our knowledge of how PGE is maintained and lost, eventually casting more light on the involvement of male-female conflict in the evolutionary dynamics of genetic systems.

Keywords: Genetic systems, paternal genome elimination, genetic conflict, meiotic drive, citrus mealybug, heterochromatinization

Endosymbiosis in Putoidae (Hemiptera: Coccomorpha): the continuing story

Matthew E. Gruwell, Haley Flick, Alex Campbell
Penn State Behrend, School of Science, P-1 Prischak Building 4205 College Drive, Erie, PA 16563 USA.

The scale insect genus *Puto* Signoret (Hemiptera: Sternorrhyncha: Coccoidea) was long thought to belong in the family Pseudococcidae, but is now placed in its own family, Putoidae. One critical piece of data that separates putoid scale insects from the mealybugs is their endosymbiotic relationships. The majority of mealybugs have primary endosymbionts in the genus *Tremblaya* (part of the Betaproteobacteria) which house a second endoysmibont, *Moranella* (Gammaproteobacteria). The known endosymbionts from Putoidae are also found in the Gammaproteobacteria, somewhat closely related to *Moranella*. However phylogenetic studies using multiple genes did not recover a monophyletic group of endosymbionts from Putoidae with respect to *Sodalis glossinidius* and various other endosymbionts. Preliminary endosymbiont genome data for *Puto echinatus* McKenzie shows a maternally inherited endosymbiotic bacteria from Gammaproteobacteria that has a small genome (~1.2 megabases) with respect to other bacteria, but somewhat large in comparison to other scale insect endosymbionts. Our goal was to sequence and describe the endosymbiont genomes from *P. echinatus* and *Puto barberi* (Cockerell) to determine some of the dietary needs of Putoidae and the unique evolutionary history of endosymbiosis in Putoidae, focusing on why endosymbionts from this family do not appear to be monophyletic.

Keywords: endosymbiosis, genomics, phylogeny

Geographic and phylogenetic patterns of scale insect diversity and diet breadth

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In most plant-feeding insect species, mothers search their environment and select good host plants for their offspring. This contrasts with scale insects, which get from one host plant to another by wind dispersal of short-lived, delicate first-instar nymphs. Scale insects' wind dispersal should be much less efficient, especially in species-rich plant communities. Aphids are also thought to disperse inefficiently; winged forms are not strong fliers and cannot survive long away from a host. In 1987, Dixon et al. presented a simple mathematical model that explains broad geographical patterns in aphid species richness, in particular the dearth of tropical aphid species, as function of the abundance of host plant species. As the number of plant species in an area increases, the number of plant species in that area that are abundant enough to be effectively used by a specialist aphid species diminishes exponentially. This negative effect can be offset by increases in diet breadth, or increases in the reproductive potential of plant-feeding insects on a particular host species. Here we report that Dixon et al.'s model does a good job of explaining broad geographic patterns in the diversity of scale insects; the proportion of scale insect to plant species richness declines exponentially with increasing plant species richness. We also show that scale insect species have broader host ranges in the tropics, presumably because the tropics have more plant species. Lastly, we address this question: if increasing diet breadth can compensate for profligate dispersal, why are so many scale insects monophagous? We present results of comparative analyses which support the possibility that scale insect monophagy results from genetic drift in small populations that have become isolated from polyphagous ancestors.

Keywords: Coccoidea, comparative analysis, life history evolution

Towards a natural classification of armored scale insects (Hemiptera: Diaspididae)

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The armored scale insects (Diaspididae) are nearly ubiquitous associates of woody plants and among the world's most invasive insects. They comprise over 2500 species, of which almost 10% are economic pests. Here we report the results of a recent comprehensive molecular phylogenetic study of the family using 4 loci and including 317 described species and 42 undescribed species, and we present an outline of a revised classification of the family. The great subfamilies Diaspididae and Aspidiotinae, as defined by Takagi, are mostly intact, but we also propose two new smaller subfamilies -- one for the cosmopolitan genus *Furcaspis* and one for a few New World pupillarial forms. The monotypic subfamily Comstockiellinaeis not a true diaspidid but is instead more closely related to Halimococcidae. The tribes Lepidosaphidini, Diaspidini, Leucaspidini, Parlatoriini, and Odonaspidini are also mostly intact, but Aspidiotini is split into two tribes, and we also erect six smaller tribes for phylogenetically isolated lineages.Thysanaspidini should be a synonym of Leucaspidini, Kuwanaspidina a synonym of Fioriniina, and and Protodiaspidina a synonym of Chionaspidina.

Keywords: Taxonomy, systematics, phylogeny, evolution.

An interactive identification key to armored scale insects of the tribe Aspidiotini (Hemiptera: Diaspididae)

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The armored scale insect tribe Aspidiotini contains a large number of polyphagous pest species commonly encountered in plant quarantine. Generic-level designations in this tribe are in dire need of revision if the taxonomy is to accurately reflect evolutionary relationships. Current molecular phylogenetic reconstructions for select taxa have revealed rampant paraphyly of aspidiotine genera; many of which contain economically damaging pest species that often require quick, accurate identification. Revisionary works must be handled with care in order to facilitate accurate identification and avoid confusion and misidentification of important pest species. Interactive identification keys to species are useful tools in this regard because they do not depend on the genus-level classification and thus are relatively robust to any changes in generic assignments of species. Online keys offer the advantage of adaptability to reflect nomenclatural changes and reduce time invested in producing and publishing updated dichotomous keys. We report on a newly available LucID interactive key to common species of Aspidiotini that will be made available for public use online, which allow users around the globe to rapidly identify the pests in this group.

Keywords: Diaspididae, Aspidiotini, LucID, identification key, taxonomy, pest species

Evolution of sensory antennal structures in the ensign scale insects (Hemiptera: Coccomorpha: Ortheziidae)

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The Ortheziidae (Hemiptera: Sternorrhyncha: Coccomorpha) are considered one of the most ancient families of infraorder Coccomorpha. In this study, the antennal structures of species belonging to the Ortheziidae are examined and combined with data from a previous phylogenetic study as well as habitat preference data. This study aims to determine: (i) the presence of *basiconic* and coeloconic sensilla and how they are distributed across the ortheziid genera, (ii) the relationships between the types of antennal sensilla and underlying generic concepts, (iii) how new antennal sensory characters affect the phylogenetic hypotheses of major clades within the family, and (iv) how the types of antennal sensilla are associated with different habitats of ortheziid species. Illustrations of the antennal structures (with a focus on the distribution of setae and sensilla) for the type species of all genera in the Ortheziidae are provided. Three main ortheziid lineages are recognized by their sensilla: (i) the Ortheziinae all possess *coeloconic sensilla;* (ii) the Newsteadiinae, which only includes *Newsteadia*, is characterized by a different type of *coeloconic sensillum*, here coined as Newsteadia-type *coeloconic sensillum*, and (iii) a clade that includes the Mixortheziinii, Nipponortheziini and Ortheziolini, all of which possess *basiconic sensilla.* It is also shown that *basiconic sensilla* occurs in insects (such as Ortheziolini, Nipponortheziini) that live on mosses, leaf litter and in the soil with a humid ecosystem. On the other hand, all insects that live on aerial plant parts in this study have *coeloconic sensillum* (i.e., Ortheziinae, Newsteadiinae).

Keywords: thermo/hygroreceptor, leaf litter, hypogeal insect, habitat

Preliminary morphological studies on immature stages of the Pseudococcidae (Hemiptera: Coccomorpha)

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Nymphs of many species of the Pseudococcidae (Hemiptera: Coccomorpha) have not been studied intensively. The aims of this study was to describe and redescribe immature stages of mealybugs and recognize the taxonomic value of their morphological characters. The specimens were collected in Poland between 2012 and 2015. Adult females were collected with their progeny in the field. Microscope slides of the cuticle of females and nymphs were prepared. I examined about 20 specimens for each instar of each species. I studied first and second nymphs of species of the Phenacoccinae and the Pseudococcinae. The diversity and arrangement of pores and setae were examined. The length and width of e.g. labium, antennal segments and segments of the legs were measured. The studied nymphs possess characters that can be used for identification.

Keywords: Pseudococcidae, nymphs, Phenacoccinae, Pseudococcinae

New single-copy nuclear loci for scale insect (Hemiptera: Coccoidea) systematics

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Despite the advent of next-generation sequencing, the polymerase chain reaction (PCR) and Sanger sequencing remain useful tools for molecular identification and systematics. To date, molecular systematics of scale insects has been constrained by the paucity of loci that researchers have been able to amplify with available PCR primers. Due to the rapid molecular evolution of scale insects, "universal" primers, and even primers developed for their sister taxon the Aphidioidea, typically fail. We used transciptome data for two armored scale insets (Diaspididae), *Acutaspis umbonifera* (Newstead) and *Chrysomphalus aonidum* (Linnaeus), together with a published aphid genome, to design novel PCR primer sets for scale insects. Our primers amplify fragments of 8 single-copy genes: ATP-dependent RNA helicase (DHX8), translation initiation factor 5 (IF5X1), DNA replication licensing factor (Mcm2), double-strand break repair protein (MRE11A), serine/threonine-protein phosphatase (PPP1CB), DNA-directed RNA polymerase II (RNApII), ribonucleoside-diphosphate reductase (RRM1), signal recognition particle receptor (SRPα), and cleft lip and palate transmembrane protein 1 (TP1). Here we report the results of tests of amplification success and phylogenetic utility of these primer sets across 7 families of Coccoidea.

Keywords: molecular systematics, PCR primers, Coccoidea, phylogenetics

Diagnostic morphological features of the neotropical species of the genus *Rhizoecus* (Hemiptera: Rhizoecidae), new contributions

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Coccomorpha (Hemiptera) or Scale Insect taxonomy is based on the adult female external morphology. For the family Rhizoecidae (Hemiptera: Coccomorpha) or hypogeic mealybugs, males external morphology have proven to be of relevant importance in recent years. In this study the external morphology (e.g., cuticular characters, antennae, legs, mouthparts) and internal morphology (genital chamber) of the adult female of 39 species of *Rhizoecus* occuring in the Neotropics is revised and discussed. Some morphologically important structures such as number of preapical spurs in the tibia and tarsus, presence of setae next to the spiracular peritrema are defined as a new taxonomic characters and the applicability of taxonomic characters previously used are discussed. In addition, shape of the genital organ was described for the first time for some species and structures previously not observed in the genus and microscopic images of the some structures are provided.

Key words: Taxonomy, solenidium, eupathidium, tubercles.

Revision of hypogeic mealybugs *Rhizoecus* (Hemiptera: Rhizoecidae) from the Neotropical region

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The genus *Rhizoecus* Künckel d´Herculais, (Hemiptera: Coccomorpha: Rhizoecidae) is cosmopolite and has 93 species worldwide. The description of its species is based on the external morphologic features and the genital organ of adult females. In this study the taxonomy of 39 species occurring in the Neotropical region is revised; morphological features of nine species are discussed; the genus is redescribed. In addition, the synonymy of *Rhizoecus tropicalis* Hambleton with *R. simplex* (Hambleton), *R. nemoralis* (Hambleton) with *R. cyperalis* (Hambleton), *R. ovatus* Hambleton with *R. macgregori* Hambleton and *R. americanus* (Hambleton), *R. latus* (Hambleton) with *R. caladii* Green. We also provide a dicotomic taxonomic key for the 35 neotropical species of genus *Rhizoecus*.

Keywords: Taxonomy, roots, morphology, taxonomic characters.

SYSTEMATIC, MORPHOLOGY AND GENETICS

POSTER SESSION

New insights on Scale insect (Hemiptera: Coccomorpha) sperm: an ultrastructural point of view

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The coccoid sperm are characterized by the absence of the conventional sperm components such as acrosome, centrioles and mitochondria. They are motile thanks to a flagellum consisting of a bundle of microtubules connected by dynein-like arms.
Recent studies have revealed that, unlike Neococcids, the flagellum *of Matsucoccus feytaudi* Ducasse (Hemiptera: Matsucoccidae) is produced by an ephemeral MTOC (Microtubule Organizing Centre) present in the early spermatids together with centrioles; these structures and portions of nucleus are eliminated at the end of spermiogenesis. It can be suggested that other Archaeococcids show similar organizations. The study of the sperm structure of *Marchalina hellenica* Genn. (Hemiptera: Marchalinidae), in fact, has revealed that the sperm flagellum show a comparable ultrastructure to that of *M. feytaudi* showing microtubular arches surrounding the axial nucleus.

