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Sex-pheromones

Mate location and sexual maturity of adult male mealybugs: narrow window of opportunity in a short lifetime

Elsa Borges da Silva, Joana Mouco, Rita Antunes, Zvi Mendel, José Carlos Franco... 3-9

Abstract: The identification of sex pheromones of several mealybug species has facilitated the development of monitoring techniques and management tactics based on these compounds. However, experience shows that the efficiency of tactics such as mass trapping, mating disruption, and lure and kill may be constrained by a lack of knowledge of basic features of the life history and mating behaviour of male insects and the mechanisms involved in their interactions with pheromone sources. Unlike neotenic adult females, male mealybugs are active fliers, do not feed and live only a few days. We study the time a male mealybug invests in mate location and mating. We tested the amount of time needed for a male of the citrus mealybug, *Planococcus citri* (Risso) to reach sexual maturation in a Petri dish. The response of males of different ages to a synthetic pheromone and virgin females was tested. Males from three different age classes (I- up to 10 hours after eclosion; II- 10-29 hours after eclosion; III- 29 or more hours after eclosion) were exposed to 100 ng of pheromone or a virgin female and the occurrence of a clear response, with copulation behaviour within 30 minutes of exposure, was noted. The insects' survival rate, in terms of time, was also determined. In a parallel study, we also examined daily flight activity rhythms based on the number of male mealybugs captured each hour in pheromone traps in a citrus orchard. In the Petri dish bioassay, no class I males and less than 20% of class II males responded to the pheromone or virgin females. On the other hand, most of class III males presented a clear response. Data suggest that, after eclosion, most *P. citri* males need to complete a period of sexual maturation of at least 30 hours before they can respond to the sex pheromone and mate. Without mating, the maximal lifespan of males was approximately five days and 50% of males lived only up to 4.4 days ($25.0 \pm 0.5^{\circ}\text{C}$). Therefore, we estimate that most *P. citri* males have less than three days to find a receptive female and mate with her. However, since *P. citri* males only fly within a period of approximately four hours after sunrise, the total effective time available for mate location by flight is actually only less than 12 hours.

Codling moth, *Cydia pomonella* (L.), canopy distribution and implications for mating disruption applications

David Epstein, Larry Gut, James Miller, Lucasz Stelinski 11-15

Abstract: Studies aimed at determining the location of searching codling moth (*Cydia pomonella* [L.]) (Lepidoptera, Tortricidae) males and calling females in mating disrupted and non-disrupted plots and the effects of varying mating disruption dispenser height in the tree canopy were conducted in Michigan, USA in 2005 through 2007. Moths were sampled 4 times during the hours of 09:00-18:00 from May 25, 2005 through June 15, 2005 and a second series of four collections were completed during the hours of 18:00-22:00 from July 20, 2005 to August 22, 2005. Only eight codling moth adults were collected during the four daylight samples. Twilight vacuum samples resulted in significantly higher moth captures ($p < 0.001$) than daylight samples. Ninety-four moths were collected during four evening samples, with equal numbers sampled in disrupted and non-disrupted plots. In mating disruption plots, 42% of females were found in the top third of the tree canopy, 46% were found in the middle third, and 12% were recovered in the lower third. There was no significant difference between females captured from the top third as compared to

the middle third of the canopy in disrupted plots ($p < 0.827$), but there were significantly more females in the top third compared with the lower third ($p < 0.052$) and significantly more females in the middle third compared with the lower third ($p < 0.033$). No significant differences in canopy height distribution of 22 females sampled from non-disrupted plots were found, with 36.4% in the top third, 36.4% in the middle third, and 27.2% in the lower third of the tree canopy. Releases of marked moths were conducted in 2006 and 2007 in screened tents to identify daytime habitats for adult moths within the orchard. Of moths recaptured, 21% of females and 34% of males were recaptured from the ground (herbicide strip and drive-row grass) after 16 hours, 40% of females and 8% of males from the ground after 40 hours, and 52% of females and 24% of males from the ground after 64 hours. In the dispenser height study, traps placed high in the tree canopy captured greater numbers of male moths at all dispenser heights (2m, 4m and a combination of 2m and 4m), with the fewest moths captured where both traps and dispensers were placed high in the tree. Mating of virgin female moths was highest when moths were tethered at 2m high in the tree of a 4m high dispenser placement treatment and when moths were tethered 4m high in the tree of a 2m high dispenser placement treatment. Overall, mating of females was lowest where dispensers were placed at a combination of heights, 2m and 4m.

