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Session 1: Overviews and trends on stored product protection

Stored product entomology: Shifting from the past to the future

Frank H. Arthur 3-6

Abstract: Knowledge of stored product insects dates back to ancient times, but the historical “Past” for stored product insects as a distinct branch of entomology begins from the early 20th century until the mid 1970s and 1980s. The present era is characterized by a decline in the number of researchers specializing in stored product insects, and a shift in research focus from stored bulk grain to structures associated with the milling, distribution, and retail sectors. Possible approaches for future research are discussed, including economics of insect control, stored-product insects as biological and ecological models, invasive or emerging species, and urban pest management.

Application of thermal disinfestations in the food industry

Navarro, S., Finkelman, S., Navarro, H. 7-18

Abstract: With the phase out of methyl bromide, there is renewed interest in using heat to control stored product insects. The heat sterilization technique in flour mills and food processing facilities uses high target temperatures ranging from 50°C to 60°C to kill stored product insects by inducing dehydration and/or protein coagulation or enzyme destruction. The length of time required to destroy stored product insects varies from a few hours for a piece of machinery to up to 24 hours for a large facility. The key to successfully eradicating the insects is achieving the target temperatures for a long enough period of time to reach lethal temperatures in areas such as machinery interiors, voids, dust collectors, and piping where stored product insects may be found. A specially designed duct system using a flow through system has been adopted for thermal disinfestation of machinery to be treated in food facilities. Thermal disinfestation of wood pallets is an accepted technology in many countries; 56°C at core temperature of the pallets for at least 30 minutes is required. Thermal disinfestation of Medjool variety dates is successfully implemented as an alternative to methyl bromide in Israel. All Israeli dates packing houses have adopted the method for this date cultivar. To study the implementation of the method to other date varieties, trials were carried out on: Deglet-Noor in branches and Zahidi in bulk (in Dolev type crates, 200kg capacity), and Halawy in factory type boxes. Laboratory and commercial scale disinfestation trials failed to cause changes in the colour of the branches and the dates of Deglet-Noor. In commercial scale trials with Halawy date cultivar stored in factory boxes (12kg capacity), air flow rate and temperature increase rate, suitable for thermal disinfestation, could be achieved.

The incidence of fungi in stored rice

Margo, A., Pera, S., Barata, M., Carolino, M., Bastos, M., Matos, O., Mexia, A. 19-24

Abstract: Rice (*Oryza sativa* L.) is a staple food for millions of people. In the tropics is the primary source of human nutrition and is one of the cheapest sources of food energy and protein. In Portugal rice is one of the most consumed cereal with an average consumption of 15kg per year and person, the highest in Europe. The growth of fungi together with the eventual occurrence of mycotoxins can be responsible for serious economic losses and public health risks. Knowing the contaminating mycota of different origins is a prerequisite for the establishment of mycotoxin control programs. In this study we have collected rice samples from different origins (national and imported) which were analyzed for fungal infection. Several genera of fungi were isolated: *Alternaria*, *Aspergillus*, *Bipolaris*, *Botrytis*, *Curvularia*, *Fusarium*, *Helicoma*, *Nigrospora*, *Penicillium*, *Rhizopus*, *Scytalidium*, *Stemphylium* and *Trichoconiella*. Some of the fungi isolated from the rice samples are potential mycotoxins producers.

Methods to evaluate the effectiveness of methyl bromide alternatives in food processing plants

Fields, P., Adler, C., Bell, C., Campbell, J., Trematerra, P. 25

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Fumigant toxicity of garlic essential oil and its active components against life stages of confused flour beetle (*Tribolium confusum* J. du Val)

Isikber, A. A., Gozek, N. 26

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Session 2: Monitoring, sampling, trapping and semiochemicals

Monitoring stored product pests and natural enemies in food processing companies by trapping and spatial analysis

Belda, C., Ribes-Dasi, M., Riudavets, J. 29-39

Abstract: Stored products are affected by a wide variety of pests, which adapt their distribution to food sources and environmental conditions in the food industry facilities. Pests' distribution is the result of the interaction of many parameters, therefore it is important to know pests' dynamics and behavior to be able to monitor the pests and apply precise and adequate control methods. In this study we focus on the lepidopteran pests and their natural enemies found in a company processing organic rice, cocoa, dried fruits and spices as raw materials, where no chemical treatments were applied. The aim of the present study is to create contour maps of the lepidopteran and natural enemies' distribution by means of pheromone and light trap captures, and thus assess if a correspondence between pests and natural enemies' distribution is feasible to evaluate over the maps. We sampled the existing natural enemies' populations. Also, located infestation origins and expansion patterns were followed through time and space with spatial analysis. A relationship was established between natural enemies' and pests capture levels and movements.

Capture unevenness of a flour beetle trap

Lidia Limonta, Massimiliano Stampini, Daria P. Locatelli 41-47

Abstract: The efficacy of a flour beetles trap, baited with 1mg of racemic 4,8-dimethyldecanal, was evaluated. The trap had the shape of a truncated pyramid with a squared basis and a rounded central pitfall with perpendicular walls. Externally the trap was made of flocked PVC, while the top and the pitfall were made of smooth PVC in order to prevent the escape of caught beetles. Tests were carried out in a squared room (area 34m²; volume 103m³) with constant conditions of 26±1°C, 70±5% RH. The conditioning unit was placed at a height of 1.56m, and separated by 0.85m from the corner of the wall; the opening of the air flow was 0.97x0.29m. Tests were carried out by rotating the traps placed in different positions (10cm from the wall): a) one trap

rotated among the different corners, b) two traps rotated together in the different corners, and c) five traps, of which one was put into the centre of the room and four in the different corners. An equal number of adults of *Tribolium castaneum* and *T. confusum* were introduced in the room. In the tests a) and b), 240 adults were released in the room. Test c) was carried out on groups of 80, 160 or 240 adults. Three replicates were carried out for each test. In all the tests, the number of adults of *T. confusum* caught by the traps was greater than the one of *T. castaneum*. The highest number was always observed in a trap located at a particular position, regardless of the number of traps present in the room. In test c) the percentage of adults decreased while the number of released individuals increased.

Five years of mass trapping of *Ephestia kuehniella* Zeller in a flour mill

Trematerra, P., Gentile, P. 49-55

Abstract: Results of applying the mass trapping method using the synthetic pheromone (Z, E)-9, 12-tetradecadienyl acetate (TDA) to contain the population of *Ephestia kuehniella* Zeller in a large traditional flour mill are presented. The surveys were carried out over a period of five years to control the infestation and protect the flour mill's output. Forty-two funnel-traps (one every 270m³), each baited with 2mg of TDA (daily release of 13µg), were installed in the mill on March 2004 and kept till November 2008; eight additional traps were placed at the exterior of the facility, especially in the wheat silo area and near the loading equipment. In almost five years, the pheromone traps attracted a total of 54,170 male Mediterranean flour moths. Considering only the catch data obtained from the traps located in the internal departments of the mill, 28,360 specimens were captured during 2004, 5,856 in 2005, 8,992 in 2006, 2,235 in 2007, and 2,218 in 2008. Outside the plant, 1,975 males were trapped in 2004, 1,405 in 2005, 1,005 in 2006, 1,010 in 2007, and 1,114 in 2008. From the trap counts obtained it was possible to identify the locations of the main foci of infestation. During the surveys, the continuous presence of pheromone traps in the mill, accompanied with other pest control measures, caused a marked decrease of the Mediterranean flour moth population from 2004 till 2008. The infestation was maintained at a low level, especially during the last two years of the study, when the IPM program applied in the plant didn't include any general fumigation but only localized insecticide treatments and careful cleaning of the various departments (wheat storage bins, processing and packaging areas, milling products warehouses and the loading zone) and of the interior of all equipment. As it is not possible at present to establish the economic injury level of insect infestations in flour mills, there is a need for investigations into how the effectiveness of Integrated Pest Management programs can be evaluated in a sound way.