Keywords: reproductive apparatus, sperm ultrastructure, MTOC, Microtubule Organizing Centre, *Matsucoccus feytaudi, Marchalina hellenica.*

A taxonomic revision of the family Cerococcidae (Hemiptera: Coccomorpha)

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Recently we revised the family Cerococcidae (Hemiptera: Coccomorpha), concentrating mainly on the Afrotropical and Indian species. During this study, we found a character not previously noted in descriptions, which we refer to as the anteroventral sclerotisation. This was found to be typical of all species within the particular geographic area studied but absent from all Cerococcidae from North America and thus absent from the type species, *Cerococcus quercus* Comstock. The presence/absence of a range of other character-states was found to correlate with this new character. The genus *Antecerococcus* Green was therefore resurrected to take species with an anteroventral sclerotisation. We also studied all other species known within the Cerococcidae (a total of 80 species) and substantially rearranged their placement within the five genera now included in this family. Our poster will describe the new character, outline the taxonomic changes within the family and also look at the geographic distribution of the genera.

Diagnosis of the tribe Paralecaniini Williams (Hemiptera: Coccomorpha: Coccidae)

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The morphological characters diagnosing the soft scale insects tribe Paralecaniini Williams (Hemiptera: Coccomorpha: Coccidae) will be outlined and illustrated using an undescribed species recently discovered in Malaysia. This tribe appears to be restricted to Asia and Australasia and is currently thought to include 8 genera plus possibly 3 more. No males of Paralecaniini had been found previously but all the developmental stages of this undescribed species are known, including the adult male.

Keywords: soft scales, taxonomy, new species, immature stages

Cryo-SEM observations and imaging of minute lesser sclerotized insects

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The study of minute cuticular details of small delicate insects is possible by slide mounting of the entire exoskeleton or part of it. This technique requires whole insect body clearing or tissue bleaching and washing. Lesser sclerotized insect body greatly suffers for such treatments and looses its natural body shape by shrinkage or by flattening, consequently. The aim of this study is to suggest an effective, fast and cheap technique to image less sclerotized insects that are prone to shrink or to wrinkle their bodies because of desiccation. Actual availability of desktop Cryo-SEM (Hitachi TM 3000 series) suggested us to experiment the opportunity to preserve natural body shape of the minute, delicate and lesser sclerotized insects in their living attitude. The technique bases on freezing the specimen, either living or previously EtOH-preserved but moved in water for the preparation, in water down to -40°C on the SEM Cryo-stage and setting it for observation in SEM vacuum chamber. Once in the vacuum a proper T°C increase at about -28/-22°C allow external ice sublimation and expose the frozen insect to direct SEM imaging. The technique appears promising because of the overall quality of results, the resolving power, the opportunity to measure the specimens.
In fact, delicate specimens as *Phylloxera ilicis* Grassi (Hemiptera: Phylloxeridae, a representative of *Phylloxera quercus* Boyer de Fonscolombe group), the Italian grape mealybugs *Planococcus ficus* (Signoret) (Hemiptera: Coccoidea) and *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae) maggots that are all usually ruined by desiccation during direct SEM observation, beautifully retain their natural body shape by this technique allowing the study and imaging of external morphology. As a further advantage there is no need to critical point drying or metal coating and the same sample can be submitted to conventional slide mounting later, after being studied by Cryo-SEM.
Finally, we present a table of the running time/cost per observation of the proposed technique.

Keywords: electron microscopy, anatomy, gross & fine morphology.

Wirjati's historic collection of Indonesian mealybugs (Hemiptera: Pseudococcidae)

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Wirjati collected mealybugs (Hemiptera: Coccomorpha: Pseudococcidae) in Indonesia in the 1950s, from a variety of hosts. Her material recorded species which were established in the country at that time. The slides, deposited at the Indonesian Ministry of Agriculture in Java, were the earliest material in the national mealybug collection. There are 181 temporary slide mounts of unstained, waxy mealybugs mounted in agar or gum chloral media that have dried out to varying degrees.Specimens were retrieved from 50 representative slides and remounted as stained, archival mounts in Canada balsam for reidentification purposes. The methods used for specimen retrieval are described. The remounted specimens were reidentified using recent identification keys, resulting in new identities for most of the specimens; 9 genera and 10 species, although 12 slides could not be identified beyond genus level. The commonest species in the collection was *Exallomochlus hispidus* (Morrison). The differences between the fauna in the 1950s and today are discussed.

Key words: historic fauna, slide curation, methodology, national collection.

A taxonomic revision of *Hypogeococcus* Rau species (Hemiptera: Pseudococcidae) from Argentina

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The genus *Hypogeococcus* Rau (Hemiptera: Pseudococcidae) includes 11 species worldwide, four of which are distributed in Argentina: i) *Hypogeococcus concordiensis* Williams and Granara de Willink (exclusive on Myrtaceae); ii) *Hypogeococcus festerianus* (Lizer & Trelles) (exclusive on Cactaceae); iii) *Hypogeococcus pungens* Granara de Willink (on Amaranthaceae, Apocynaceae, Cactaceae and Portulacaceae), and iv) *Hypogeococcus spinosus* Ferris (on Cactaceae and Euphorbiaceae). One native species from Argentina, considered by many experts as *Hypogeococcus pungens* Granara de Willink, was used in the 1980s as a biological controller of *Harrisia martinii* (Labour.) Britton (Cactaceae) in Australia and South Africa. Then it was accidentally introduced to other countries, probably through trade of ornamental plants. Currently in Puerto Rico strong attacks of this "mealybug", becoming a major pest of cactaceaes, especially native columnar, threatening the economy and biodiversity of the island it was recorded. The first step to implement a plan to biological control is properly know the species in question, then we began to study the *Hypogeococcus* species presents in Argentina. The objective of this work is to present the complex *Hypogeococcus* species, based on morphological characters, from Argentina and their host plants. The material studied comes from the entomological collections of INTA Castelar (Buenos Aires) and Instituto - Fundación Miguel Lillo (Tucumán) –IFML-, and numerous samples collected from different locations in Argentina (Jujuy, Salta, Tucumán, Catamarca, La Rioja, Mendoza) by researchers of FuEDEI (Buenos Aires) and INSUE (Tucumán). All material was prepared by standard techniques of clarification, dehydration and mounting observations in optical microscopy and part of it for scanning electron microscopy (SEM). The presence of the four species mentioned for Argentina is confirmed, and we present a complex of five Hypogeococcus species, from samples of Salta, Catamarca and Mendoza, registered on the Cactaceae: *Harrisia pomanensis*, *Cleistocactus smaragdiflorus* (F.C.A. Weber) Britton and Rose and *Cereus aethiops*(Haw.), and *Alternanthera pungens* (Kunth) (Amaranthaceae).

Keywords: Biodiversity, cactaceae, morphological characters, SEM

Tuesday, 14th June

Investigations on the immature stages of some Eulecaniinae species (Hemiptera: Coccomorpha: Coccidae)

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Currently, identification of most species of Coccomorpha depends on the morphology of the adult female. In this work, we consider the significance of the morphology of nymphal stages of four species belonging to the subfamily of Eulecaniinae (Hemiptera: Coccomorpha: Coccidae), namely *Paleolecanium bituberculatum* (Signoret), *Physokermes piceae* (Schrank), *Rhodoccus perornatus* (Cockerell & Parrott) and *Sphaerolecanium prunastri* (Fonscolombe). Nymphal morphology of these species are described and illustrated and keys are provided for determination of the first- and second-instar females and males. In addition, the nymphal morphology of *Coccus hesperidium* L., the type species of the family Coccidae, is described. The results show that the morphology of the nymphal stages are useful for the determination of soft scale species.

Keywords: Nymphal stages, description, key, Eulecaniinae, Coccidae

Repeated replacement of an intrabacterial symbiont in the tripartite nested mealybug symbiosis

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Stable endosymbiosis of a bacterium into a host cell promotes cellular and genomic complexity. The mealybug *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae) has two bacterial endosymbionts; remarkably, the first, the gammaproteobacterium *Moranella endobia* (Gammaproteobacteria: Enterobacteriales) lives in the cytoplasm of the second, the betaproteobacterium *Tremblaya princeps* (Betaproteobacteria: Burkholderiales). These two bacteria, along with genes horizontally transferred from other bacteria to the *P. citri* genome, encode complementary gene sets that form a complex metabolic patchwork. Here we test the stability of this three-way symbiosis by sequencing host-symbiont genome pairs for five diverse mealybug species. We find marked fluidity over evolutionary time: while *Tremblaya* is the result of a single infection in the ancestor of mealybugs, the innermost gammaproteobacterial symbionts result from multiple replacements of inferred different ages from related but distinct bacterial lineages. Our data show that symbiont replacement can happen even in the most intricate symbiotic arrangements, and that pre-existing horizontally transferred genes can remain stable on genomes in the face of extensive symbiont turnover.

Keywords: organelle, horizontal gene transfer, intrabacterial, symbiont replacement, *Sodalis*

ZOOGEOGRAPHY, FAUNISTIC AND ALIEN SPECIES

ORAL PRESENTATIONS

Known distribution and pest status of fluted scale insects (Hemiptera: Monophlebidae: Iceryini) in South America

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The tribe Iceryini (Hemiptera: Monophlebidae) is composed by 84 species distributed in five genera, i.e., *Crypticerya* Cockerell, *Icerya* Signoret, *Echinicerya* Morrison, *Gigantococcus* Pesson & Bielenin, and *Gueriniella* Targioni Tozzetti. Of these, only *Crypticerya* and *Icerya* are known from South America. Twelve of 27 described species of *Crypticerya* and six of 35 species of *Icerya* have been recorded from one or more South American countries. In South America, the pest species are commonly called fluted scales because the female (often hermaphroditic) produces a white waxy ovisac marked with longitudinal grooves or flutes. The species of greatest economic importance in South America are *Crypticerya brasiliensis* (Hempel), *C. multicicatrices* Kondo & Unruh, *C. genistae* (Hempel), *C. montserratensis* (Riley & Howard), *C. palmeri* (Riley & Howard), *C. zeteki* (Cockerell), *Icerya purchasi* Maskell and *I. seychellarum* (Westwood). All of the above species are polyphagous and attack plant species of economic importance. For example, *C. multicicatrices* is known to feed on 147 plant species and, when outbreaks occurred on San Andres Island, the most common hosts included essentially all palm species (Arecaceae), breadfruit (*Artocarpus altilis* (Parkinson) Fosberg), *Citrus* spp., guava (*Psidium* spp.), all leguminous trees and weeds (Fabaceae), *Ficus* spp., M*ammea americana*, *Melicocca bijuga* and *Spondias* spp. Another species, *C. genistae* has been reported on 80 species of plants, and was reported recently in Colombia, where it is considered a pest of chili peppers. We provide information on the distribution and host plants of the pest species and discuss their economic importance.

Key words: Coccomorpha, distribution, host range, biology, economic importance.

The scale insects (Hemiptera: Coccomorpha) present on *Leptospermum scoparium* (mānuka) in New Zealand.

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Leptospermum scoparium (mānuka) (Myrtaceae) is a widespread indigenous shrub species in New Zealand and is tolerant of a wide range of environmentally stressful conditions. Mānuka has been recorded as a host plant for 22 species of scale insects most notably *Acanthococcus orariensis* (Hoy) which was considered the primary cause of a serious epidemic of mānuka blight during the 1950's following its accidental introduction to New Zealand from Australia in the 1930's. There has been subsequently little research on the diversity of scale insect species on mānuka and on effective methods to control them. Importantly, mānuka is valued for its medicinal honey and there is now a sudden interest in plantation mānuka to farm the plant for its honey. Research aims to bridge this gap by exploring the relationship of scale insects on the growth of mānuka and subsequently the effect on density of flowers and the quantity and quality of the nectar. Insecticides were used to reduce scale insect population. Host plants from a range of different genotypes were assigned to be sprayed or non-sprayed in a split-plot design in a common garden experiment. Monthly monitoring revealed a partial efficacy of the treatment with sprayed plants showing reduced densities of scale insects which included a variety of species from the families Eriococcidae, Pseudococcidae and Diaspididae. Interestingly, *Acanthococcus leptospermi* (Maskell) and *A. campbelli* (Hoy) were present but not *A. orariensis*. The benefits of the reduction of scale insect density on growth rates and nectar quality and quantity are currently being evaluated.