CIRCE – an addition to the toolbox for assessment / improvement of mating disruption

Uwe T. Koch, Eric Doye, Klaus Schumann, Ulf Andrick 17-24

Abstract: A field test for pheromone formulations intended for use in mating disruption is described. It consists of a pair of cages, one of them placed in a treated area, the other in an untreated control field. Male insects are released in these cages, and caught in traps baited with females. By comparing the fraction of males caught in the treated compared to the control, the effectiveness of the formulation can be assessed. By removing the dispensers from the test area and placing them around the control cage, the role of test and control are exchanged and differences in cage properties are cancelled out. The variable actually measured is the suppression of mate finding, usually termed as communication disruption. Since complete communication disruption is a necessary condition for the success of a mating disruption treatment, this method is capable of measuring the essential function of a pheromone treatment under realistic field conditions. The advantages of this method over classical field tests are evident: highly significant results in a few weeks, with no interference by weather conditions, population density and beneficial organisms. A wide range of questions in mating disruption is proposed which now can be investigated with reasonable cost and time.

Mating disruption of the oriental fruit moth by concentrated applications of micro-encapsulated pheromone in Turkey

Orkun Baris Kovanci, Nimet Sema Gencer, Tom Larsen, Alan Knight 25

Abstract only

Mating disruption of codling moth, *Cydia pomonella* (L.), using Isomate C plus dispensers in apple orchards of Bulgaria

Hristina Kutinkova, Jörg Samietz, Vasilij Dzhuvinov, Pierre-Joseph Charmillot, Vittorio Veronelli 27-32

Abstract. Codling moth, *Cydia pomonella* (L.) (Lepidoptera: Tortricidae), is an important pest of pome fruit and walnut orchards throughout the world and the respective key pest in Bulgaria. Codling moth resistance to many insecticides has been recently detected in Bulgaria. As part of anti-resistance strategy mating disruption with Isomate C plus dispensers (ShinEtsu, Japan) was tested against codling moth (CM) in the two consecutive years 2006 and 2007. In both years Isomate-C plus dispensers inhibited completely the CM captures in the pheromone traps installed in the experimental plot. This indicated that mating disruption was very successful. Before harvest, damage stayed there at in a low level – 0.06% in 2006 and 0.5% in 2007. As comparison in the conventionally treated orchard, eleven to fifteen treatments (17-23 active ingredients) were applied during the season to control CM, leaf miners, leaf rollers and San Jose scale. Eight to fourteen of them (14-21 active ingredients) were timed against codling moth. In spite of that, fruit damage before harvest reached 3.4% in 2006 and 5.2 in 2007. The overwintering population in autumn 2006 reached 1.1 larvae per tree, but increased to 3.3 larvae per tree in 2007. CM

population in the conventionally treated orchard was apparently resistant. The results of this investigation will open the possibilities for usage of the pheromone dispensers as an alternative measure to control codling moth in Bulgaria. This should promote ecological fruit products and preservation of the natural environment, in accordance with the European standards for integrated fruit production. The studies are being continued.

Sustainable codling moth mating disruption in diverse agricultural environments

Peter McGhee, David Epstein, Donald Thomson, Larry Gut 33-39

Abstract: A three year research project in Michigan apple demonstrated that the deployment of area-wide codling mating disruption (AW-CMMD) resulted in significantly better control of codling moth than did mating disruption applied to individual blocks (CMMD) or blocks not treated with mating disruption (No-CMMD). Pheromone baited traps were deployed at 1 per ha over 850 ha of AW-CMMD, 20 ha CMMD, and 20 ha of No-MD. The average capture of CM in AW-CMMD declined while levels remained steady or increased respectively in the CMMD and No-MD programs. Injury to fruit and the overall number of insecticides targeting CM decreased each year in the AW-CMMD program while injury remained the same in CMMD orchards and increased significantly in the No-MD orchards.