Evaluation of factors impacting trap catches of red flour beetle

James F. Campbell 57-62

Abstract: An effective monitoring program is the foundation of good Integrated Pest Management programs for food facilities such as mills, processing plants, warehouses, and retail stores. The red flour beetle, *Tribolium castaneum*, is a major stored-product pest of food facilities, especially mills, and a number of pheromone/food based traps are commercially available. Unfortunately, the level of response by adults to these traps is typically not high and appears to be strongly influenced by the internal state of the insect and the environment surrounding the trap. This perceived low effectiveness has limited adoption of pheromone trapping for this pest as part of IPM programs. Recent research on evaluating trap response by red flour beetles adults and some factors that impact the level of response will be presented. The implications of these factors for implementation and interpretation of monitoring programs will also be discussed.

Comparison of bait stations acceptance in wild populations of house mice (*Mus musculus musculus*)

M. Novakova, R. Aulicky, D. Frynta, V. Stejskal 63

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Potential of using sex pheromone for mating disruption of stored product Pyralidae <i>Sutherland, J., Athanassiou, C. G., Stejskal, V., Trematerra, P.</i>	67-78
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Abstract: Field trials were carried out in order to evaluate the use of the pheromone TDA, known also as ZETA (Z,E,-9,12-tetradecadienyl acetate), for mating disruption of species of Pyralidae that associated with stored products. The trials were conducted in Czech Republic, Greece and Italy, during 2007 and 2008. The facilities tested varied in their size and type, and included flour mills, retail stores, storage rooms with currants and raw grain stores; however, in most cases the Mediterranean flour moth, *Ephestia kuehniella* Zeller, and the Indian meal moth, *Plodia interpunctella* (Hübner). After a pre-treatment monitoring period, during summer period, in order to assess the population of pyralid moths in these facilities, dispensers, containing TDA were placed, until late autumn, when moth presence was extremely low. Adjacent storerooms (or facilities), without dispensers, were used as control units. In all cases, pheromone-baited traps were suspended in order to monitor the population fluctuation of the pyralid moths. The presence of dispensers reduced notably the number of adults found in the traps, in comparison with control storerooms. Monitoring of oviposition by mated females, by recording numbers of larvae in cups containing food, indicated that, there was a reduction in the number of larvae in the areas with dispensers, for both years examined. The results of the present work show that the use of mating disruption is feasible against pyralid moths in storage facilities, and should be further evaluated under the basis of an IPM-based control strategy.

Experimental study of acoustic equipment for real-time insect detection in grain bins – Assessment of their potential for infestation risk prediction during long term storage periods <i>Marie-Pierre Leblanc, Damian Gaunt, Francis Fleurat-Lessard</i>	79-88
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Abstract: An insect detection probe was recently developed to detect and identify the sounds of different stages and species of primary grain pest insects whilst operating directly from the surface of grain bulk. A laboratory acoustic device with the same technology as the probe was also developed for hidden insect detection in grain samples. A campaign for the testing of the performances of the acoustic probe and the laboratory acoustic device in field conditions was undertaken by the ONIGC in the cereal production area of western France after the 2007 harvest. The data on insect presence / absence from the acoustic probe were compared in parallel with the observation of insect presence / absence in grain samples taken at the acoustic probing location. This comparative study was carried out on 60 grain storage sites. The parallel grain samples were sieved after transport at the official laboratory (ONIGC, La Rochelle) prior to a check for hidden infestation by the “laboratory acoustic device”. Afterwards, samples were incubated at room temperature (23-25°C) before a second sieving 35 days later for recovery of emerged adults. From the data delivered by the acoustic probe compared to the insects recovered from the incubated grain samples, it was established that this equipment enables to predict the presence of live hidden insects with a confidence factor greater than 90%, as it is capable of detecting the activity of all insect stages, either adults or hidden stages, and a range of acoustic detection covering a 30kg grain mass. The confirmation of hidden infestation performed with the “lab device” before sample incubation showed that convergence of diagnosis for presence / absence was observed in 79% of samples. This study confirmed the detection of a hidden infestation at a density level far lower than the threshold of conventional detection of adults by sieving alone. It enables to predict the risk of adult detection during a further storage period. Additionally, the

early detection of insect presence in a grain bulk is valuable information for the grain storekeeper which enables optimisation of insect control strategy or grain lot sale before the insect presence become detectable with the reference method.

Xlure-MST- the multi species pheromone trap for monitoring

major stored product insects

M. Nayemul Hassan, Shakir Al-Zaidi 89-92

Abstract: In the present study it showed that by integrating three pheromone lures of *Tribolium* spp. *Lasioderma serricorne*, *Trogoderma granarium* and two food attractants wheat germ oil, carob volatile a synthetic pheromone trap (Xlure-MST) has been developed that is attractive to *Tribolium*, *castaneum*, *Tribolium confusum*, *Lasioderma serricorne*, *Trogoderma granarium*, *Trogoderma variabile*, *Oryzaephilus mercator*, *Oryzaephilus surinamensis*, *Sitophilus granarius*, *Sitophilus oryzae* and *Stegobium paniceum*. The presence of pheromones and food attractants in one trap increased its attractiveness. Moreover, captures of a given species did not reduced due to repellent characteristics of a pheromone from another species. The efficiency has been evaluated against *T. castaneum* in a laboratory bioassay, and the results indicated that Xlure-MST is attractive to *T. castaneum*, with a mean catch efficacy of more than 80% after 24 hours of trap evaluation. Also, once the beetles are caught in the trap they are unable to escape. The slope of the trap does not present an obstacle to the ease of entry by the beetles into it. It provides a single cost effective detection tool to monitor wide range of insect pests which is likely to attack any food stock of manufacturing facility.

Liposcelis bostrychophila (Psocoptera: Liposcelididae) Xlure-MST- comparison of morphological and molecular identification

Zuzana Kučerová, Zhi-Hong Li, Meng Qin, Vaclav Stejskal 93-100

Abstract: Stored product psocids of the genus *Liposcelis* (Psocoptera: Liposcelididae) are quite difficult to identify. *L. bostrychophila* Badonnel, the common cosmopolitan parthenogenetic stored product psocid, was chosen as the model species for morphological and molecular diagnosis. Two different geographical populations (Czech Republic and P. R. China) of this species were compared based on decisive morphological characters, size measurements, SEM micrographs, and PCR-RFLP and sequencing molecular diagnostic methods. Advantages and limitations of both methodological approaches were compared. Both morphological and molecular methods are able to properly identify the species. Significantly distinguishable differences between geographical populations of *L. bostrychophila* were found only using the molecular methods.