Keywords: *Leptospermum scoparium*, *Acanthococcus*, scale insect, insecticide.

Scale insects (Hemiptera: Coccomorpha) of coffee roots from Colombia and Mexico

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The populations of scale insects (Hemiptera: Coccomorpha) had arisen in coffee (*Coffea arabica* L. (Rubiaceae) crops in recent years causing high economic losses with the consequent need to identify the Coffee-associated species to develop an effective IPM strategy. In this research, we identified species of hypogean scale insects present on coffee crops from Colombia and Mexico. Federación Nacional de Cafeteros personnel collected Colombian samples; the authors gathered the species from Mexican. The specimens were preserved in alcohol-75%; slide preparation for microscopy followed Systematic Entomologic Laboratory's protocol (SEL-USDA); morphological studies were developed in Entomological Museum UNAB, Landscape and Ornamental Pests Laboratory (Purdue University) and SEL-USDA. Eight hundred twenty-nine specimens were analysed: 23 species distributed along 12 genera were identified from samples of Colombia. *Puto barberi* (Cockerell) was the most common species, present in 41 (56%) of 73 localities sampled. *Dysmicoccus mackenziei* Beardsley, *D. radicis* Green and *Mixorthezia minima* are found for the first time in Colombia. *Phenacoccus solani* (Ferris) is reported for the first time associated with coffee plants. A new species of *Pseudorhizoecus* Green was determined. Six species of six genera were identified from samples of Mexico: *Mixorthezia minima* Konczné Benedicty & Kozár, *Ripersiella campestris* (Hambleton), *Pseudorhizoecus proximus* Green and a new species of *Williamsrhizoecus* Kozár & Konczné Benedicty are reported for the first time in this country. An updated list of scale insects in the coffee crop for each country and an alpha-taxonomic key for the identification of Coccomorpha in coffee to Colombia is provided.

Keywords: Rhizoecidae, Neotropical region, Pests insects, *Coffea arabica*, phytosanitary status, diversity.

Mealybugs (Hemiptera: Pseudococcidae) associated with persimmon *Diospyros kaki* L. (Ebenaceae) in Southern Brazil

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Temperate fruit production is an important economic activity in Southern Brazil. In this region, persimmon *Diospyros kaki* L. (Ebenaceae) is grown in small farms for domestic consumption and internal market. Mealybugs are often found in at least 50% of the orchards causing damages on fruits due to the honeydew secretion. However, there is a lack of information about species composition damaging orchards in Southern Brazil. In this work, we present a survey of mealybugs associated with persimmon trees in the Serra Gaúcha Region, Rio Grande do Sul, Brazil. Mealybugs were collected from commercial orchards between 2013 and 2015. Identification was carried out by using morphological features and DNA characterization. The species found infesting fruits, leaves and branches of persimmon trees were: *Anisococcus* sp. n., *Dysmicoccus brevipes* (Cockerell), *D. sylvarum* Williams & Granara de Willink, *D. texensis* (Tinsley), *Ferrisia cristinae* Kaydan & Gullan, *Ferrisia* sp. n., *F. terani* Williams & Granara de Willink, *F. williamsi* Kaydan&Gullan, *Nipaecoccus jacarandae* Williams & Granara de Willink, *Phenacoccus gregosus* Williams & Granara de Willink, *Ph. tucumanus* Granara de Willink, *Pseudococcus meridionalis* Prado, *Ps. nakarahai* Gimpel & Miller), *Pseudococcus* sp. n., Ps. sociabilis (Hambleton), *Ps. viburni* (Signoret) and *Pseudococcus* sp. Three of these species are new to science and three are new records for Brazil. *Ph. gregosus* and *Ps. nakaharai* were recorded for the first time in South America. A. sp. n., *D. brevipes*, *Ps. sociabilis* and *Ps. viburni* are the most common mealybugs found in persimmon trees.

Keywords: Coccomorpha, fruit trees, fauna, new species.

The armored scale insects (Hemiptera: Diaspididae) of Alabama, USA

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A continuing survey of the armored scale insects of Alabama has resulted in recording 114 species in 46 genera, among the tribes Aspidiotini, Diaspidini, and Odonaspidini, that have been collected in Alabama. Alabama now ranks second among states in the southeastern United States in number of species of armored scales, trailing only Florida with its 150+ species. Comments on some of the more notable diaspidids, not previously collected in Alabama, will be made along with notes on their hosts and distribution in the State.

Keywords: faunistic survey, Aspidiotini, Diaspidini, Odonaspidinae.

Scale insects (Hemiptera: Coccomorpha) on sugarcane from Colombia

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Seven species of scale insects (Hemiptera: Coccomorpha) were recorded on sugarcane, *Saccharum officinarum* L. (Poaceae) in Colombia, i.e., Pseudococcidae: *Dysmicoccus boninsis* (Kuwana), *D. brevipes* (Cockerell), *Pseudococcus calceolariae* (Maskell), *Saccharicoccus sacchari* (Cockerell); Coccidae: *Pulvinaria elongate* Newstead; Diaspididae: *Duplachionaspis divergens* (Green) and *Serenaspis minima* (Maskell). *S. minima* report in Colombia is doubtful as there are no voucher specimens and since the distribution of this species is currently limited to the Australasian region. *Pseudococcus calceolariae* record on sugarcane is also doubtful in Colombia, although it is present in other hosts. We report for the first time the presence of *Pinnaspis strachani* (Cooley) and a new species of *Tillancoccus* (Hemiptera: Coccidae), collected in Colombia on sugarcane. The given alpha-taxonomic key permits to identify the nine species of Coccomorpha infesting sugarcane in Colombia with their listed distribution, biological information, and mutualistic ants.

Keywords: *Saccharum officinarum*, taxonomy, phytosanitary status, Neotropic region, diversity.

An upgrade of scale insect fauna of some Sicilian endemic plants

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The authors report the scale insects species for the first time recorded on some endemic plants of Sicilian flora, namely, *Abies nebrodensis* Mattei (Pinaceae), *Astragalus siculus* Biv. (Fabaceae), *Betula aetnensis* Rafinesque (Betulaceae) and *Zelkova sicula* Di Pasquale Garfi & Quezel (Ulmaceae).
A. nebrodensis, is present in a single small population on the Madonie Mountains. On this conifer the fir scale *Parlatoria parlatoriae* (Šulc) was collected. On *B. aetnensis*, that colonizes the lava substrates of Etna Volcano mainly at 1300-1900 m.a.s.l., a consistent population of a *Diaspidiotus* species (still under specific evaluation) was collected. Moreover, on *A. siculus*, characteristic of the upper part of the volcano, specimens of *Lepidosaphes ulmi* (Linnaeus) were detected and collected. *Z. sicula* is a very rare relict of Tertiary, belonging to a genus of plants already extinct in Continental Europe; only two small populations live in restricted woodland areas in south oriental Sicily where two scales were collected: *Aspidiotus nerii* (Costa) and *Partenolecanium* sp. (still under specific evaluation).

Key words: Mount Etna, Madonie Mountains, Mount Iblei massif, Diaspididae, Coccidae.

BIOLOGY, ECOLOGY AND POPULATION DYNAMICS

ORAL PRESENTATIONS

Bio-ecology of cedar scale insect *Torosaspis cedricola* (Balachowsky, Alkan) (Hemiptera: Diaspididae) in Ankara, Turkey

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Torosaspis cedricola (Balachowsky, Alkan) (Hemiptera: Diaspididae), The cedar scale insect is one of the important pests of cedar trees in Turkey. *Torosaspis cedricola* is common from sea level up to 1700 m altitude in areas from the coast of Mediterranean region, but the population is in low density. However, in city centers, *T. cedricola* populations on cedar are generally high. The bio-ecology of *T. cedricola* on *Cedrus libani* A. Rich. (Pinaceae) was examined during two year (2008 and 2009) at four locations in Ankara, Turkey. *T. cedricola* has two generations per year and overwinter as mated females. The sex ratio was found in favor of females in the population. It occurred only on the leaves of cedar trees. Male flights were seen two times (July and September – October) in a year. Average eggs number of *T. cedricola* were 3.5- 5.3 per female. *Adalia bipunctata* (L.), *Chilocorus bipustulatus* (L.), *Exochomus quadripustulatus* (L.), *Harmonia quadripunctata* (Pont) (Coleoptera: Coccinellidae) and *Cybocephalus fodori minör* (Endrödy) (Coleoptera: Cybocephalidae) were identified as predators, whilst *Diaspiniphagus (Coccophagoides) moeris* Walker (Hymenoptera: Aphelinidae) a parasitoid of the cedar scale insect. Impact of these natural enemies on scale insect populations of *T. cedricola in* Ankara was discussed.

Keywords: *Cedrus libani*, *Diaspiniphagus (Coccophagoides) moeris*, predator, population fluction

Effect of temperature on bioecological characteristics of *Chrysomphalus dictyospermi* Morgan (Hemiptera: Diaspididae)

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In this study, some biological characters of *Chrysomphalus dictyospermi* Morgan (Hemiptera: Diaspididae) in three different temperatures (22.5, 27.5 and 30 °C ± 1) were investigated under constant relative humidity (65% ± 5) and photoperiod (16:8 L/D) climatic conditions. Eggs produced by adult females were transferred to clean pumpkins one by one. After hatching, settlement of crawlers on pumpkins was monitored and then, square cells in about 2x2 cm were drawn with a special stickem around the settled crawlers. Each crawler in the cells was observed every day from birth to death in order to determination mortality, male-female discrimination and duration of preoviposition, oviposition, and postoviposition periods and recorded. The life table analysis was practiced according to Euler-Lotka equation. In the study, it was shown that the intrinsic rate of increase (rm) of *C. dictyospermi* was 0.028 female/female/day at 22.5 °C, 0.04 female/female/day at 27.5 °C and 0.061 female/female/day at 30 °C. The reproductive rate (Ro) of the pest was determined as 19.295, 17.932 and 67.537 females/female/generation at three different temperatures, respectively. The generation time (To) was found 102.464, 66.403 and 68.742 days at 22.5, 27.5 and 30 °C, respectively. In addition the gross reproduction rate (GRR) was calculated as 25.152, 24.706 and 103.557 females/female, the doubling time (T2) was 23.995, 15.945 and 11.310 days and also, the finite rate of increase (λ) was 1.029, 1.044 and 1.063 females/female, respectively in three different temperatures.

Key words: *Chrysomphalus dictyospermi*, life table, pumpkin, temperature

Life history of *Parthenolecanium* spp. (Hemiptera: Coccidae) in urban landscapes of southern United States

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Parthenolecanium corni (Bouché) and *Parthenolecanium quercifex* (Fitch) (Hemiptera: Coccidae) are commonly found in mixed populations as pests of oaks (*Quercus* spp.; Fagaceae). Their phenology is poorly understood, which in turn hinders pest managers' ability to develop an integrated management program. This research aims to better understand the life history of *Parthenolecanium* spp. in the urban landscapes of Georgia, North Carolina, South Carolina and Virginia. Eggs hatched between mid-April to early June, second instars began to occur in October, and third instars and adults in mid-March to early April. Using the temperature and emergence data, degree-day models were developed to better estimate the timing of crawler emergence. Crawler emergence occurred when 229 Celsius-degree-days had been accumulated with the simple-average method at a base temperature of 12.8^{O}C (55^{O}F), and at the first bloom of southern magnolia, *Magnolia grandiflora* L. (Magnoliaceae). Each parthenogenetic female produced 177 to 2398 eggs. Fecundity was found to be proportional to weight of females (including eggs) and body length, width and height.