The use of pheromone mating disruption technique for the control of *Ostrinia nubilalis*: preliminary research and field applications.

Fabio Molinari, Andrea Iodice, Piergiorgio Cappellaro, Carlo Bassanetti, Paolo Sambado, Manuela Cigolini, Matteo Anaclerio, Francesco Savino 41-44

Abstract: With the aim of finding out new means for controlling the European corn borer (ECB), but with low environmental impact, during the years 2003-2006 studies were carried out in order to verify the possibility of applying mating disruption (MD) on *Ostrinia nubilalis*. Capillary type dispensers from Shin-Etsu Chemical Co. Ltd containing the insect pheromone blend E11-14Ac: Z11-14Ac (50:50) were utilized. In 2003-2004 the application was on seed corn and cow food corn with no additional insecticides, instead on 2005, 2006 and even on 2007 the trials were conducted on sweet corn with or without additional insecticides. On cow food corn, control plot was with no insecticide spray whereas on sweet corn the efficacy comparison was done with standard farm strategy plots and, where possible, no insecticide plots. The best results were obtained on seed corn, where the MD application determined reduction of damages to one third. On sweet corn, where pheromone applications were integrated with Bt spray, results were unsteady. The efficacy were greatly affected by initial pest population pressure of the target insect. Other factors that played an important role were the possible difficult movement of the pheromone inside the corn vegetation that may have lead to a non homogeneous distribution of the compound. Although MD against *O. nubilalis* can be a possible tool to reduce the reproductive potential of the target pest, its possible application and integration with standard control strategies needs further investigation.

Use of mating disruption for *Zeuzera pyrina* control

Maria Isabel Patanita, Enrique Vargas 45-51

Abstract: Sex-pheromone mating disruption can be an effective method for the control of *Zeuzera pyrina*. Investigation on mating disruption began in the 90`s and continued in the last decade. In this study we tested the efficacy of this method in walnut orchards. An experiment was carried out at Monte da Raposinha (Beja, Portugal) from 2002 to 2004. An area of 10.5 ha was treated with mating disruption and a 2 ha plot was used as control. In the treated area, the number of larvae and pupae in branches was reduced by 98% compared to the control. The percentage of trees with larval galleries was also significantly reduced by the pheromone. While a 97% (3.5% to 0.1%) decrease in branch damage was recorded in the treated plot, an increase up to 70% (6.1 to 20%) was found in the control. These results showed that, at the population level of this study, mating disruption was a highly effective method for the control of *Z. pyrina*.

Commercial use of codling moth mating disruption: a success story despite the limitations