Patterns of diversity in Psocoptera using near infrared spectroscopy

Sonia M. N. Lazzari, Fabiane C. Ceruti, Jaime I. Rodriguez-Fernandez,

George Opit, Flavio A. Lazzari 101-109

Abstract: Metabolomics, the analysis of the global metabolic profile of organisms, is a novel approach to study diversity in insects by near infrared spectroscopy (NIRS). The NIRS is a type of vibrational spectroscopy which uses light energy at wavelengths from 750 to 2500nm. Interaction between light and matter at such frequencies generates qualitative and quantitative information at the molecular level. Metabolomic usually provides more extensive data at a lower cost than genomics and other molecular methods. The objectives of this research are to demonstrate that NIRS based metabolomics is a valuable and non-destructive tool and to propose, test, and organize a hypothesis on diversity patterns and discrimination of Psocoptera species. Six species (four specimens each) from the genus *Liposcelis* (Psocoptera: Liposcelidae) and one species of *Lepinotus* (Psocoptera: Trogiidae) were tested. Each specimen was placed on a diffuse reflectance accessory of a NIR spectrometer to obtain the respective spectrum. All spectra were analyzed by combined methods of multivariate analysis using the technique of crossed validation for the multivariate models. The analysis discriminated the seven species without significant overlapping among the species spectral patterns. The NIRS revealed quantitative variation in the metabolomic profile both at intra and inter-specific levels based on dispersion patterns of

individual specimens. We assume NIRS to be, by concept and potential application, the true life barcoding that may be associated with morphological, genomic, and biogeographic data to reveal significant information of a given taxonomic hierarchy. NIRS produces a matrix of spectral data that can, biologically speaking, tell the life history of not only psocids but of any other organism.

Seasonal abundance and distribution of psocids in an animal feed warehouse

George P. Opit, Edmond L. Bonjour, Randy L. Beeby 111-122

Abstract: In the last 15 years, psocids (Psocoptera) have risen to prominence worldwide as serious pests in stored grain, grain processing facilities, and food-product warehouses. In the U.S., no previous studies have been conducted in food-product warehouses to determine the species, abundance, and distribution of stored-product psocids. Therefore, we sampled psocids in a 1,800m² animal feed warehouse located in Stillwater, Oklahoma from May 21, 2008 to March 25, 2009 to determine the species present and their abundance and distribution. Walls in all four cardinal directions (east, north, south, and west) of the warehouse were sampled using 8.9 x 12.7cm corrugated cardboard refuges. Biweekly sampling was conducted using five refuges in each cardinal direction. Refuges in each cardinal direction were placed next to the wall, at equal distances from each other, for one week. Temperature and relative humidity (RH) data were recorded in each cardinal direction. We found seven psocid species, namely, *Lepinotus reticulatus* Enderlein (Trogidae), *Liposcelis decolor* (Pearman) (Liposcelididae), *Liposcelis rufa* Broadhead, *Liposcelis bostrychophila* Badonnel, *Liposcelis entomophila* (Enderlein), *Liposcelis pearmani* Lienhard, and *Liposcelis paeta* Pearman. *Liposcelis decolor* comprised 96% of the total number of psocids sampled. The numbers of psocids found in each of the five positions within each cardinal direction and in each cardinal direction were highly variable. Percentages of psocids found in the north, west, east, and south were 2, 5, 11, and 82%, respectively. In the south, 97% of all psocids found were *L. decolor*. Relative humidity and food availability had the most influence on psocid abundance. Psocid populations in the south began to increase in mid-May and had two peaks in June and September which coincided with RH peaks. The number of psocids remained low during winter before starting to increase in the spring.

A survey of the mite fauna of Greek flour mills

Nickolas E. Palyvos 123-125

Abstract: The mite fauna of 11 Greek flour mills was studied during 2004-2005. A total of 70 samples were examined from the following groups of stored products: I. animal fodder (wheat, maize), II. flour and bran, and III. residues. The taxa collected were categorized using the criteria of dominance and frequency. Approximately 46% of the samples examined carried mite infestations and 26 taxa of mites were identified belonging to 10 families and 3 orders. The highest percentage of infestation was recorded in residues (68.2%). Fewer infestations occurred in animal fodder and flour. *Tyrophagus putrescentiae* (Schrank), *Lepidoglyphus destructor* (Schrank) and *Acarus siro* L. were dominant and accidental whereas *Gohieria fusca* (Oudemans) and *Tydeus* sp. were influent and accidental.

Blaptica dubia (Blattodea, Blaberidae): Damage to photographs

Elena Ruschioni, Donatella Mate, Marianna Adamo, Ubaldo Cesareo 127-134

Abstract: Insects, micro-organisms and rodents can degrade cultural heritage kept in museums, archives and libraries by provoking aesthetic and structural damage of various kinds and degrees. Damage to cultural heritage caused by insects varies greatly depending on the kind of pest responsible, to the extent that, in some cases, by examining the type of degradation and tell-tale signs left by the causative organism, it is possible to identify the kind of insect species involved. Photographic patrimony is a category of heritage that only for the last ten years or so has been subject to the norms which govern the management and safeguarding of cultural heritage. In this study, cockroaches (Blattodea), which figure among the insects considered particularly harmful to photographic patrimony, have been investigated. These omnivorous insects, which are quite widely distributed in museum environments, and above all in archives, can provoke public health problems such as allergies, and sometimes even transmit infectious diseases to cultural heritage personnel, in addition to damaging heritage.

In this paper, we present the results of a study carried out to investigate the damage caused by *Blaptica dubia*, a cockroach belonging to the Blaberidae family, to sacrificable samples of photographic prints of various kinds, drawn from a range of historical periods, including: albumen photographic paper; black and white gelatin silver bromide photographic paper; gelatin silver chloride photographic paper - Velox black and white; non-resin coated gelatin colour process photographic paper and resin coated gelatin colour process photographic paper. The sample photographs were exposed to live specimens of *Blaptica dubia* and monitored for a period of four weeks. The results obtained demonstrated various degrees of palatability among the photographic materials tested, and confirmed that Blattoids represent a serious cause of biodeterioration to photographic heritage, since they are able to cause serious erosion of materials and their excrement and/or regurgitations leave damaging and unsightly stains.

Beyond seeking to assess types of damage and the length of time needed for them to be caused, our experiments were aimed at carrying out a preliminary investigation in order to identify the materials that are the most palatable to these insects, and hence the photographic supports which are most vulnerable to this kind of degradation.

Determination of weed seeds contaminating wheat grains in Southeastern Anatolia region of Turkey

Nichat Tursun 135-139

Abstract: This study was conducted to determine species of weed seeds and their average ratios within wheat grains. The samples were taken randomly and mixed in a sample bag. 154, 50, 100, 214, 43, 46 and 110 wheat samples were collected in Adıyaman, Batman, Diyarbakır, Gaziantep, Kilis, Siirt and Şanlıurfa provinces respectively between 2001 and 2005. The weight and number of weed seeds in wheat samples were determined. The number of weed seeds in 1kg of the sample taken from Adıyaman was 801.89 (=16.72g), while it was 995.72 (=14.79g) for Batman, 538.49 (=16.96g) for Diyarbakır, 680.54 (=15.32g) for Gaziantep, 1025.36 (=16.41g) for Kilis, 492.86 (=12.84g) for Siirt and 1337.16 (=24.14g) for Şanlıurfa.