Keywords: soft scale, integrated pest management, life cycle, ornamental tree

Biology, ecology and potential impact of *Ceroplastes sinensis* Del Guercio (Hemiptera: Coccidae) on the invasive *Baccharis halimifolia* L. (Asteraceae) in France

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The introduction of invasive species is deemed to be the second greatest threat to biodiversity after habitat loss. In this context, *Baccharis halimifolia* L. (Asteraceae), a native plant to the USA, was introduced to France in 1683 as an ornamental, and has since become invasive. It is highly competitive, which is particularly harmful in Camargue, southern France, where its colonization modifies habitats, at the expense of local plants and birds. Its control represents a major problem and, as a result, biological control represents an avenue of research worth exploring. In 2014, fauna inventories on Baccharis allowed scientists to identify a potential biological control agent: the Chinese wax scale, *Ceroplastes sinensis* Del Guercio (Coccidae). The objectives of this study were 1) to increase our knowledge on the biology *C. sinensis* in the protected area of Camargue, 2) to assess the *in vivo* and *in situ* impact of *C. sinensis* on B. halimifolia and 3) to find out if this impact is sufficient to consider this coccid as a potential biological control agent. Our study site was the Grande Cabanes du Vaccarès Sud, in the Rhone Delta. We introduced *C. sinensis* in newly Baccharis colonized areas, and we measured the relative impact on plants. The results showed that, within a period of 2 months, at low larval densities, the direct impact of *C. sinensis* on Baccharis' growth, leaves aspect and water content, and number of dry leaves was not significant. Although the successful artificial *C. sinensis* colonization was observed on both *in vivo* and *in situ* Baccharis trees, the direct impact of this coccid to reduce Baccharis population density was not promising. However, a significant relationship was found between scale density and plant shininess (resulting from the presence of honeydew), and reducing the fitness of the plant, as well as between scale density and salinity of the soil. We will present data on the indirect impact of *C. sinensis*, in particular on the late development of the sooty molt fungus, which may negatively impact *Baccharis* populations in the long term.

Keywords: invasive species, biological control, *Ceroplastes*, *Baccharis*

Does *Unaspis euonymi* (Comstock) (Hemiptera: Diaspididae) host *Serratia symbiotica* Moran (Bacteria: Enterobacteriaceae)?

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Unaspis euonymi (Comstock) (Hemiptera: Diaspididae) is a well-known and invasive armoured scale insect that infests and damages mostly *Euonymus* spp. (Celastraceae) such as *japonicus* Thunb. and *europaeus* L., all around the world. Recently, specimens of the diaspidid were scrutinized for *Serratia* spp. while searching about the symbiosis between insect and bacteria. Surprisingly enough *Serratia symbiotica* was regularly identified in many individuals of *Unaspis euonymi* collected in Sofia (Bulgaria) during September 2013. We identified the bacterium by Denaturing Gradient Gel Electrophoresis (DGGE) and subsequent 16S rRNA sequence analyses of about 600bp PCR fragments obtained from total DNA extracted from single and pooled insects. Our sequences showed 99% of identity with *Serratia symbiotica* (Bacteria: Enterobacteriaceae) strain CWBI-2.3 recently described as a free-living symbiont of the Black Bean Aphid, the *Aphis fabae* (Scopoli) (Hemiptera: Aphididae). We discuss the meaning of this finding and the need to gather further evidence on the presence of the bacterium in association with the armoured scale in different places and on different host plants.

Keywords: Synecology, insects-bacteria interaction

ZOOGEOGRAPHY, FAUNISTIC AND ALIEN SPECIES

POSTER SESSION

A checklist of the scale insects (Hemiptera: Coccomorpha) in Luxemburg

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The scale insect fauna of Luxemburg has received scant attention. This paper lists all of the scale insects recorded in Luxemburg up to 2015. At present the number of scale insects known in the country has reached 34 species. The species belong to 7 families. The most numerous are the Coccidae (11), Diaspididae (10) and Pseudococcidae (6).

Keywords: Hemiptera, scale insects, checklist, Luxemburg.

Current Situation of *Eurhizococcus brasiliensis* (Hemiptera: Margarodidae) in Brazil

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One of the most prominent insect pests that limits the production in different wine-producing regions of Brazil is the Brazilian ground pearl *E. brasiliensis* (Wille). This scale attacks roots of grape vines causing damage due to its sap-sucking habits, which leads to a reduced production and eventually to plant death. *E. brasiliensis* has a complex biological cycle. Parthenogenetic eggs are laid inside mature cysts, and the crawlers emerge from the ruptured cysts. In the mobile phase, nymphs have little self-dispersal capacity. They move close to the roots and remain feeding until full development. The complete life cycle usually lasts for one year. The parthenogenetic females appear and remain alive inside the cysts until they lay their eggs (asexual reproduction). The species can also reproduce sexually; in this case, the cyst becomes a mobile female that goes to the surfaces at the time of mating, to copulate with the winged male, and later returns to the ground to lay their eggs. One of the important aspects of the survival of *E. brasiliensis* is its interaction with ants (Hymenoptera: Formicidae) that harvest sugary excretions ('honeydew') they produce in a mutualistic association, in which both the ant and scales are benefited. *Linepithema micans* (Forel) is the most frequent and abundant ant that disperses *E. brasiliensis* in vineyards in southern Brazil, the main grape-producing region in the country. *E. brasiliensis* has been controlled using neonicotinoid insecticides applied to the soil by drench or fertigation. However, there are restrictions on the presence of toxic residues in fruit and the risk of environmental contamination. An alternative to reduce scale infestation in vineyards may be the control of *L. micans* with toxic baits. Experimental results has shown that hydramethylnon baits are efficient in the control of *L. micans*, being another tool to reduce the infestation of *E. brasiliensis* in vineyards (CNPq, Fapergs).

Keywords: Coccomorpha, Formicidae, hydramethylnon, control, vineyards.

Scale insects (Hemiptera: Coccomorpha) on mulberry trees in Turkey

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In Turkey commonly cultivated mulberry species are *Morus alba* L., *M. nigra* L., and *M. rubra* L. (Moraceae) fruits are widely consumed freshly or as traditional products such as mulberry pekmez, mulberry pestil and mulberry kome. Also their leaves are used to sericulture. In this study, scale pests of mulberry trees have been researched mainly in Ankara province and some other regions in Turkey. Nine scale insect namely *Ceroplastes floridensis*, *C. japonicus C. rusci*, *Neopulvinaria innumerabilis*, *Parthenolecanium corni* (Coccidae), *Pseudaulacaspis pentagona* (Diaspididae), *Phenacoccus aceris*, *Planococcus ficus* and *Pseudococcus comstockii* (Pseudococcidae) are found on *Morus* spp. *P. pentagona* was the commonest and important pest of mulberry trees in Turkey. Population of *C. japonicus*, *N. innumerabilis*, *P.comstockii* are found very high level some local gardens.

Key words: *Morus* sp. *Ceroplastes floridensis*, *Planococcus ficus*, *Pseudococcus comstockii*

Eriococcidae (Hemiptera: Coccomorpha) infesting Fabaceae in Argentina

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Eriococcidae (Hemiptera: Coccomorpha) includes phytophagous insects known as felt scale, with worldwide distribution. The Fabaceae family, of great economic and ecological importance, of cosmopolitan distribution, with numerous native representatives in Argentina, includes trees, shrubs and herbs, recognizable by their legume type fruit and composed and stipulated leaves. Ten genera and 34 species of Eriococcidae, eight of which were recorded on Fabaceae in Argentina namely: *Acanthococcus diversispinus* (Leonardi), *A. gracielae* González & Claps, *A. siambonensis* González & Nicosia, *Hempelicoccus alba* González, *H. leguminicola* (Morrison), *H. mendozae* (Morrison), *H. santiaguensis* (González & Granara of Willink) and *H. tucumanensis* (González & Nicosia). The objective of this work is to expand knowledge of Eriococcidae and their hosts on Fabaceae family. The examined material, 48 slides with 111 adult females, is deposited in the collections: Instituto Fundación Miguel Lillo, Tucumán (IFML) and INTA Castelar, Buenos Aires, Argentina. Twelve Eriococcid species belonging to the genus *Acanthococcus* Signoret (six species) and *Hempelicoccus Kozár* (six species), are recorded. The hosts are 11 species of Fabaceae plants belonging to Caesalpinioideae and Mimosoideae subfamilies. They are distributed in the Neotropical region; subregion Chaco, Chaco and Pampa provinces; subregion Paranaense, Paranaense Forest province and Transition American Area; Prepuna and Monte provinces.

Key words: felted scales, *Acanthococcus*, *Hempelicoccus*

Distribution of scale insects (Hemiptera: Sternorrhyncha: Coccomorpha) on citrus plants in Croatia

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During the faunistic investigation in 2015, within the scope of Survey program „Organisms harmful to plants – Croatian 2015 Official Survey“, we have monitored citrus plants in order to determine eventual presence of quarantine scale insects. Survey was conducted along the coastal area, especially in the southern counties with majority of citrus production, in intensive and extensive orchards and solitary plants belonging to species within the genera of *Citrus* spp. (Rutaceae), *Fortunella* spp. (Rutaceae) and *Poncirus* spp. (Rutaceae). This preliminary survey on citrus plantations gave negative results on quarantine species and confirmed several scale insects from family Coccidae: *Coccus hesperidum* Linnaeus, *C. pseudomagnoliarum* (Kuwana) and *Saissetia oleae* (Olivier); Diaspididae: *Aonidiella aurantii* (Maskell) and *Lepidosaphes beckii* (Newman); Margarodidae: *Icerya purchasi* Maskell and Pseudococcidae: *Planococcus* citri (Risso).
Distribution and host plants of these species in Croatia will be reported.

Key words: Croatia, faunistic investigation, scale insects, citrus plants

Scale Insects (Hemiptera: Sternorrhyncha: Coccomorpha) on host plants from family Ericaceae in Croatia

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During ten years of faunistic research on scale insects in Croatia (2006-2015), ten scale insect (Hemiptera: Sternorrhyncha: Coccomorpha) species of four families were found on host plants from family Ericaceae: Coccidae: *Coccus hesperidum* L., *Saissetia oleae* (Olivier); Diaspididae: *Aspidiotus nerii* Bouche, *Chrysomphalus dictyospermi* (Morgan), *Diaspidiotus bavaricus* (Lindinger); Margarodidae: *Icerya pruchasi* (Maskell) and Pseudococcidae: *Nipaecoccus delassusi* (Balachowsky), *Planococcus citri* (Risso), *Peliococcus calluneti* (Lindinger) and *Pseudococcus longispinus* (Targioni Tozzetti). The localities where scale insects have been collected are listed.

Key words: Coccidae, Diaspididae, Margarodidae, Pseudococcidae, Ericaceae, Croatia

A review of alien scale insects (Hemiptera: Coccomorpha) in Bulgaria

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The increased trade interactions among countries and the import of plants, cut blossoms and bonsai has created great potential for the introduction of non-native scale insects. Based on bibliographic sources, Bulgarian scale insect fauna currently comprehends some 147 species, of which 34 of alien origin. The majority of Bulgarian non-native scale insect species are Diaspididae, mostly recorded on ornamentals, whereas other families, such as the Asterolecaniidae, Cerococcidae, Kermesidae, Matsucoccidae, Monophlebidae, Putoidae and Ortheziidaeare poorly represented. The aim of this study is to provide information on alien scale insect species in Bulgaria, based on literature sources including first detection date, validation source, zoogeographic area of origin and host plants.

Key words: alien scale insects, Bulgaria

The history of *Dactylopius coccus* (Modeer) (Hemiptera: Dactylopiidae) in the Mediterranean basin: the Sicilian episode

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Dactylopius coccus (Modeer) belongs to the family Dacylopiidae (Hemiptera: Coccomorpha), that includes species that live exclusively on Cactaceae and are native in America as well as their host plants. From the dried body of the females, rich in carminic acid, can be extracted the red carmine dye used primarily for food, clothing and cosmetic coloring. In Mexico this species was already reared for that purpose by native people before the discovery of America. The Spanish conquistadors continued the rearing of the cochineal and adopted strong control measures setting up a monopole of the production and commercialization of the colorant. After the decay of their domination, the insect and its hostplants, i.e. various Cactaceae of *Opuntia* and *Nopalea* genera, were introduced to other territories (Africa, Mediterranean basin and Canary Islands) with the purpose to obtain the precious dye. The acclimation of both plant and insect was sometimes unsuccessful. It is the case of Italy, where repeated attempts were carried out to rear *D. coccus* for the carmine dye production, introducing strains in areas with mild climate (e.g. Sardinia and Sicily) but only the hostplant was able to find suitable conditions of life. In Sicily, the prickly pear *Opuntia ficus-indica* was subsequently widely cultivated and appreciated for the edible fruit.
More recently, at the end of 90s in Sicily, another attempt of rearing the cochineal on cultivated prickly pear plants in glasshouse conditions was carried out. Based on the achieved results, it was possible to conclude as the high level of mortality of the nymphal stages of the scale, that hindered the maintaining of the population, was related with the relative humidity values, although low temperatures (till 0° C) were tolerated by crawlers that survived, by entering quiescence. Technically *D. coccus* could be reared for commercial purposes in the Mediterranean area only if temperature and humidity can be controlled (e.g. in glasshouse), avoiding any eventual threat related to its natural dispersal as occurred with other *Dactylopius* spp. that can compromise the fruit production.