Don Thomson, Jay Brunner, Jack Jenkins, Larry Gut 53-60

Abstract: Forty years have past since the first publication demonstrating the potential of deploying sex pheromones for insect pest control. Following that landmark paper, extensive research has focused on the development of control tactics that employ synthetic copies of insect sex pheromones to control a wide variety of pests in agriculture and forestry. These tactics include attract-and-kill, mass trapping, and mating disruption. Sex pheromone-mediated mating disruption is the tactic that has emerged as a commercial success, most notably for the control of lepidopteran pests in pome and stone fruit, grapes, tomatoes and cotton. Cardé and Minks (1995) identified constraints to the successful use of mating disruption in moth pest control including: the inherent population dynamics of the pest, the complexities of the mating system and the limitations imposed by management systems. They went on to argue that these limitations were the main reason why mating disruption could not be successfully implemented for all species. Pink bollworm, oriental fruit moth and tomato pinworm were held up as very amenable targets for the approach, with levels of control similar or better than that achieved with insecticides. Codling moth control using mating disruption was considered more problematic. For codling moth, Cardé and Minks (1995) stated that the technical reliability of the mating disruption technique had not been fully achieved and therefore, the routine large use of the mating disruption technique was not yet possible. They specifically identified 3 limiting factors including the need for: (1) low populations, (2) a high degree of isolation from adjacent non-pheromone treated orchards and (3) a limited number of generations per year. Despite the concern that these limitations might preclude wide-scale adoption of mating disruption for codling moth, substantial progress had been made. In 1991, Isomate[®]-C became the first mating disruption product registered for the control of codling moth in the United States. The use of Isomate C and other codling moth mating disruption technologies soon gained acceptance in other apple producing regions. Codling moth mating disruption is now deployed to a lesser or greater degree in many countries around the world including Australia, parts of the European Union, South Africa, Argentina, Chile, Mexico and the United States. It is now estimated that codling moth mating disruption is used on approximately 162,000 hectares. It is deployed most widely in the western states of the USA, parts of Europe and areas of South America. In states such as Washington and California and the South Tyrol region of Italy, codling moth mating disruption is now deployed on well over 50% of the pome fruit hectares and is considered an integral part of pest management practices for this pest. It is important to understand why it has been so successful and adopted so widely in many highly prolific fruit growing areas. In this article, we will not only address the technical progress that has been made vis a vis formulation development and progress towards a better understanding of the mechanisms of disruption, but we will also discuss the other possible driving factors in different regions of the world that have expanded or curtailed adoption of codling moth mating disruption. Finally, we will discuss how this information might be used to develop more cost effective formulations and what impact this will have on wider adoption.

Opportunities and limitations of mass trapping of difficult-to-control fruit pests: efforts in Hungary

Erzsebet Voigt, Miklos Tóth 61-66

Abstract: a basic requirement of mass trapping is the availability of high capacity trap designs using highly active attractant bait, mass trapping can be advised to be attempted only in special cases against certain pests, mass trapping can be attempted in cases when the traps catch the damage-causing life stage (i.e. the adult in case of scarabs), or when the target pest is not a good flier (i.e. *Cossus cossus*). If the bait is a sex pheromone, only males can be trapped, in the hope of decreasing male numbers to an extent which results in lack of fertile matings with females, despite the fact that in case of scarabs the traps capture very high numbers, a part of the population remains not trapped.

Host volatiles

Odour signals for detection and control of indoor pyralid moths

Olle Anderbrant, Camilla Ryne, Edyta Sieminska, Glenn P. Svensson, P.-O.

Christian Olsson, Erling Jirle, Christer Löfstedt 69-74

Abstract: Three pyralid moths, the Mediterranean flour moth (*Ephestia kuehniella*), the almond moth (*Ephestia cautella*) and the Indian meal moth (*Plodia interpunctella*), infest food products all over the world and cause severe problems in factories, shops and households. For health and environmental reasons chemical control becomes more and more restricted. We here present some promising results offering efficient detection and control of these species based on semiochemicals, and line up a number of remaining questions to be answered in order to improve the reliability and competitiveness of the methods used. For *P. interpunctella* and *E. cautella* we found that more complex pheromone blends were superior to the commercially available one-component blend in attracting males, and should be used if increased sensitivity is desired. The almond moth, males as well as females, can be trapped in buckets with tap water, which will give an estimate of the population level without use of pheromone traps. All three species show positive response to odours identified from chocolate, and this could possibly be developed further and used to determine relative population densities. For population suppression the pheromone-mediated mating disruption technique was employed in localities with infestations of all three species. Based on several indirect methods to estimate the population densities we conclude that this technique has a large potential for controlling all three moth species.

Development of semiochemical attractants, lures and traps for raspberry beetle, *Byturus tomentosus* at SCRI; from fundamental chemical ecology to testing IPM tools with growers

A. Nicholas E. Birch, Stuart Gordon, Carolyn Mitchell, Tom Shepherd, Wynne

Griffiths, Graham Robertson, Rex Brennan 75-78

Abstract: Raspberry beetle adults are attracted to flowers of their hosts primarily by colour and odour (floral volatiles). SCRI scientists have investigated this chemical ecology interaction for several years, using a multi-disciplinary approach involving phytochemistry, insect behaviour, and GC-EAG electrophysiology. We will present a historical overview, explaining how these techniques have allowed us to identify the key flower attractants from a complex mixture of volatiles emitted by raspberry flowers and then go on to explain how recent (EU CRAFT, Horticulture Development Council) and current (Defra Hortlink) work has progressed the optimization of raspberry beetle traps for U.K. growers needing IPM solutions due to demands for zero pesticide residue levels on fruit. We will explain how we are developing and testing slow release lures and different trap designs, together with collaborators at East Malling Research, Natural Resources Institute, Agrisense Ltd and also with Norwegian scientists, testing prototype traps on organic soft fruit farms.