Differential levels of mite infestation of wheat and barley in Czech grain stores

Aulicky, R., Hubert, J., Kucerova, Z., Nesvorna, M., Stejskal, V. 140

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Temporal dynamics of excretion of fluorescent non-toxic bait in house mice (*Mus musculus*)

Eliasova, B., Novakova, M., Aulicky, R., Stejskal, V., Frynta, D. 141

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Screening of chickpea (*Cicer arietinum* L.) genotypes for resistance to pulse beetle (*Callosobruchus maculatus* F.)

Erler, F., Toker, C., Ceylan, F. O., Erdemir, T. 142

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Mass trapping and mating disruption to control *Cadra cautella* (Walker) in a confectionary factory

Luciano Süss, Sara Savoldelli 143-149

Abstract: A mass trapping system was established in a chocolate factory to control *Cadra cautella*, using plastic containers filled with water. In order to interfere with mating, a mating disruption system was applied in a confined area. Results confirmed that water is a considerable attractant for almond moth: a great number of males and females were caught, while the pheromone traps, placed in the same areas, caught a limited number of males. The analysis of females allowed to determine the mating status: the most part of caught females was mated; in the area where mating disruption was applied the percentage of unmated females was higher as compared with the control area. The use of water as mass trapping system and mating disruption allow to eliminate large number of females and to reduce mating. Mass trapping and mating disruption can be taken into account in the IPM program.

Effect of harvesting time in preventing infestation of the garlic moth,
Dyspessa ulula Staudinger (Lep., Cossidae) in store
Khanjani, M. 151
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Screening for bruchid resistance and marker assisted selection
of common beans (*Phaseolus vulgaris* L.) in Ethiopia
Teshale, Assefa, Battisti, A., Cardona, C., Matthew Blair, M., Lucchin, M. 152
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Session 3: Biological Control

Effect of short-term high temperatures to the survival and parasitism of the
koinobiont endoparasitoid *Venturia canescens* (Hymenoptera: Ichneumonidae)
against *Plodia interpunctella* (Lepidoptera: Pyralidae)
Stefanos Andreadis, Christos Spanoudis, Matilda Savopoulou-Soultani 155-159

Abstract: Effect of short-term high temperatures on survival rates, longevity and parasitization efficiency of *Venturia canescens* Gravenhorst (Hymenoptera: Ichneumonidae) parasitizing larvae of *Plodia interpunctella* Hübner (Lepidoptera: Pyralidae) was studied in the laboratory. Experimental adults of *V. canescens* were exposed for 1 hour under various temperature regimes (37, 38, 38.5, 39, 39.5, 40, 40.5 and 41°C) in a circulating bath. The temperature that caused 50 and 90% mortality was 39.26 and 40.64°C respectively. Longevity of *V. canescens* after being exposed for 1 hour to high temperatures was significantly reduced compared to the control. Moreover, *V. canescens* lost gradually its parasitization efficiency as it was exposed to higher temperature regimes. After only 1 hour being exposed to 39 and 40°C, parasitization efficiency dropped by 63 and 69% respectively, in comparison to control.

Some like it hot – some not differences in temperature preference
of two different Pteromalidae species
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Biology of *Cephalonomia tarsalis* (Hymenoptera: Bethyridae), a video film
Prozell, S., Schöller, M. 162
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Potential of *Xylocoris flavipes* (Hemiptera: Anthocoridae) to control
Tribolium confusum (Coleoptera: Tenebrionidae) in Central Europe
Schöller, M., Prozell, S. 163-168

Abstract: The discovery and investigation of control strategies for the flour beetles *Tribolium castaneum* and *T. confusum*, especially for use in flour mills and processing facilities, is a major challenge for stored product protection. In this study, the control potential of the Anthocorid predator *Xylocoris flavipes*, the warehouse pirate bug, is evaluated for temperate regions. Data on the suppression effect of *X. flavipes* against *T. confusum* in the presence of thin flour layers or little amounts of flour is presented. A control strategy and further research needs are suggested.

Mechanisms contributing epizootics of *Bacillus thuringiensis* in
Plodia interpunctella populations
Mohammad Shojaaddini, Saeid Moharramipour, Mahvash Khodabandeh,
Ali Asghar Telebi 169-173

Abstract: Epizootics of *Bacillus thuringiensis* Berliner (Bt) among stored product pests were rarely reported in the literature however under specific conditions epizootics do occur in either laboratories or in populations infesting stored products. In order to investigate the mechanisms

behind Bt epizootics including possible correlations between distribution of *cry* genes to the ability of causing epizootics; comparison of *cry* gene content of a newly isolated Bt strain (BTA), caused several epizootics in laboratory populations of Indianmeal moth, *Plodia interpunctella*, to other previously reported strains isolated from epizootics in different environmental conditions was done. Assays were accomplished to evaluate the ability of BTA and *B.t. kurstaki* HD1 strains in spreading within laboratory cultures of indianmeal moth. No significant correlation between *cry* gene content of epizootic strains and ability to cause epizootics was found, however, *cry1I*, *cry2Ab*, and *cry9B* were present in all epizootic strains. Transmission of Bt from infected larva to another healthy larvae highly differed in relation to the density of the last instar larvae and the presence or absence of food. It was shown that transmission was increased with increasing in host density and with more shortage of food. It was concluded that the dynamics of spreading Bt in a population mainly related to the biological activity of the pathogen as well as exotic factors including population density and the structure of the environment.

Insecticidal effect of fenitrothion, diatomaceous earth and *Beauveria bassiana* against Coleopteran pests of stored grain

Gustavo Dal Bello, Cecilia Fuse, Patricia Juarez, Nicolas Pedrini,

Augusto Imaz, Susana Padin 175-180

Abstract: Pest insects of stored grains can cause losses in weight, quality, commercial value and seed germination. Toxicity and protectant potential of a chemical and two biological insecticides against two major stored-grain beetle species: *Tribolium castaneum* (Herbst) and *Rhyzopertha dominica* (F.) were investigated in the laboratory. The organophosphate fenitrothion at 100% and 50% of the labelled rate, and two biological insecticides: diatomaceous earth (DE) at 3000ppm and the entomopathogenic fungi *Beauveria bassiana* (Balsamo) Vuillemin (Hyphomycete) at 1ml/kg grain of water suspension (1×10^8 conidia/ml), were applied both or combined on hard wheat grain. For grains bioassayed after 14 days of storage following chemical treatment at least 98% mortality was obtained in *T. castaneum* and *R. dominica* even with the lowest dose. For both insect species DE powder + *B. bassiana* formulations showed a mortality significantly higher than each biological insecticide alone. When *T. castaneum* and *R. dominica* were exposed to *B. bassiana* or DE, the mortality means were 2% and 45% respectively, but when the weevils were treated with both the fungus and DE, there were 20% mortality for *T. castaneum* and 54% for *R. dominica*. The results suggest that additive effect was evident for the fungus-diatomaceous earth combination and the application of *B. bassiana* and DE may be a way to overcome some of the constraints of virulence on fungal entomopathogens as biocontrol agents against stored-product insect species.