Key words: cochineal dye, Italy, Cactaceae, rearing.

BIOLOGY, ECOLOGY AND POPULATION DYNAMICS

POSTER SESSION

Parthenolecanium corni (Bouché) (Hemiptera: Coccidae) associated to vineyards in Portugal: morphology, life cycle, bioecology and type of reproduction

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Due to the type of damage associated with scale insects of genus *Parthenolecanium* sp. (Hemiptera: Coccidae) on vineyards and the increase of its importance, these phytophagous insects have been studied in central region of Portugal. For this research, we addressed the followed objectives: i) identification and characterization of species associated to vineyards; ii) life cycle; iii) bioecology, iv) type of reproduction; v) identification of parasitoids; vi) assessment the interaction between scale insects infestation (6 shoots/pruning and fertilization modality; total of 60 replicates/date) and pruning systems (i.e. manual, mechanical) and also the fertilization supplies (i.e. control without any supply, bovine manure, solid manure compound from municipality, sludge waste from water treatment station, vegetal coal).

The species of soft scale insects were identified as *Parthenolecanium corni* (Bouché). *Coccophagus lycimnia* (Walker) (Hymenoptera: Aphelinidae) and *Metaphycus dispar* (Mercet) (Hymenoptera: Encyrtidae) were identified as parasitoids associated with *P. corni*. Based on laboratory and field observations, it was possible to describe the life cycle, number of generation/year and it can be inferred that *P. corni* has sexual reproduction.

The analysis of the pruning effect revealed that the pruning method significantly influences the intensity of *P. corni* infestation, i.e. the percentage of infestation were significantly higher in the mechanical pruning modality when compared with manual pruning. The analysis of the fertilizers effect revealed no significantly influences on the intensity of *P. corni* infestation.

This research was supported by Programa de Desenvolvimento Rural/PRODER (project FertilPoda, 4.1 "Cooperação para a Inovação" PRODER, P.A. 0203970-24071, partnership 397) and FCT: UID/AGR/00239/2013.

Key-words: Coccidae, females, males, pruning, parasitoids.

The influence of host plant species on *Coccus hesperidum* L. (Hemiptera: Coccidae) honeydew amino acids composition

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The primary metabolites are the chemical groups playing an important role in the interaction between phytophagous insects and their host plants, determining the taste acceptability of a plant to insects. The phytophagous insects use these metabolites mainly as essential nutrients to synthesize body tissue for their growth and development and to serve as energy sources. In this study, the influence of plant species on honeydew amino acids composition was determined. Analysis of the plant-sap extracts (infested and non-infested) and honeydew produced by *Coccus hesperidum* L. (Hemiptera: Coccidae) feeding on different plant species namely, *Ficus benjamina* L. (Moraceae), *Nephrolepis biserrata* (Sw.) Schott (Lomariopsidaceae), *Citrus limon* var. *Ponderosa* (L.) Burm.f. (Rutaceae)) was carried out by HPLC analysis. Chromatographic analysis of the plant extracts and honeydew showed the presence of 10 components, which were: glutamic acid, asparagine, alanine, proline, isoleucine, leucine, phenylalanine, cysteine, histidine and tyrosine. We observed the influences of the host plant quality and specificity of honeydew amino acids components and contents. Specifically, the amino acids concentrations in the honeydews were lower than those measured in the extracts of either non-infested or infested plants. The amino acid profiles differ between the host plant extracts and the scale insects excretion product, as well.

Keywords: amino acids, soft brown scale, honeydew

Impact of mealybug (Hemiptera: Pseudococcidae) infestation on metabolism of amino acids and phenolic compounds within orchid leaves

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Amino acids and phenolic compounds play different roles in plant metabolism and biochemical defence against herbivorous arthropods. Amino acids are primary metabolites limiting nutritive value of plant tissues to phytophagous insects. On the other hand, secondary phenolic metabolites are generally regarded as defensive molecules and are thought to play the main role in determining the suitability of the plant species for colonization and exploitation by herbivores and thus governing host preferences and acceptability in herbivores. This study was acomparison of changes in the content of free amino acids and phenols, and in the activity of L-phenylalanine ammonia-lyase (PAL; EC 4.3.1.5) and L-tyrosine ammonia-lyase (TAL; EC 4.3.1.) caused by the grape mealybug *Pseudococcus maritimus* (Ehrhorn) (Hemiptera: Pseudococcidae) in orchid leaves. Obtained results showed that amino acid content and the ratio of amino acids to total phenols, both increased in orchids leaves infested by the mealybug. However these changes a little extent depended on changes in the activity of the analyzed enzymes. As it was observed the enzymatic changes affected rather accumulation of total phenols. The induction of PAL activity in mealybug-infested orchid leaves during the first five hours preceded the increase in the content of total phenolics during the first week of the insect feeding and upturn in the TAL activity.

Keywords: amino acids, phenolic compounds, phenylalanine and tyrosine ammonia-lyases, grape mealybug

Symbiotic microorganisms in *Acanthococcus aceris* Signoret and *Gossyparia spuria* (Modeer) (Hemiptera: Coccomorpha: Eriococcidae)

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The aim of this research was to analyze the symbiotic systems of two species of scale insects belonging to the Eriococcidae (Hemiptera: Coccomorpha) family: *Acanthococcus aceris* Signoret and *Gossyparia spuria* (Modeer). Ultrastructural and molecular investigations have indicated that examined species of scale insects are hosts for small, rod-shaped bacteria belonging to the genus *Burkholderia* (phylum: Proteobacteria). The bacteria are localized in the cytoplasm of the fat body cells. In both eriococcid species symbionts are transovarially transmitted from one generation to the next. Bacteria invade ovarioles containing vitellogenic oocytes. These microorganisms migrate to ovariole through the follicular epithelium in their neck region. Bacteria may migrate both between neighboring follicular cells and through their cytoplasm. After migration, symbionts gather in the perivitelline space and initially form the cub-like structure. When the growth of the oocyte is completed bacteria disperse around the oolemma and start to enter the oocyte cytoplasm.

Keywords: endosymbionts, Eriococcidae, *Acanthococcus aceris*, *Gossyparia spuria*

Nidularia pulvinata (Planchon) (Hemiptera: Kermesidae) gall-inducing attitude

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Recurrent *Nidularia pulvinata* (Planchon) (Hemiptera: Kermesidae) outbreaks off *Quercus ilex* L. (Fagaceae) led us to scrutinize large amount of infested and damaged trunks, branches and twigs. Dense populations of *Nidularia pulvinata* were purposely observed at Bari, Foggia, Lecce (2012-2016) on *Quercus ilex* L. (Fagaceae). Therefore, trunks and twigs of infested trees were studied in the laboratory.
A long series of detailed observations suggest the attitude of the Kermesid saliva to induce *phloem/xylem* disorganization that results into considerable trunk and branches prominences. Evidences suggest the need to study the effect of the saliva of *Nidularia pulvinata* on the phloem/ xylene of its oak host. Infested bark surfaces are prone to produce crevices that provide further shelters for crawlers that increase the infestation, in turn.
Observations on transverse section, corroborated with polarized light microscopy and Scanning Electron Microscopy suggest that the scale stylets strongly disturb the explored plant tissues while feeding.
The plant tissues respond to the injury with considerable overgrowing and necrosis.
By observations and evidence we discuss the opportunity to consider *Nidularia pulvinata* a gall-making species, also comparing its attitude with that similar of other Kermesidae and Asterolecaniidae.

Keywords: scale insect-host plant interaction, synecology, urban entomology and greenery

Kermes vermilio Planchon and *Nidularia pulvinata* (Planchon) (Hemiptera Kermesidae) outbreaks off urban *Quercus ilex* L. (Fagaceae)

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Kermes vermilio Planchon and Nidularia pulvinata (Planchon) (Hemiptera: Kermesidae) intense outbreaks are lethal to young holly oaks and strongly damage adult trees. Such infestations are common in several South Italian urban and peri-urban areas and have been reported for a while. Recently we have been observing in Bari (Apulia region) a new considerable invasion of both *N. pulvinata* and *K. vermilio* on *Q. ilex* not scale-infested hitherto. The phenomenon is possibly in connection with the new northward expansion of *N. pulvinata* that is presently recorded in Italian areas with a continental climate as Veneto and Romagna regions. City surveys and damage estimations revealed the entity of kermesidae impact regarding direct and indirect costs for the maintenance of urban parks, public gardens and leisure areas, avenues and boulevards. Moreover, we discuss the synecology of the two species evaluating the prevalence of mixed infestations on the same plant or the reciprocal competitive displacement. Possible causes of the actual outbreak may lie in ecological disturbance along the rural-urban transition zone, changes in the available range of insecticides, wrong or absent tree maintenance, changes or fluctuation in climatic parameters.
Oaks were scored in five ascending infestation intensity: 1 = very low infestation, symptomless; 2 = infested, no dieback; 3 = infested, moderate dieback; 4 = infested, intense dieback; 5 = deadly infested. Over 141 checked oaks the % scores are: 30,5 in 1; 23,4 in 2; 26,24 in 3; 16,31 in 4 and 3,55 in 5. We presume that infestation intensity will increase in the next years seriously damaging or killing more plants, if any rationale pest control measure will be taken.

Keywords: urban entomology, urban greenery, damage phenology.

Density, structure and natural enemies of *Delottococcus aberiae* (De Lotto) (Hemiptera: Pseudococcidae) populations on Spanish citrus groves.

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Delottococcus aberiae De Lotto (Hemiptera: Pseudococcidae) is a mealybug of Southern African origin that has been detected recently in citrus groves in Eastern Spain. It causes severe distortions to young citrus fruits and represents a growing threat to Mediterranean citrus production. The presence of this pest was previously unknown in Europe, and this is also the first report of the mealybug causing damage in citrus groves worldwide. Therefore, nothing is known about the behaviour of the insect on this crop. This work aims to get a better understanding of the biology and ecology of *D. aberiae* to improve the management of the pest. To determine the spatial and temporal distribution of *D. aberiae*, as well as the number of generations that develops in our area of studies, we selected citrus groves where the pest is present. These orchards have been sampled periodically, since March 2014, to determine the presence and developmental stage of the mealybug on different parts of the plant. The composition and abundance of natural enemies was also studied. Results show that *D. aberiae* has several generations per year, reaching its highest density population between May and June. This maximum occurs simultaneously with the formation of the fruit, a period in which the insect is able to cause damage. Part of the *D. aberiae* population move towards the trunk of the tree and arrive until the ground, where gravid females can be easily seen around the base of the trunk, especially in spring. Parasitism, by native species, was practically absent. The predator *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae) showed some potential to control *D. aberiae*, but was not efficient enough. Therefore, biological control of this pest, in Spain, has proven unsatisfactory.

Key words: mealybug, sampling, fruits, biology, management, *Cryptolaemus montrouzieri*.

Biological observations of *Matsucoccus josephi* Bodenheimer & Harpaz (Hemiptera: Matsucoccidae) in Turkey

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Observations on the biology of *Matsucoccus josephi* Bodenheimer & Harpaz (Hemiptera: Matsucoccidae) were made at four natural red pine (*Pinus brutia* Tenore, Pinaceae) forest of Antalya (1), Aydın (1) and Muğla (2) between the years 2009 and 2011. Infested branches of red pine were collected twice during March - November, once in winter months in the years. In addition pheromone traps were used to monitor male scale and predators. All stages of *M. josephi* were examined and counted. Some individuals were preserved into 70 % ethyl alcohol for the identification of life-stages. Nymphs and adults predator that feed on *M. josephi*, were reared into jars with their host. As results, It was determined that *M. josephi* overwinter as second stage (cyst) under the bark of pine trees and has 4 generations (at least). *Elatophilus hebraicus* Pericart (Hemiptera, Anthocoridae) is common and effective predator in Turkey.