Kairomonal response of a parasitic wasp to the sex pheromone of the vineyard mealybug

Elsa Borges da Silva, Taiadjana Fortuna, José Carlos Franco, Leonor Campos,

Manuela Branco, Anat Zada, Zvi Mendel 79-82

Abstract: The attraction of *Anagyrus* sp. nov. near *pseudococci* (Girault) (Hymenoptera: Encyrtidae) to the female sex pheromone of its major hosts, the citrus mealybug, *Planococcus citri* (Risso), and the vine mealybug, *Planococcus ficus* (Signoret) (Hemiptera, Pseudococcidae), was investigated. The response of the parasitoid to the pheromone was tested in the field, with pheromone traps set in citrus and fig orchards and vineyards, and in the laboratory, using static air olfactometer bioassays. In both the field and laboratory experiments, the female wasps were attracted to the sex pheromone of *P. ficus*, (*S*)-lavandulyl senecioate. The wasps did not respond significantly to the sex pheromone of *P. citri*. Despite the similarity between the structures of (*S*)-lavandulyl senecioate and (*S*)-lavandulyl isovalerate, the parasitoid did not respond to the latter compound.

A bioassay-based approach for the evaluation of host-plant cues as oviposition stimuli in grapevine moth

Marco Tasin, Gianfranco Anfora, Elisabetta Leonardelli, Claudio Ioriatti, Andrea Lucchi, Antonio De Cristofaro, Ilaria Pertot 83-86

Abstract: Grapevine moth *Lobesia botrana* is a severe agricultural pest of grape. It lays eggs on grape at different phenological stages. Little is known about the sensory cues guiding oviposition behaviour. The aim of this study was to set-up an oviposition dual choice bioassay in which the effect of single and combined sensory cues could be evaluated. To this end, plastic devices were used in order to provide the moths with different combinations of host signals (O=olfaction, V=vision, C=contact). In a test where females could choose between OV and O stimuli, moths laid a significant higher number of eggs on the OV device, showing a possible influence of vision. However, when olfaction and vision were compared with only vision (OV vs V), females preferred the first option, indicating a possible effect of olfactory cues on oviposition. When a visible grape in a cup was compared with a hidden grape (V vs blank), females did not exhibit any preference. According to this result, visual cues may become a strong stimulus only when co-occurring with odours. Results from these experiments showed that the bioassay may be employed as an useful tool for studying how the different host-cues drive oviposition.

Oviposition response of grapevine moth to microorganisms isolated from grape

Marco Tasin, Carmela Sicher, Ilaria Pertot 87-89

Abstract: Oviposition choice experiments were done to examine the behavioral response of gravid *L. botrana* females to healthy or microorganism inoculated grape. In a first experiment, a healthy and a fungus (*Botrytis cinerea*) infected grape were compared. Females laid a significantly higher number of eggs on the healthy grape. This behaviour was observed also when the contact cues from the grape were not accessible to the insects. Conversely, moths exhibited a preference for a grape inoculated with a pool of grape-born yeast, either grown on a medium or on grape berries, over a healthy grape. Volatiles compounds released by the grape-microorganisms system encoded for attraction or repellence to gravid grapevine moth females.