Effectiveness of *Metarhizium anisopliae* (Metschnikoff) Sorokin (Deuteromycotina: Hyphomycetes) along with diatomaceous earth against the rice weevil *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae)

Waqas Wakil, Muhammad Usman Ghazanfar, Tahira Riasat 181-190

Abstract: The aim of this research was to evaluate efficacy of a local isolate (WG-01) of *Metarhizium anisopliae* (Metschnikoff) Sorokin (Deuteromycotina: Hyphomycetes) along with diatomaceous earth (DE) against the adults of the rice weevil, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae). The rice kernels were treated with three different doses i.e. 2.78×10^6 , 2.78×10^7 and 2.78×10^8 conidia kg⁻¹ alone and also in combination with Protect-It at 100 and 200ppm, respectively. The mortality of adult weevils was determined after 7d, 14d and 21d of exposure intervals at the conditions of $25 \pm 2^\circ\text{C}$ and 55% r.h. After every count of mortality the dead adults were removed and then they were kept for next 62d to check the production of the progeny. The results revealed that the rice treated with the highest dose rate of *M. anisopliae* when combined with 200ppm of Protect-It gave the maximum mortality of *S. oryzae* and reduced progeny production. These findings showed that the entomopathogenic fungi when combined with DE are more effective in comparison with the application of either fungi or DE alone, against *S. oryzae*.

The control of stored product pests in UK grain stores using the entomopathogenic fungus *Beauveria bassiana*
Bryony Taylor, Belinda Luke, Dave Moore, Maureen Wakefield 191-195

Abstract: The UK grain industry houses many tons of its produce in grain stores every year, however a complex of insect pests may infest these stores and many tons of pesticide are applied to control the problem. Control of insect pests within the grain store environment is becoming more important as EU legislation is restricting the number of chemical pesticides available for use and alternative methods of control need to be sought. Entomopathogens provide an important alternative for chemical control and *Beauveria bassiana* is a very promising candidate for further development. Different isolates of *B. bassiana* were isolated from insects found within grain stores and after investigation, two isolates were chosen for further study. These isolates were further researched so that they would have improved efficacy in grain store conditions. Laboratory investigations optimized the mass production technology used in order to produce conidia that are more tolerant and effective in drier environments. Formulations of both isolates were investigated to ensure that the conidia remain viable and are suitable for a final product. Efficacy of the mass produced and formulated conidia was tested at both a lab and pilot scale level within a grain store environment. Results from the project have been very promising and an overview of findings is reported here.

Induction of micronuclei in ovaries of *Tribolium castaneum* exposed to gamma radiation and *Rosmarinus officinalis* essential oil
Ahmadi, M., Moharramipour, S., Mozdarani, H., Babaii, M. 196
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Bioassays with dry conidia of isolates of the entomopathogenic fungus *Beauveria bassiana* (Bals.) Vuill. against *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae)
Slavimira Draganova, Firas Zidan, Doncho Obretenchev 197-203

Abstract: An investigation with thirteen isolates of the entomopathogenic fungus *Beauveria bassiana* (Bals.) Vuillemin was carried out against adults of *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) with a goal to estimate the virulence of the isolates using dry conidia (108 conidia/mg) for the treatment. Insects were treated by contact with 1 mg of dry conidia mixed with crumbled wheat grains. Lethal effect of the isolates was evaluated as percentages of cumulative daily mortality due to mycosis. Virulence of each fungal isolate was estimated by values of the median lethal time (LT50), calculated by log probit analysis. The highest lethal effect (90%) was established in the variant with the isolate 559 of *B. bassiana* on the 7th day and it attained to 100% on the 10th day after the treatment. The isolate 513 of *B. bassiana* caused mycosis to adults of *R. dominica* with less lethal effect – 65% on the 10th day and 80% on the 14th day. All other examined isolates caused <60% mortality on the 14th day. The isolates 559 and 513 in the form of dry conidia had the highest virulence against adults of *R. dominica*. The values of LT50 calculated at significance level $p < 0.05$ varied within narrow confidence intervals from 4.9 to 5.5 days and from 7.9 to 8.9 days, respectively. The isolates 483, 471, 460 and 459 caused the lowest virulence to *R. dominica* adults. The calculated average values of LT50 for these isolates were 26.1, 28.9, 39.0 and 63.8 days, respectively.

Tyrophagus putrescentiae (Astigmata: Acaridae) as biological control agent for *Lasioderma serricorne* (Coleoptera: Anobiidae) larvae
Clauco da Cruz Canevari, Fernanda Rezende, Leda Rita D' Antonino Faroni, Jose Eduardo Serrao, Smaro Ch. Papadopoulou, Jose Cola Zanuncio, Constantin Th. Buchelos 205-208

Abstract: The predatory effectiveness of *Tyrophagus putrescentiae* against *Lasioderma serricorne* larvae was studied in the present work. The predation of larvae of *L. serricorne* in the presence or not of *T. putrescentiae* was evaluated in an entirely randomized design with four

replications. This mite had high predation rate on *L. serricornis* larvae. The mortality of *L. serricornis* larvae varied among treatments, with values of 54, 68 and 78% from the fourth, fifth and sixth days by *T. putrescentiae* ($P < 0.05$).

- The use of beneficial insects against stored product pests- results and experience from three years of field tests in Switzerland
Kraaz, I., Meierhofer, B., Fassbind, D., Wyss, G. S., Zigg, D. 209
Abstract only

- The functional response of *Cheyletus malaccensis* (Acari: Cheyletidae) to various densities of *Ephesia kuehniella* (Lepidoptera: Pyralidae) eggs
Nickolas E. Palyvos, Nickolas G. Emmanouel 211-214
Abstract: The functional response of protonymphs, adult females and males of the predatory mite *Cheyletus malaccensis* Oudemans, to increasing density of eggs of the mediterranean flour moth *Ephesia kuehniella* Zeller, was determined. The predation trials were conducted over a 24-h period in environmental incubators at $25 \pm 1^\circ\text{C}$ and $80 \pm 5\%$ r.h. without light. Four prey densities (3, 5, 10, 15 eggs per arena) were tested. The results showed that the type of functional response curve for females, males and protonymphs of *C. malaccensis* followed the type II curve, as predicted by Holling's disc equation. The female adults of *C. malaccensis* were the most effective predatory stage, whereas no significant differences were noted between protonymphs and adult males.