Key Words: *Pinus brutia*, Mediterranean basin, Predator, *Elatophilus hebraicus*, Pine bast scale

Biology, natural enemies and distribution *Physokermes hellenicus* Kozar & Gounari (Hemiptera: Coccidae) in Turkey

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Physokermes hellenicus Kozar & Gounari (Hemiptera: Coccidae) is a new record for Turkish scale insect fauna. Studies on its biological cycle and natural enemies were made on *Abies nordmanniana* (Steven) (Pinaceae) in Ankara during 2014-2016. We found that *P. hellenicus* hibernate as third instar and has one generation per year in Ankara. The following natural enemies were found associated with *P. hellenicus: Anthribus nebulosus* Forster (Coleoptera: Antribidae), *Chilocorus renipustulatus* (Scriba) (Coleoptera: Coccinellidae), Atroctotomus spp. (Hemiptera: Anthocoridae) and the parasitoid *Aphycoides clavallatus* (Hymenoptera: Aphelinidae). Among the natural enemies, *A. clavallatus* was the main cause of mortality of *P. hellenicus* populations in Ankara. The scale insect was found on *Abies cilicica* (Antoine & Kotschy) Carrière in Kahramanmaraş, Konya and on *A. nordmanniana* in Eskişehir and Ankara,

Keywords: Fir, *Physokermes hellenicus*, biology, *Chilocorus renipustulatus*, *Aphycoides clavallatus*

Tuesday, 16th June

SCALE INSECT PEST CONTROL

ORAL PRESENTATIONS

Enhancing biological control of pest mealybugs using semiochemicals: a case study

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Semiochemicals are often used as cues by parasitoids, in the process of host selection for each of the sequential steps, habitat location, host location, host recognition, and host acceptance. Therefore, semiochemicals may be applied as a tool in biological control by manipulating the spread and distribution of parasitoids aiming at intesifing their recruitment and retention within the crop. Parasitoid dispersal away from the release site after augmentative releases may also be reduced by applying semiochemicals. *Anagyrus* sp. *near pseudococci* (Girault) (Hymenoptera: Encyrtidae) is frequently used in biological control of the citrus mealybug, *Planococcus citri* (Risso) and the vine mealybug, *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae), in different crops. In an earlier study we found that the females of this encyrtid respond to (S)-(+)-lavandulyl senecioate, the sex pheromone of *P. ficus*. Later on, we have shown this compound functions as a kairomone for the parasitoid in host location. Here we integrate our findings of different experiments in the last decade in order to discuss the implementation of this kairomone in manipulating the behaviour of *A.* sp. *near pseudococci* in order to improve the management of pest mealybugs.

Keywords: *Planococcus*, pheromones, parasitoids, *Anagyrus nr. pseudococci*, host location, behavioural manipulation of insects

Rhizaspidiotus donacis (Hemiptera: Diaspididae), an effective biological control agent of *Arundo donax* (Poaceae) in the United States.

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Arundo donax L. (Poaceae) is an invasive perennial weed native to the Mediterranean Basin and Asia Minor. It was introduced in North America in the early 1500s for its uses in building construction and fence lines, and now is well established and invasive in the southern part of the United States and in Mexico. It is considered a threat to biodiversity, as it forms dense patches that consume scarce water in arid riparian regions, excludes native plants, burns easily, and recovers quickly after fire. Arundo also causes stream bank erosion and structural damage to bridges and canals. Phytophagous insects showing host-specific relationships with this target weed in laboratory studies have been considered for biological control. The arundo armored scale *Rhizaspidiotus donacis* Leonardi (Hemiptera: Diaspididae) was selected because of its great impact on arundo, as it reduced photosynthesis rates in greenhouse tests, and reduced lateral shoot growth and rhizome weight in its native field range in Spain. Upon verification of its host-specificity to feed, survive and reproduce only on arundo, *R. donacis* was approved for release in the United States in 2011, becoming the first armored scale insect species used in the history of biological control of weeds. Arundo scale colonies from Spain, Italy (Sicily) and Greece have been released and are well-established in several sites along the Rio Grande, in southern Texas and Mexico, as well as northern California. The arundo armored scale requires 5-6 months to complete its life cycle and builds up dense populations of reproductive females after several years. In Texas, *R. donacis* is reducing survival of lateral arundo shoots, as well as of new main shoots emerging from rhizomes. The arundo armored scale is therefore reducing arundo density, with benefits for water conservation and protection of biodiversity.

Key words: armored scale, biocontrol, host range, weeds, giant reed.

Determination of releasing dosage of *Aphytis melinus* DeBach (Hymenoptera: Aphelinidae) for the biological control of California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) in Turkey

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California red scale, *Aonidiella aurantii* (Maskell) (Hemiptera: Coccomorpha: Diaspididae) is a key pest of citrus in all growing regions of Turkey. Augmentative releases of *Aphytus melinus* DeBach (Hymenoptera: Aphelinidae) are conducted in Turkey in biological control schemes of the red scale. We studied the timing and regime release the parasitoid.
The *A. melinus* releasing programme was conducted in two orchards in Adana and Erzin (Hatay) in the years 2013 and 2014. Each orchard divided in four equal areas. Each releasing date we release 2500 and 5000 parazitoids in per 0.1 Hectare in two releases regimes: (i) 4 releases from April to June, (ii) multiple releases from April to October every 15 days.
The release regimes and parasitoid dosage were evaluated not with control plots but comparing the density of the red scale on fruits, leaves and twigs before the release of *A. melinus* was conducted and after the release period was ended in October. There were no statistical differences between scale infestation densities between the two releases regimes. The infestation rate of red scale on fruits before releasing of *A. melinus* was 8% in Adana 10% in Erzin; after releasing the red scale infestation rate were in Adana 6% in 2013 and 4% in 2014 and in Erzin 5% in 2013 and 5% in 2014. Leaf populations of red scale were different before and after release in both released orchards but twig populations were not significantly different before and after releasing.

Key words: *Aphytis melinus*, *Aonidiella aurantii*, biological control, Turkey

The temperature-dependent development and life table parameters of *Rhyzobius lophanthae* Blaisdell (Coleoptera: Coccinellidae) on *Aspidiotus nerii* Bouche (Hemiptera: Diaspididae)

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Turkey has an important place in citrus production and production has increased day by day. Because of growing production, large increases have been observed in population of harmful pests and their numbers. Producers have applied various methods to prevent this. Biological control is one of these methods. *Rhyzobius lophanthae* Blaisdell (Coleoptera: Coccinellidae) which has an important role in this process, is very effective against scale insects.
The study investigated the age-specific life table parameters of the predator at different temperatures (20, 26, 28, 30, 32, 34, 36 °C). The experiments were carried out in different climatic chambers set to 60% humidity and 16:8 light/dark photoperiod. Potato tubers, infected by *Aspidiotus nerii* Bouche (Hemiptera: Diaspididae), were used as food. Life table parameters of the predator at different temperatures were calculated with RmStat-3 according to Euler-Lotka equation.
Resulted showed that the intrinsic rate of increase (rm) was found 0.041, 0.121, 0.131, 0.103, 0.005 females/female/day, respectively. The net reproductive rate (R0) was found 50.333, 36.566, 54.988, 22.186, 1.074 females/female/generation, respectively. The mean generation time (T0) was found 95.770, 29.806, 30.653, 30.085, 30.007 days, respectively. At 34 °C, while most of the eggs couldn't hatch into the first larval stage in this process, only two eggs could hatch into this stage. And then, these larvae died in this stage. Besides, all eggs died in this period at 36 °C. According to the results, it is possible to say that mass production of the predator in laboratory conditions can be more economical and rapid in between 26 and 28 °C.

Key words: Biological control, different temperatures, life table, predator, *Rhyzobius lophanthae*

Host range and suitability of six parasitoid species (Hymenoptera: Encyrtidae) and their implication to biological control of three invasive *Phenacoccus* spp. (Hemiptera: Pseudococcidae) in Israel

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During the last two decades, three American *Phenacoccus* spp. (Hemiptera: Pseudococcidae) were established in Israel, i.e. the solanum mealybug P. solani Ferris, the cotton mealybug *P. solenopsis* Tinsley, originated from North America and the lantana mealybug *P. parvus* Morrison, native to South America. All three species invaded different areas of the globe causing significant economic losses to various extents. In Israel, the main concern is related to damage caused to greenhouse crops, cotton fields (*P. solenopsis*) and ornamentals (*P. parvus* and P. solenopsis). Various species of parasitic wasps emerged from colonies of these Phenacoccus spp. sampled outdoors or examined in the lab. Among the six studied encyrtid species (Hymenoptera: Encyrtidae); *Anagyrus* sp. *nr pseudococci* (Girault), *Leptomastix ephyra* Noyes & Hayat and *Leptomastix algirica* Trjapitzin belong to the local fauna, whereas *Aenasius phenacocci* Ashmead, *Aenasius arizonensis* (Girault) and *Anagyrus californicus* (Compere) belong to the Nearctic fauna and are considered control agents of *P. solani* and *P. solenopsis*. *Anagyrus sp. nr pseudococci* often emerged from *P. parvus* in the wild and could be reared on P. solani in the lab; it suffers from heavy egg encapsulation by all three studied *Phenacoccus* spp. *Leptomastix ephyra* successfully developed on *P. solani* and *P. solenopsis*, although very few individuals actually emerged from *P. solenopsis*. Unlike the case of *P. solani* in which only about 5% of *L. ephyra* eggs were encapsulated, *P. parvus* caused 100% encapsulation. *Leptomastix algirica* could complete its development in all tested *Phenacoccus* spp. and similarly to *L. ephyra* successful development was observed on *P. solan*i with only about 5% of eggs encapsulated, whereas poor development was registered on the other studied *Phenacoccus* spp., with 95% egg encapsulation when *L. algirica* parasitized *P. parvus*. Both *Leptomastix* spp. could develop in the lab on *Phenacoccus peruvianus* Granara de Willink and *Phenacoccus madeirensis* Green; however, most of their eggs were encapsulated by the latter mealybug. *Leptomastix algirica*, but not L. ephyra, developed also on *Pseudococcus* cryptus Hempel, *Pseudococcus longispinus* (Targioni Tozzetti) and *Pseudococcus viburni* (Signoret), with about half of its eggs being encapsulated. *Leptomastix algirica* could not develop on species of other genera tested (*Ferrisia*, *Nipaecoccus* and *Planococcus*). *Aenasius phenacocci* was collected in California and released in Israel to control *P. solani;* this wasp was less reproductive in the lab and efficiently inferior in greenhouse trails than *L. algirica* and *L. ephyra*. Its development on *P. solani* was, in fact, much longer than the latter wasps and almost 70% of its eggs were encapsulated. In the lab, *A. phenacocci* could complete its development also on *P. solenopsis*, *Ps. longispinus* and *Ps. viburni*, al-

though only few offspring were obtained in these cases. *Aenasius phenacocci* niether develop on *P. parvus* nor on the other tested mealybug genera. *Aeanasius arizonensis* and *A. californicus* could be reared on both *P. solenopsis* and *P. solani*, although their performance was better on one of the mealybug species, respectively. The possible impact of this parasitoid complex on the pest situation of the three target *Phenacoccus* spp. in Israel will be discussed.

Keywords: *Phenacoccus*, parasitoid host range, physiological suitability, Israel

Isonet® PF, a new mating disruption product for the control of *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae)

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The vine mealybug (VMB) *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae) is a serious pest in grapevine-growing areas worldwide, such as the Mediterranean Basin, North and South Africa, the Middle East, California, Mexico and Argentina. Like other mealybugs, *P. ficus* feeds on the phloem of trunk, canes, leaves, clusters and roots of the grapevine and several other plants. It causes severe damage to table and wine grapes, affecting crop quality and yield with the production of a great amount of honeydew. This can accumulate on the clusters leading to the development of sooty mold fungi that reduces photosynthetic activity in leaves. In table grapes, any live or dead mealybugs together with the honeydew or sooty molds will cause aesthetic damage thus reducing the marketability of the grapes and increasing the risk of ochratoxin a contamination. *P. ficus* is also a vector of several viral diseases and is therefore considered an economic pest even with low levels of infestation.
The main active component of the vine mealybug sex pheromone was identified by Hinkens and coauthors 15 years ago as (S)-lavandulyl senecioate.
Experiments to test the efficacy of mating disruption (MD) against *P. ficus* started about ten years ago in California with Suterra sprayable microencapsulated formulations. Later on, Suterra reservoir dispensers were also used, both in USA and Europe.
In our research we applied a new reservoir dispenser, Isonet® PF, which was developed by Shin-Etsu Chemical Co. and CBC (Europe) S.r.l, and tested in collaboration with the University of Pisa. Trials carried out in vineyards in Castagneto Carducci (Livorno, Tuscany) and in Marina di Acate (Ragusa, Sicily) in 2014 and 2015 gave promising results, significantly lowering the mealybug density in the MD vineyards in comparison with “conventional” vineyards.