Chemical communication of European cabbage flea beetles (Coleoptera: Chrysomelidae, Halticinae): overview of research in Hungary

Miklós Tóth, Éva Csonka 91-99

Abstract: In the past years both host-plant related and pheromonal chemical communication of this economically important beetle group was studied at our laboratory. As for host-plant related communication, first the species spectrum of flea beetles responding to allyl isothiocyanate was studied. This plant-derived compound has been described in the literature to attract *Phyllotreta cruciferae* and some other flea beetle species. In our field tests conducted in Hungary, Slovenia and Bulgaria, the attraction of *Ph. vittula*, *Ph. undulata*, *Ph. nigripes*, *Ph. nodicornis*, *Ph. balcanica*, *Ph. atra*, *Ph. procera*, *Ph. ochripes*, *Ph. diademata* and the closely related *Psylliodes chrysocephalus* (Coleoptera, Chrysomelidae, Halticinae) was demonstrated for the first time, while the attraction of *Ph. cruciferae* was strongly confirmed. These species include 6 important agricultural pests. At all sites a great portion of the catch (ranging from ca 30 to 98%) was *Ph. cruciferae*, irrespective of the plant culture. The second most abundant species present at most sites was *Ph. vittula*, which damages not only Cruciferae, but also monocotyledonous plants like maize or cereals, and thus appears to be of outstanding economic importance. When studying several synthetic isothio- and thiocyanates, *Ph. vittula* responded much better to 3-butenyl isothiocyanate than to allyl isothiocyanate, while *Ph. cruciferae* catches were always greater in allyl isothiocyanate baited traps. This suggests that there are significant differences in host-plant related chemical communication of these two important flea beetle pests. Several male-specific pheromone candidate compounds have recently been identified from North American populations of *Ph. cruciferae* by Robert J. Bartelt's team (Peoria, USA). In joint research with the Bartelt team we managed to show that traps baited with a mixture of these compounds was only slightly active when presented alone, but it significantly increased catches when presented together with allyl isothiocyanate. In tests with optically pure synthetic compounds, a blend of the optically pure compounds present in the male beetles was as attractive as the blend of racemic compounds, but a blend of the opposite enantiomers was not active. Through subtraction tests it was found that

the single compound, (6*R*,7*S*)-2,2,6,10-tetramethylbicyclo[5.4.0.]undeca-9,11-diene (compound A), had the same level of activity as the whole mixture, suggesting that this compound was a key pheromone component. We demonstrated the presence of the same male-specific compounds in volatiles from European populations of *Ph. cruciferae*, from *Ph. vittula* and some other *Phyllotreta* spp. Catches of *Ph. vittula* in traps with 3-butenyl isothiocyanate were synergized by the addition of compound A in a similar way as those of *Ph. cruciferae* for allyl isothiocyanate baited traps. It may be possible in the future by careful selection of isothiocyanates and pheromone compounds to produce baits which are tuned to the capture of a given *Phyllotreta* species, depending on need and pest importance.

Others

The leaf beetle *Diabrotica virgifera virgifera* LeConte: a merciless entomological challenge for agriculture

Hans E. Hummel, Arno Deuker, Günter Leithold 103-110

Abstract: *Diabrotica v. virgifera* (Western Corn Rootworm, WCR) is one of the most successful invasive insect species and owes this success to its close association with mankind, to worldwide trade and commerce connections, and to widely practiced monoculturally oriented production patterns which are characteristic for contemporary agriculture. Without a drastic change in attitudes and approaches of a globalizing agriculture, WCR will in the foreseeable future have invaded all maize growing areas. Unfortunately, WCR already has secondary hosts and, through accelerated microevolution, soon may acquire more of them. The beetle may be seen as a clever follower in the footsteps of *Homo sapiens* and may thrive on our worldwide ecological mistakes. Without major new paradigms in control and management approaches, WCR will be one of the big winners of globalization and mercilessly occupy the niches opening up. Some biotechnical and cultural alternatives are discussed which, in combination with biocontrol, may help to circumvent the approaching impasse of the accelerating resistance problem.