- Temperature-dependent development of the koinobiont endoparasitoid *Venturia canescens* (Hymenoptera: Ichneumonidae) parasitizing *Plodia interpunctella* (Lepidoptera: Pyralidae)
C. G. Spanoudis, S. S. Andreadis, A. K. Solonos, M. Savopoulou-Soultani 215-218
Abstract: The effect of various constant temperatures on the growth rate and adult longevity of *Venturia canescens* Gravenhorst (Hymenoptera: Ichneumonidae) parasitizing larvae of *Plodia interpunctella* Huebner (Lepidoptera: Pyralidae) was studied in the laboratory. Newly parasitized fifth instar larvae of *Plodia interpunctella* were transferred to constant conditions of seven different temperature regimes (15, 17.5, 20, 22.5, 25, 27.5, 30°C) and the days needed for the emergence of the parasitoid's pupa and adult eclosion were measured. Adult longevity was also studied under the same conditions. The development of *Venturia canescens* at 15°C was totally inhibited. Overall, developmental time decreased significantly with increasing testing temperature. The shortest developmental time was observed at 27.5°C (20.8 days from parasitism to adult eclosion). Adult longevity was also affected by temperature, as it was significantly reduced at 27.5°C (8.3 days) and 30°C (9.4 days) compared to that at 20°C (21.7 days) and 25°C (17.8 days). These findings provide us with useful information regarding the potential of using *V. canescens* as a biological agent in IPM programs.

- Mixing of *Beauveria bassiana* (Balsamo) Vuillemin (Hyphomycetes: Moniliales) with diatomaceous earth for the control of *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) on stored wheat
Waqas Wakil, M. Usman Ghazanfar, Tahira Riasat 219-227
Abstract: In order to determine the insecticidal efficacy of *Beauveria bassiana* (Balsamo) Vuillemin (Hyphomycetes: Moniliales) and diatomaceous earth (Diafil 610) against *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) a laboratory assay was designed. The fungus *B. bassiana* was applied at 4.23×10^7 , 4.23×10^8 and 4.23×10^9 conidia kg^{-1} of wheat individually as well as mixed with 400 and 800ppm of Diafil 610. The conditions for the trials were $30 \pm 2^\circ\text{C}$ with 55% RH and the counts for mortality were made after 8, 16 and 24 d. All the dead adults were removed after every count and the vials were kept for next 60 d to assess the emergence of F1 generation. The findings from these studies proved that the extended exposure interval and the highest combined dose rate of the entomopathogenic fungus and the diatomaceous earth gave the maximum mortality of the beetles. The emergence of the progeny was also highly suppressed where the maximum dose rate of the synergized treatments were applied.

Session 4: Phytochemicals

- Management of moth pests of stored yam tubers (*Dioscorea* spp.) using plant powders
Ashamo, M. O. 231
Abstract only
- Stability of tolerance to monoterpenoids in *Sitophilus*, *Rhyzopertha* and *Cryptolestes* selected populations
Lopez, M. D., Stefanazzi, N., Pascual-Villalobos, M. J. 233-239
Abstract: On a previous work, we selected for tolerance to some monoterpenoids (linalool, camphor, γ -terpinene, *S*-carvone, geraniol, estragole, *E*-anethole and fenchone) in three stored rice pests, *Sitophilus oryzae* (L.) (Coleoptera: Curculionidae), *Rhyzopertha dominica* (F.) (Coleoptera: Bostrychidae) and *Cryptolestes pusillus* Schönherr (Coleoptera: Cucujidae). These monoterpenoids had shown volatile toxicity against the insects and populations were selected for tolerance up to the seventh generation for each monoterpenoid although the degree of resistance gained evolved slowly. In this work we report the stability of tolerance to each monoterpenoid in each insect species comparing LC₅₀ of populations of the tenth generation with or without selection pressure from the 7th to the 10th generation. For most cases lethal concentrations were similar irrespective of the selection pressure being applied. In some cases, however, a loss of tolerance was evident: for example in *S. oryzae* TRA10F and TRA10 had a LC₅₀ of 188.414ppm and 433.657ppm, respectively or LIN10F and LIN10 had a LC₅₀ of 49.802ppm and 282.528ppm, indicating that the tolerance was reversible when monoterpenoid applications ceased. This study looks into how populations of stored product pests treated with volatile monoterpenoids would evolve in terms of resistance to each product and therefore to gain useful information for their control.
- The fungicide activity of clove and laurel essential oils against storage fungi
Margo, A., Matos, O., Bastos, M., Carolino, M., Mexia, A. 241-246
Abstract: Nowadays there is an increased concern and awareness by the public opinion related to the utilization of pesticides and to the presence of their residues in foodstuff. This fact leads the scientific organisations to search for new forms of foodstuff protection against microorganisms' contamination. The biologically active compounds produced by plants are an example of substances considered as safe. Plant extracts have a better acceptance by the public opinion and are potentially less harmful to health than the synthetic known ones. In this work, the essential oils of clove (*Syzygium aromaticum* (L.) Merr. and Perry.) and laurel (*Laurus nobilis* L.) were studied for their fungicidal activities on the fungi affecting stored food products. Results provide useful information on new sources of active substances able to reduce fungi crop losses.
- Efficacy of essential oil from *Callistemon viminalis* applied as an insecticidal fumigant and powder to control *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae)
Ndomo, A. F., Tapondjou, L. A., Tchouanguep, F. M. 247
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- Fumigant toxicity of *Elettaria cardamomum* (L.) Maton. and *Bunium persicum* (Boiss.) Fedtsch. oils against *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae)
Moravvej, G., Azizi-Arani, M., Yaghmai, F., Of-Shahraki, Z. 248
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- Nanoencapsulated *Artemisia sieberi* essential oil as a new formulation against *Callosobruchus maculatus*
Negahban, M., Moharrampour, S., Sarbolouki, M. N. 249
Abstract only

Insecticidal activity of extract from *Datura stramonium* (F.) (Solanaceae) against

Callosobruchus maculatus

Habib Abbasipour, Fahimeh Rastegar, Mohammad Mahmoudvand,

Mohammad Hossein Hosseinpour 251-256

Abstract: Higher plants are a rich source of novel insecticides. Plant materials with insecticidal properties have been used traditionally for generations throughout the world. Botanical insecticides compared to synthetic ones may be safer for the environment, are, generally, less expensive, easily processed and used by farmers and small industries. However, many plant species, especially from tropical regions, have the potential to be used as botanical insecticide or as font of bioactive compounds. In this study, extract of powdered leaves, stems and seeds from *Datura stramonium* was obtained by a rotary evaporator apparatus and was tested under laboratory conditions for its ability to control some stored products from attack by *Callosobruchus maculatus*. The experiments were conducted at $27\pm 1^{\circ}\text{C}$, $60\pm 5\%$ R.H. and in dark condition. The mortality of adults was tested at different concentrations and two exposure times (24 and 48h). The effect of different concentrations on egg hatching was also tested after 6 days. Also sublethal effect of different concentrations was tested on oviposition rate. The results showed that the mortality increased with increases in concentration and exposure time. After 12h, high increases in mortality were seen. Data probit analysis demonstrated that lethal concentration to kill 50% of the population (LC_{50}) was estimated as 1680 and 16058ppm, for 24 and 48h, respectively. These results suggest that extract of *D. stramonium* may be of high value in grain storage against *C. maculatus*, especially in subsistence agriculture where the plants are locally available to farmers with little resources to meet the high cost of pesticides.