Keywords: Vine mealybug, pheromones, biological control

Nidularia pulvinata (Planchon) (Hemiptera: Kermesidae) urban outbreaks associated with entomopathogenic fungi

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Pest outbreaks often give to insect pathogens the opportunity to infect their host species eventually leading them to death. Recent *Nidularia* outbreaks off urban *Quercus ilex* L. showed some cases of entomopathogenic fungi virulence, apparently sustained by species of Fusarium and other fungi. Infection is apparent on the *Nidularia* population because fungi provoke the scale color shifting to orange or dull-green in medium in large patches. After the isolation in an axenic culture of the Kermesid-associate Mycota, ITS genomic regions amplified by PCR using the universal ITS5/ITS4 primers were sequenced by external service (Macrogen, Seoul, South Korea) for molecular identification.
Blast analysis (http://blast.ncbi.nlm.nih.gov/Blast.cgi) of the ITS sequence showed a high homology with *Quambalaria cyanescens* (de Hoog & G.A. de Vries) Z.W. de Beer, Begerow & R. Bauer 2006 (Fungi: Basidiomycota), (identity: 97-96%; e-value 0.0; coverage 82-75%), *Fusarium acuminatum* Ellis & Everh. 1895 (Fungi: Ascomycota) and *Fusarium avenaceum* (Fr.) Sacc. 1886 (Fungi: Ascomycota) (identity: 99%; e-value 0.0; coverage 82-80%), and *Penicillium sumatraense* Svilv. 1936 (Fungi: Ascomycota) (identity: 100%; e-value 0.0; coverage 95-91%). We investigate the biological and ecological role of the above-recorded fungi by correlating the age of infected scale and their age. Mass culturing of the most promising pathogen will lead to semi-field trials to demonstrate the isolate entomopathogenic ability.
Finally, we discuss the case of homonymy between the fungal Taxon named *Nidularia pulvinata* (Schwein.) (Gasteromycetes) and the scale *Nidularia pulvinata* (Planchon) that can lead to some confusion.

Keywords: urban greenery, urban entomology, entomopathogenic opportunistic fungi

Development and Life table parameters of predator *Rhyzobius lophanthae* Blaisdell (Coleoptera: Coccinellidae) on three armored scale insects (Hemiptera: Diaspididae)

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Citrus groving is one of the most important fruits cultivated in Turkey. Among all agricultural activities, plant protection processes such as the control of pest and disease are one of the major factors increasing crop yields. There are more than 150 pest species causing damage on *Citrus*. Scale insects are the most devastative pests among these species. *Rhyzobius lophanthae* Blaisdell (Coleoptera: Coccinellidae) is a polyphagous species regarded as one of the most important predators of armored scale insects.
The study investigated the age-specific life table parameters of the predator on three armored scale insects (*Aspidiotus nerii* Bouche (Hemiptera: Diaspididae), *Chrysomphalus dictiyospermi* (Morgan) (Hemiptera: Diaspididae) and *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae)). For this purpose, *Rhyzobius lophanthae* was fed on three different armored scale insects in a climatic chambers set to 26°C, 60% relative humidity and 16:8 (L:D) hours light period. Life table parameters of the predator groups were calculated with RmStat-3 according to Euler-Lotka equation.
Life table parameters of the predator three armored scale insects namely *Aspidiotus nerii*, *Chrysomphalus dictiyospermi*, *Aonidiella aurantii* was calculated as follows; the net reproductive rate (R0), intrinsic rate of increase (rm), mean generation time (T0) were found 36.027, 12.520 and 6.600 females/females/generation, 0.120, 0.061 and 0.041 females/females/day, 30.005, 41.151, and 45.826 days, respectively. The doubling time (DT) and finite rates of increment (λ) of the predator groups were calculated 5.803, 11.286 and 16.832 days, 1.127, 1.063 and 1.042 individual/females/day, respectively. Based on the results, it is possible to say that mass production of the predator in laboratory conditions can be more economically and rapidly on the armored scale insect, *A. nerii*.

Key words: *Aonidiella aurantii*, *Aspidiotus nerii*, *Chrysomphalus dictiyospermi*, life table, *Rhyzobius lophanthae*

The use of scale insects as biocontrol agents of weeds

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Scale insects (Hemiptera: Coccomorpha), principally known for their roles as invasive agricultural pests, directly affect crops by damaging fruit, and indirectly affect crops via by transmitting viruses. Though mostly polyphagous, some groups are host specific, and can be used as biological control agents against invasive exotic plants. We will present a detailed review of case studies that have illustrated the direct and efficient role of scale insects in reducing populations of invasive weeds. Using data collected from years of impact studies, we present the results of several projects including the impact of the armoured scale *Rhizaspidiotus donacis* Leonardi (Diaspididae) on rhyzomes and photosynthesis of giant reed in the U.S., and the potential role of *Ceroplastes sinensis* Del Guercio (Coccidae) on groundsel tree in France. The most common negative impacts are generally observed on upper parts of the target weeds with sooty molt covering leaves and shoots, but also on the root system by an intensive feeding activity of the scale colony. It is interesting to highlight that before the field release in Texas of *R. donacis*, armoured scales were never before used for biological weed control despite that over 200 pest species were reported from the family. Like leafhoppers and planthoppers, which despite their prominence as worldwide agricultural pests can also be used to control invasive weeds, we strongly support the idea that scale insects should be considered as potential candidates for weed biocontrol during field exploration surveys.

Keywords: Classical biological control, Coccids, diaspids, specificity,

SCALE INSECT PEST CONTROL

POSTER SESSION

Natural enemy associates of *Parthenolecanium* spp. (Hemiptera: Coccidae) in urban landscapes of southern United States

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*Parthenolecanium corn*i (Bouché) and *Parthenolecanium quercifex* (Fitch) (Hemiptera: Coccidae) are common pests of oaks (Quercus spp.; Fagaceae) grown as shade trees in urban landscapes in the southern United States. The natural enemies were surveyed in Virginia in the 1980s but its natural enemy assemblage across the entire southeastern United States is poorly understood. This study documented and compared the species composition, seasonal activity and impacts of parasitoids and predators of *Parthenolecanium* spp. in Georgia, North Carolina, South Carolina and Virginia. Twenty-one parasitoid species and twelve predator species were found associated with the lecanium scales. The parasitoid community in Georgia was different from those of the other states and the predator communities were different among the four states. Parasitism rates were 27–92% in South Carolina. Five main parasitoid species [*Blastothrix* sp. 1 (Encyrtidae), *Coccophagus lycimnia* (Walker) (Aphelinidae), *Encyrtus* sp. 1 (Encyrtidae), *Eunotus* sp. and *Pachyneuron* sp. (both Pteromalidae)] emerged from adults and parasitism by these species significantly reduced scale insect fecundity. *Coccophagus lycimnia* was the only parasitoid species that emerged from immature scales. Chrysoperla rufilabris (Burmeister), *Chilocorus stigma* (Say), *Hyperaspis signata* (Olivier) sp. group were the major predators. In the southeastern U.S., about 90% of the populations occurred from late March to late August for the parasitoids, and between late April to late October for the predators.

Keywords: integrated pest management, biological control, ornamental tree, predator, parasitoid

Effects of some entomopathogenic fungi on Citrus Mealybug *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae)

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Citrus Mealybug *Planococcus citri* (Risso) (Hemiptera: Pseudococcidae) is an economically important pest species causing harm to citrus growing and some ornamental plants in Turkey. This pest not only directly damage plants by sap sucking, but also cause indirect damage by secreting honeydew, virüs transporting and inducing the formation of sooty molds. Chemical control is rather difficult because of the wax layer on the insect. Fort his reason alternative control methods are important to control this species on different crops and ornamental plants. In this study, effects of *Beauveria bassiana* (Balls.) Vuill. (Hypocreales: Cordycipitaceae), *Paecilomyces fumosoroseus* (Wize) A.H.S.Br. & G.Sm. (Eurotiales: Trichocomaceae) and *Purpureocillium lilacinum* (Thom) Luangsa-ard, Houbraken, Hywel-Jones & Samson (Hypocreales: Ophiocordycipitaceae) against second instar larvae of citrus mealybug were investigated. Entomopathogens were produced on PDA plates and spore suspensions with 108 conidia/ml concentration were prepared. Potato tubers were dipped into spore suspensions and then infested with mealy bugs. Potatoes were then transferred to 10x10x5 cm plastic boxes and kept in a climatic room with 25±1°C temperature, 60±5% humidity and 16:8 hours light:dark conditions. Experiments were performed in completely randomized design with 5 replicates. Alive and dead mealybug individuals were counted 3, 5 and 7 days after applications. Abbott formula was used to calculate the efficiency of the applications. As a result, the three entomopathogens showed different rates of efficiency against the pest. *B. bassiana* isolate showed the highest effect and killed all pest individuals 5 days after the application. Efficiencies of *P. fumosoroseus* and *P. lilacinum* were lower in the first two observations, while they showed 95% and 75% efficiency on the seventh day, respectively.

Key words: *Beauveria bassiana*, *Paecilomyces fumosoroseus*, *Planococcus citri*, *Purpureocillium lilacinum*

Biological control of the vine mealybug *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae) on table grape vineyards in Murcia (Spain)

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Planococcus ficus (Signoret) (Hemiptera: Pseudococcidae) (VMB) is the pest that causes the most serious economic damage to table grape vineyards in Murcia (Spain), where it can lead to considerable yield losses especially inthe varieties Red Globe and Crimson.
Pesticides play a role in the mealybug management, although some compounds are not effective against mealybug colonies under the bark. Modern systemic insecticides also provide mixed results due to in appropriately timed applications.
Fortunately, a large number of natural enemies contribute to *P. ficus* control. The most successful biocontrol programs carried out against VMB have relied primarily on the release of the encyrtid wasp, *Anagyrus* sp. *nr. pseudococc*i (Girault) and the ladybird *Cryptolaemus montrouzieri* Mulsant.
This study summarizes the project carried out in Murcia over the last few years, by releasing the two afore mentioned natural enemies into organic table grape vineyards in Alama.
Approximately 1,000 adults per hectare of *A.* sp. *nr. pseudococci* were employed in 2-3 subsequent releases, starting from the end of April. In addition, about 500 *C. montrouzieri* adults per hectare were released in June, distributing the insects in such a way as to protect the areas of the vineyard withthe highest infestations.
In addition to the release of natural enemies, appropriate agricultural practices and the management, through “ad hoc” traps, of the ant populations occurring in the plot, which couldhave impactednegativelyon the releases, contributed decisively tothe effective control of VMB.

Keywords: Encyrtidae, Coccinellidae, parasitoid, predator, natural enemies

Synthesis of mealybug sex pheromones and their field mating disruption application

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Sex pheromones of some mealybug species (Hemiptera: Pseudococcidae), such as the Vine mealybug (*Planococcus ficus* Signoret), the Japanese mealybug (*Planococcus kraunhiae* Kuwana), the Passionvine mealybug (*Planococcus minor* Maskell) and the Grey pineapple mealybug (*Dysmicoccus neobrevipes* Beardsley) are irregular monoterpene esters, possessing the common C-10 framework. Synthesis of these pheromones has been studied toward synthetic process suitable for industrial scale-up in order to supply sufficient amounts of the active ingredients for actual application in the field.
Polymer tube dispensers were designed and manufactured for controlled release of the synthetic pheromones, and field mating disruption (MD) trials have been conducted in Europe, South Africa and Japan since 2013. MD efficacy was demonstrated through clean trap shutdown of males, suppression of populations, and damage reduction in crops.
Pheromone-based MD of mealybugs would be one of the promising tools for IPM for these annoying hemipteran pests.