External complex of leaf-eating Lepidoptera on apple in two regions of Bulgaria

Penka Peeva, Nyonka Velcheva 111-121

Abstract: Investigations have been carried out for the species diversity, dominance and temporal changes of the complex of external leaf-eating and fruit surface damaging Lepidoptera of apple orchards during 2005 and 2006. The mean density of larvae and the rate of parasitism were determined as well. Three orchards in Plovdiv region (Central South part of Bulgaria) with different types of cultivation practice were observed: conventionally managed, organic and abandoned. An abandoned orchard in Sofia region (West part of Bulgaria) was sampled for comparison. Significant differences in the species composition and dominance were established in connection with the cultivation practice, the regional peculiarities and the year of study. The highest diversity was recorded in the abandoned orchard in Sofia district, in which 44 species belonging to 11 families were identified during 2005 and 40 species of 9 families during 2006. The number of lepidopteran larvae reached the threshold of damage in this orchard during both years. The percentage of parasitized larvae was similar over the two seasons (8% and 7.7% in 2005 and 2006, respectively). Although a similar number of families were recorded in the organic orchard in Plovdiv during 2005 in comparison with the abandoned orchard in Sofia district, only 17 species were identified. In the next year in the organic orchard 11 species belonging to 6 families were found. The rate of parasitism was 3% and 6.2% in 2005 and 2006, respectively. The density of the larvae reached the threshold of damage in this orchard in 2005. The same tendency of decreasing species diversity was found in the abandoned orchard situated in the same region: 14 species of 9 families in 2005 and 6 species of 5 families in 2006. This was probably due to a very low sum of the precipitations during May 2006. As may be expected, the lowest species diversity was recorded in the conventionally managed orchard. In all orchards the most consistent was the presence of specimens of family Tortricidae with dominant species *Hedya nubiferana* Hw. As a result of our study *Conistra rubiginosa* (Scopoli, 1763), *Colocasia coryli* (Linnaeus, 1758), *Swammerdamia pyrella* (Villers, 1789) *Diurnea fagella* ([Denis & Schiffermüller], 1775) *Teleiodes vulgella* ([Denis & Schiffermüller], 1775), *Acleris comariana* (Lienig & Zeller, 1846), *Ematurga atomaria* (Linnaeus, 1758), *Eupithecia insigniata* (Hübner, 1790), *Argyresthia cornella*

(Fabricius 1775) and *Carcina quercana* (Fabricius, 1775) were recorded for the first time to feed and develop on apple trees for Bulgaria.

Spatio-temporal distribution of *Ceratitis capitata* trap catches in an agricultural landscape

Andrea Sciarretta, Daniela Cesare, Roberto De Salvador, Maria Rosaria Tabilio, Pasquale Trematerra 123-129

Abstract: Early detection of the Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) is very important and monitoring programmes using lures and attractants are required to localize the presence of foci. Identifying key habitats in which the fly develops early in the season under low population densities could help to prevent the establishment of infestations and increase the efficacy of pesticide application. Hence, the main purpose of our work was to investigate the spatio-temporal dynamics of fruit fly, inside and outside orchards and to evaluate the effect of the landscape elements on pest distribution by using traps baited with trimedlure. The research was undertaken in an agricultural landscape of 5 km² located in central Italy. In this area, mixed fruit orchards are surrounded by hedgerows, small woodlots, private gardens and cereal fields. The activity of *C. capitata* adults was monitored using 48 baited-sticky traps of the delta type, placed at the end of April 2006. Geostatistical methods were used to characterize the spatial distribution of adults. Spatial analysis was carried out using Surfer software with *x*, *y* representing latitude and longitude expressed as Universal Transversal Mercator coordinates, and *z* the trap counts. The obtained interpolation grid was graphically represented by a contour map which shows the configuration of the surface by means of isolines representing equal *z*-values; a base map showing the experimental area with the same coordinate system was placed on top of the contour map. Our results showed that the adults of *C. capitata* were primarily distributed inside the fruit orchards, with the peak of maximum density found in the months of September and October inside late cultivars of peach orchards. Some captures were also observed in following periods in proximity of peach, apple and kaki trees when fruits remained on the trees. Away from the principal host plants, particularly in cereal fields, the number of trapped individuals always resulted scarce or absent. Contour maps allowed to highlight the hot spots in the sampled area and the spread of *C. capitata* inside and outside orchards and to evaluate the role of cultivated or wild host plants and landscape elements on the spatial distribution of adults.

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