Fumigant toxicity of three plant essential oils against adults of

Ephestia kuehniella Zeller (Lep.: Pyralidae)

Habib Abbasipour, Alireza Seyedi, Mohammad Mahmoudvand 257-261

Abstract: Recently, there has been a growing interest in research concerning the possible use of plant extracts as alternatives to synthetic insecticides. Essential oils are among the best-known substances tested against insects. These compounds may act as fumigants, contact insecticides, repellents and antifeedants. The objective of the present study was to test the possible properties of medicinal plants, *Ferula gummosa* Boiss (Apiaceae), *Rosmarinus officinalis* L. (Lamiaceae) and *Mentha piperita* (Lamiaceae) essential oil vapors against *Ephestia kuehniella* to elucidate their fumigant toxicity. The experiments were conducted at $27\pm 1^{\circ}\text{C}$, $60 \pm 5\%$ R.H. and in dark condition. The essential oils were obtained from resin of *F. gummosa* and dried leaves of *R. officinalis* and *M. piperita*, and subjected to hydrodistillation using a modified Clevenger-type apparatus. The mortality of adults was tested at different concentrations and different exposure times (1–24h). The results showed that the mortality increased with increases in concentration and exposure time. After 12h, high increases in mortality were seen. Data probit analysis demonstrated that lethal concentration to kill 50% of the population (LC_{50}) for *F. gummosa*, *R. officinalis* and *M. piperita* was estimated as 44.26, 2.15 and $0.97\mu\text{l/l}$ air, respectively. Between these essential oils, *M. piperita* was almost more toxic than *R. officinalis* and *F. gummosa*. The present study suggests that essential oils from these medicinal plants may be potential grain protectants as botanical alternative fumigants.

Efficacy of *Mentha longifolia* and *Thymus kotschyanus* essential oils

on nutrition indices and oviposition deterrence of *Tribolium castaneum*

Hoda Akrami, Saeid Moharrampour, Sohrab Imani 263-269

Abstract: Plant extracts contain compounds that show antifeedant, deterrent and toxic in insects. Therefore, efficacies of essential oils from *Mentha longifolia* L. and *Thymus kotschyanus* Boiss and Hohen were tested on nutritional indices and oviposition deterrence of *Tribolium castaneum* (Herbst). Essential oils were extracted by hydrodistillation using Clevenger type apparatus. Several experiments were designed to measure the nutritional indices such as relative growth rate (RGR), relative consumption rate (RCR), efficiency of conversion of ingested food (ECI) and feeding deterrence index (FDI). Treatments were evaluated by the method of flour disk bioassay

in dark, at $27\pm 1^\circ\text{C}$ and $65\pm 5\%$ R.H. Several concentrations (200, 1000, 1500, 2000, 3000 and 4000ppm) were used to assess antifeedant activity of the essential oils. In this experiment, 10 insects were introduced into each treated disk, and the indices were estimated three days later. Oviposition deterrence was evaluated using black filter papers impregnated with several concentrations of the essential oils (6000-38000ppm). Results showed that *M. longifolia* oil was highly effective compared with *T. kotschyanus* and decreased the RGR, RCR and ECI significantly. Moreover, *M. longifolia* significantly increased feeding deterrence. The plant essential oils tested reduced the oviposition rate of *T. castaneum* significantly. At the highest concentration (38000 ppm) of *M. longifolia* and *T. kotschyanus*, oviposition deterrence was 95.9% and 89.43%, respectively. Findings indicate the capability of these plant essential oils in the management of *T. castaneum* in storage.

Insecticidal activity of essential oils isolated from Rue (*Ruta graveolens* L.) and Galbanum (*Ferula gummosa* Boiss.) on *Callosobruchus maculatus* (F.)
 Mohammad Hossein Hosseinpour, Alireza Askarianzadeh, Saeid Moharramipour, Jalal Jalali Sendi 271-275

Abstract: In recent years, essential oils of medicinal plants have received much attention as pest control chemical agents because of their insecticidal, repellent and antifeedant properties. In this research, the fumigant activity of essential oils of *Ruta graveolens* L. and *Ferula gummosa* Boiss. was tested against adults of *Callosobruchus maculatus* (F.). The essential oils were obtained from dry leaves of Rue and gum of Galbanum plant and subjected to hydrodistillation using a modified Clevenger-type apparatus. The experiments were conducted at $27 \pm 1^\circ\text{C}$, $65 \pm 5\%$ RH and in dark conditions. Fumigant toxicity of essential oils was tested against 1-7 days old adults of *C. maculatus*. Mortality of adults was tested at different concentrations ranging from 7.1 to $57.1\mu\text{l/l}$ air. Results showed that LC_{50} values of Rue and Galbanum to be 14.7 and $29.41\mu\text{l/l}$ air, respectively for 24 hours fumigation. This finding show that essential oil of *R. graveolens* may be much more effective than *F. gummosa*. Therefore, these essential oils could have potential for controlling of *C. maculatus* in organic food management.

Fumigant toxicity of *Lavandula angustifolia* Mill and *Zataria multiflora* Boiss. on *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae)
 Moravvej, G., Azizi, M., Hatefi, S., Golestani, Z. 276
Abstract only

Fumigant toxicity of essential oil from *Zhumeria majdae* against *Callosobruchus maculatus*
 Mehrnoosh Nikooei, Saeid Moharramipour, Ali Asghar Talebi 277-280

Abstract: Pest control in many storage systems depends on fumigation with chemical insecticides. Due to the development of insecticide resistance and risks to human health and the environment of synthetic compounds, the search for alternative insecticides is encouraged. Recently, there have been several studies on alternative substances with insecticidal activity, such as essential oils of plants on stored insect pests. *Zhumeria majdae* Rech. F. and Wendelbo (Lamiaceae) is one of these plants that have medicinal effects on human. An experiment was conducted to investigate fumigant toxicity of the essential oil that was extracted by hydrodistillation from dry aerial parts of the plant. In this study, fumigant toxicity was tested against 1-3 days old adults of *Callosobruchus maculatus* (F.) with five replications at $27\pm 1^\circ\text{C}$ and $65\pm 5\%$ RH in dark condition. The mortality was increased with concentration from 37.03 to $259.25\mu\text{l/l}$ air and with exposure time from 3 to 24h. At the lowest concentration ($37.03\mu\text{l/l}$ air), kills of the insects reached 20% with a 3h exposure. Concentrations from 111.11 to $259.25\mu\text{l/l}$ air and exposure time of 6h were enough to obtain more than 50% kill of the insects. The mortalities of the insects reached 100% at concentrations higher than $37.03\mu\text{l/l}$ air and 12h exposure time. The findings indicate the strong insecticidal activity of *Z. majdae* oil and its potential role as a fumigant for stored product insects.

Chemical composition and insecticidal activity of essential oil from
Zataria multiflora Boiss. (Lamiaceae) against *Callosobruchus maculatus* (F.)
(Coleoptera: Bruchidae)
Fahimeh Rastegar, Saeid Moharramipour, Mahmood Shojai,
Habib Abbasipour 281-288

Abstract: In recent years essential oils of medicinal plants have received much attention as pest control chemical agents. The discovery of active compounds that are less persistent will be beneficial for both the environment and agricultural product consumers. *Zataria multiflora* is a plant belonging to the Iran, Pakistan and Afghanistan. The essential oil of dried leaves and flowers were obtained by Clevenger-type apparatus. The composition of the essential oil was analyzed by GC- MS. Sixteen compounds representing 95.91% of total oil were identified. The major components in the oil were Thymol (30.72%) and Carvacrol (29.95%). Fumigant toxicity of essential oil from *Z. multiflora* was tested against adults, different ages of larvae and eggs. The experiments were carried out at $25 \pm 1^\circ\text{C}$ and $65 \pm 5\%$ RH under dark condition. The essential oil showed strong adulticidal, larvicidal and ovicidal activity. Probit analysis showed that the LC_{50} values for adults were $8.81\mu\text{l/l}$ air, for 1, 7 and 14 days larvae were 8.47, 10.37, $13.36\mu\text{l/l}$ air and for 1, 3 and 6 days eggs were 4.55, 3.63, $3.01\mu\text{l/l}$ air, respectively. On the basis of these LC_{50} values, eggs were much more susceptible than adults and larvae. The essential oil *Z. multiflora* may be suitable as fumigants because of its high volatility and safety.