Key-words: mealybug, pheromone, industrial synthesis, mating disruption

The vine mealybug, *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae) in Emilia Romagna (Italy): state of the art and control strategies

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Planococcus ficus (Signoret) (Hemiptera: Pseudococcidae) is widespread all over the world and causes damages due to honeydew, virus transmission and negative effects on winemaking. This species is steadily increasing, among the reasons of its outbreaks there are favorable climatic and agronomic conditions.
In Emilia Romagna region, *P. ficus* has 3-5 generations per year and overwinters on vine as 2nd and 3rd larval instar and adult. It is a phloem-sap feeding species, its reproduction is amphigoric although suspected parthenogenetic reproduction was observed. Females live a few months and can lay more than 700 eggs. Males live 1-3 days and mate multiple times during their lifetimes with different females. In Italy vine and fig were reported as host of *P. ficus*, but it was observed on approximately 20 plants in other countries. The species is characterized by rapid outbreaks causing severe damages on plants and grapes.
The control in Italy is based on organophosphate insecticides (in particular chlorpyrifos-methyl -MoA 1B), neonicotinoids (thiametoxam-MoA4A) or IGR (buprofezin - MoA16, type 1) and recently ontetramic acid derivate (spirotetramat -MoA23). By preliminary assays here reported, Spirotetramat proven to be the most effective and persistent. Early application and large volume of insecticide solution provided the best results.

Keywords: *Planococcus ficus*, behavior, control, Italy

Observations on microorganisms infecting *Kermes quercus* (Linnaeus) (Hemiptera: Kermesidae)

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Histological observations on larvae and adult females of *Kermes quercus* (Linnaeus) (Hemiptera: Kermesidae) have revealed that they were infected by yeast-like microorganisms. These microorganisms were localised inside fat body cells in large number. They were not observed in other organs (such as ovaries, midgut) or in eggs. The yeast-like microorganisms harbored in the fat body cells are reproduced by budding. The presence of these microorganisms in the body of females of *K. quercus* did not cause any damage to the structure of the ovaries and the course of oogenesis. Females infected by them produced about 1300 crawlers. The mode of yeast-like microorganism transmission between generations of *K. quercus* is unknown. However, the lack of these microorganisms in the cytoplasm of eggs indicates that there is not a transovarial transmission from the mother to the progeny.
The role of yeast-like microorganisms to their host insects remains unknown - it may be pathogenic or beneficial. Since we never observed the negative influence of these microorganisms on the morphology of their internal organs and rate of reproduction, we suggest that they may represent the newly acquired symbionts.

Keywords: Kermes, yeast-like microorganisms, fat body cells

Those strange black matter with armoured scale insects (Hemiptera: Diaspididae) embedded

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While studying *Septobasidium* interaction with Diaspididae off *Laurus nobilis* L. (Lauraceae), *Phillyrea latifolia* L. and *P. angustifolia* L. (Oleaceae) in Apulia we found small - 1 to 3 millimetre - brown/black particles on plant bark. Each particle embeds or lays one or more dead armoured scales belonging to *Aonidia lauri* (Bouche) or *Lepidosaphes flava* (Signoret), depending on the host plant. The brown-black bodies were irregularly hemispheric, lobated and dull in appearance. We report the results of observations by light microscopy, SEM and X-rays microanalysis of foamy black matters that constitute most of the particles and embeds the scale. Findings of hyphae (?) inside the dead insect bodies in connection to Diaspidid scale phenology at the time of death suggest that the particles result from an entomopathogenic or saprophytic interaction.

Keywords: Mediterranean woods, symbiosis.

Potential for management of *Protopulvinaria pyriformis* (Cockerell) (Hemiptera: Coccidae) in organic avocado in eastern Sicily, Italy

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Organic avocado (*Persea americana Mill.* (Lauraceae) farming is a growing industry in eastern Sicily, and in this environment *Protopulvinaria pyriformis* (Cockerell) (Hemiptera: Coccidae) is a key pest. Biological control strategies against this invasive scale are thus crucial for the sustainability of this cropping system. A field trial was performed to record the natural enemy complex in early autumn, and for comparing the efficacy of a paraffinic oil application (Biolid E® at 2L/ha), of the release of adults (1/m2) of the predator *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae), and of their combined application, i.e. oil spray and after one week predator release. In the pretreatment sampling a high proportion of ovipositing female, 38.64% of the entire population, was recorded. The natural parasitoid community of *P. pyriformis* consisted of two primary parasitoids and one facultative hyperparasitoid species. *Metaphycus helvolus* (Compere) (Hymenoptera: Encyrtidae) accounted for 81% of the parasitoids recovered; *Microterys nietneri* (Motschulski) (Hymenoptera: Encyrtidae) for 8%, and the secondary parasitoid *Pachyneuron muscarum* (L.) (Hymenoptera: Pteromalidae) for 11%. The mean percentage of parasitism recorded was 2.45%, however, an encapsulation rate of 1.78% was also observed. Adults and larvae of generalist predators belonging to the genera *Scymnus* spp, *Exochomus* spp. (Coleoptera: Coccinellidae) and larvae of *Chrysopa* spp. (Neuroptera: Chrysopidae) were also noticed actively feeding on immature stages of the soft scale. The number of live scales (N2-oviposting females) was reduced by 54.16, 55.73 and 19.58 % following the oil application, the oil plus predator release and predator alone, respectively. While, in the control plots the number of live scales increased by 23.4%, and no changes in the presence of natural enemies was recorded in the sprayed plots. The recorded data suggest that any pesticide application should take into account and thus respect the activity of the rich natural enemy assemblage. In addition, artificial releases of *C. montrouzieri* were not able to effectively control the scale population.

Keywords: Pyriform scale; natural enemies; Coccinellidae; Encyrtidae; IPM

Red scale in Sicily citrus orchard now is under effective biological control

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Almost all citrus, in the Sicilian island, is grown for fresh market, which requires pesticides in order to ensure yield and prevent cosmetic damage on fruits. *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) is considered as one of the most concerning citrus pest in this area. Growers mostly used organophosphates such as chlorpyrifos. However, by the late 1990s, they began to realize the importance of pesticidal effects on secondary pests and their natural enemies. Changes and improvements in pests management approaches have occurred in response to the spectacular invasion of Citrus leafminer and pest outbreaks (i.e. the woolly whiteflies *Aleurothrixus floccosus* (Maskell) (Hemiptera: Aleyrodidae) as the consequence of secondary effects of some very disruptive pesticides used for the control. In order to enhance the biological control in our orchards, we built a mass-rearing facility for production of the red scale parasite *Aphytis melinus* Debach (Hymenoptera: Aphelinidae). During the period 2007/2015 the wasps were released in about 3,000 hectares orchards. The activity of the secondary pest Argentine ants, *Linepithema humile* (Mayr) (Hymenoptera: Formicidae) has been prevented from climbing trees by skirt pruning and the selective use of sticky materials applied on top of a tree wrap to the bark as well as with chlorpyrifos treatments. Unfortunately, the chlorpyrifos trunk treatment became very popular. Finally a monthly Citrus IPM newsletter was prepared and sent to about 500 stakeholders. Now in Sicily, especially Tarocco orange growers can purchase *A. melinus* wasps to control *Aonidiella aurantii*.

Keywords: *Aonidiella aurantii*, Citrus ants, *Aphytis melinus*, augmentative release

Isoclast™ active: efficacy against scale insects in citrus

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Isoclast™ (sulfoxaflor, Closer™), which was developed by Dow AgroSciences Research, is a new insecticide belonging to the sulfoximine chemical family. Sulfoximines are active on the nicotinic acetylcholine receptors, but have characteristics that distinguish them from other insecticides that act on the same receptors (Sparks et al., 2012).
Isoclast™ has a unique mode of action and is not a neonicotinoid. IRAC has classified Isoclast™ mode of action in the new subgroup 4C of sulfoximine. Isoclast™ is extremely effective against many sap-feeding insects, including scales, mealybugs, aphids, whiteflies and plant hoppers, in all major crops, such as pome fruits, stone fruits, citrus, vegetables and ornamentals.
Between 2011 and 2013, field trials were carried out in citrus orchards, in southern Europe (Greece, Italy and Spain), in order to evaluate the efficacy of Isoclast™ against the red scale, *Aonidiella aurantii* (Maskell) (nine trials) and the citrus mealybug, *Planococcus citri* (Risso) (six trials).
In general, Isoclast™, applied once at 48 g. a.i./ha or twice at 24 g. a.i./ha, provided good control of both *A. aurantii* and *P. citri*, comparable to the standard insecticides, spirotetramat (150 g a.s./ha) and pyriproxifen (60 g a.i./ha).
Isoclast™ is an ideal tool for use in Integrated Pest Management, due to its high efficiency combined with a prolonged activity against many sap-feeding insects which are resistant to neonicotinoids and other classes of insecticides, and also to its favourable toxicological and ecotoxicological profile.

Keywords: sulfoximine, Isoclast™, sulfoxaflor, scales, *Aonidiella aurantii*, *Planococcus citri*

Isoclast™ active: efficacy against scale insects in stone and pome fruits

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Between 2011 and 2013, field trials were carried out in Europe (Italy, Greece, Spain and France), in stone and pome fruits orchards, in order to evaluate the efficacy of Isoclast™ against *Pseudaulacaspis pentagona* Targioni Tozzetti (12 trials), and *Comstockaspis perniciosa* (Comstock) (9 trials).
In general, Isoclast™, applied once at 48 g. a.i./ha or twice at 24 g. a.i./ha, provided good control of both *C. perniciosa* and *P. pentagona*, comparable to the standard insecticides, spirotetramat (150 g a.i./ha) and pyriproxifen (60 g a.i./ha).
Isoclast™ is an ideal tool for use in Integrated Pest Management, due to its high efficiency combined with a prolonged activity against many sap-feeding insects which are resistant to neonicotinoids and other classes of insecticides, and also to its favourable toxicological and ecotoxicological profile.

Keywords: sulfoximine, Isoclast™, sulfoxaflor, scales, *Comstockaspis perniciosa*, *Pseudaulacaspis pentagona*

Induced responses of *Bougainvillea glabra* Choisy (Nyctaginaceae) against *Phenacoccus peruvianus* Granara de Willink (Hemiptera: Pseudococcidae) attack: preliminary results.

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Plants are frequently attacked by herbivores and therefore have acquired constitutive and induced defenses during the course of their evolution. Primary and secondary metabolites have been implicated in plant defense against insect pests. Oxidative stress, resulting from the generation of reactive oxygen species (ROS), such as superoxide, hydrogen peroxide andhydroxyl radicals, is a common phenomenon in many plant defense against insect attack. Catalase, which degrades H2O2 into water and oxygen, is one of the major involved antioxidant enzymes. The effectiveness of oxidative defense system in plants can be measured by the activities of antioxidant enzymes and by the levels of non-enzymatic antioxidants. Malondialdehyde (MDA) is generally taken as a tool to assess the severity of the oxidative stress and the degree of plant sensitivity towards ROS induced oxidation. Proline may protect protein structure and membranes from damage, and reduce enzyme denaturation.
As well, phenylpropanoid pathway is an important pathway to produce secondary plant metabolites and phenylalanine ammonia lyase (PAL), as a key enzyme, catalyzes the deamination of phenylalanine to cinnamic acid, the entry and key regulatory step into the phenylpropanoid pathway.
In the present study, plants of *Bougainvillea glabra* Choisy (Nyctaginaceae) were artificially infested with the obligate phloem-feeding pest *Phenacoccus peruvianus* Granara de Willink (Hemiptera: Pseudococcidae), introduced to Mediterranean basin since 1999 (in Sicily 2002), and compared with control, uninfested plants. Leafsamples were taken at 2, 6, 12, 24, 48, 96, 144 hours after infestation and also after a longer period, many months later, to monitor the plant response. Pro, MDA, Chla, Chlb and Chla+b, Car, CAT and PAL activities were measured at each sampling date.
Proline, MDA, CAT and PAL assays showed a higher content at longer period in the infested samples. Regarding Chl, collected data did not show any significant difference between infested plant and control.
However, these preliminary results appear significant in understanding of Bougainvillea plant defense against mealybugs because any information are not reported in the literature. Further analyses concerning other enzymatic and molecular responses are necessary.

Keywords: Ornamental plant, Mealybug, Proline, Chlorophyll, Enzymatic assays.

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