Insecticidal and repellent activities of *Citrus reticulata*, *Citrus limon* and
Citrus aurantium essential oils on *Callosobruchus maculatus* (F.)
(Coleoptera: Bruchidae)
Mahdieh Saeidi, Saeid Moharramipour, Fatemeh Sefidkon,
Sirous Aghajanzadeh 289-293

Abstract: In this research, fumigant toxicity of *Citrus reticulata* Blanco (Rutaceae), *Citrus limon* L. (Rutaceae) and *Citrus aurantium* L. (Rutaceae) peel essential oils was examined on adults of *Callosobruchus maculatus* (F.) at $27\pm 1^\circ\text{C}$ and $65\pm 5\%$ RH in darkness. The oils were extracted from the fruit peels using water steam distillation. A Y-tube olfactometer was used to examine the repellency of the essential oil. Adults (1-7 days old) of cowpea beetles were introduced individually into the introduction chambers. The LC_{50} values (%95 fiducial limits) for *C. reticulata*, *C. limon* and *C. aurantium* were estimated to be 8.70 (8.30-9.15), 7.21 (6.79-7.71) and 6.33 (5.88-6.88) $\mu\text{l/l}$ air, respectively. LC_{50} values indicated that *C. maculatus* was significantly less sensitive to *C. reticulata*. Also *C. reticulata* was significantly more repellent to *C. maculatus*. The findings showed the strong insecticidal and repellent activity of Citrus peel essential oils and their potential role as fumigants for stored product insects.

Susceptibility of eggs of *Tribolium confusum* du Val. (Coleoptera: Tenebrionidae),
Ephestia kuehniella (Zell.) and *Plodia interpunctella* (Hübner)
(Lepidoptera: Pyralidae) to four essential oil vapours
O. Saglam, A. A. Isikber, N. Ozder 294
Abstract only

Ovicidal effect of methanolic extracts of *Spinacea oleracea* L. on
Ephestia kuehniella Zeller
Bibi Zahra Sahaf, Saeid Moharramipour 295-298

Abstract: Many plant species produce phytoecdysteroids. There is increasing evidence that phytoecdysteroids are used as a chemical defense by plants against non-adapted insects. Phytoecdysteroids are analogues of insect steroid hormones, and have proposed as new tools for insect pest control, because of their endocrine disruption on different stages of insects. Spinach is one of the very few crop plants which produce large amounts of phytoecdysteroids, specially 20 hydroxyecdysone. Therefore, we used methanolic extract of *Spinacia oleracea* L. (Chenopodiaceae) on one-day eggs of *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae). The methanolic extract was obtained from leaves of *S. oleracea*. The aqueous methanol phase

contained the ecdysteroidal profile of spinach. The experiments were conducted with three replications at $27 \pm 1^\circ\text{C}$, $65 \pm 5\%$ R.H. and in dark condition. The eggs soaked in different concentrations of the extracts. The results demonstrated that the hatching rate decreased as concentration of the extracts increased. Data probit analysis demonstrated that lethal concentration to kill 50% of the eggs (LC_{50}) was 24.65%. However, complete kill of the eggs were occurred at 70%. The present study demonstrated the ecdysteroidal components of the spinach as an ovicide and effective on the hatching rate of *E. kuehniella*. Therefore, this extract may be potential grain protectants as botanical alternative agent.

Efficiency of essential oil from *Salvia mirzayanii* against nutritional indices of *Tribolium confusum*

Safieh Soleimannejad, Saeid Moharramipour, Yaghoub Fathipour, Mehrnoosh Nikooei 299-302

Abstract: Application of plant essential oils has been considered as an important feeding deterrence in integrated pest management (IPM) programs. In this study, we evaluated the effects of *Salvia mirzayanii* (Rech. F. and Esfand) oil on the nutritional indices of adults of *Tribolium confusum* (J. du Val.) at $27 \pm 1^\circ\text{C}$, $50 \pm 5\%$ RH in continuous darkness. Nutritional indices of adults were investigated at different concentrations from 925.92 to 4629.62 $\mu\text{l/l}$ air. In a no-choice experiment, a flour disc bioassay was used to test nutritional indices such as relative consumption rate (RCR), relative growth rate (RGR), efficiency of conversion of ingested food (ECI) and feeding deterrence index (FDI). All of the indices varied significantly as concentration of the essential oil increased. Increasing oil concentration from 925.92 to 4629.62 $\mu\text{l/l}$ air reduced RCR from 0.19 to 0.07 mg/mg/insect as well as RGR from 0.14 to 0.02 mg/mg/insect, respectively. ECI was reduced from 77.21 to 39.47% at the same concentrations. However, FDI of *T. confusum* adults was increased significantly from 6.04 to 64.27% with increasing concentration from 925.92 to 4629.62 $\mu\text{l/l}$ air, respectively. Findings indicated that *S. mirzayanii* oil could toxically interfere severe dietary effects in adults of *T. confusum*. Therefore, *S. mirzayanii* oil could be a proper antifeedant agent for *T. confusum*.

Session 5: Fumigation, controlled atmospheres, modified atmospheres and extreme temperatures

Susceptibility of cigarette beetle life stages to elevated temperatures

Subramanyam, Bh., Yun, C., Flinn, P. 305
Abstract only

Freezing for pest control in spices, nuts, herbs or dried fruits

Cornel Adler 306
Abstract only

A rapid laboratory method for comparative assessment of heat tolerance and lethal upper temperature level for different stored-product insect species by thermo-respirometry

Francis Fleurat-Lessard, Bernard Fuzeau, Jean-Baptiste Enjelvin 307-319

Abstract: The effect of a fast temperature increase on the physiological condition of four insect pest species of grain and cereal processing plants (*Sitophilus zeamais*, *Rhyzopertha dominica*, *Tribolium castaneum* and *Tribolium confusum*) was evaluated through the monitoring of their metabolic rate during a temperature increase from 25-28°C (optimal temperature) up to 60°C, i.e. beyond the lethal temperature. The criterion used for the quantification of metabolic rate was the carbon dioxide release rate by insect groups (200 individuals) in using an open-flow micro-respirometer. The definite changes observed along the curve of CO_2 released by the insects during a progressive heating process at a rate of $0.5^\circ\text{C min}^{-1}$ enabled to accurately determine the temperature levels at which significant events occurred corresponding with a known

physiological foundation. This test enabled to accurately determine remarkable physiological changes: the spiracle closing temperature, the heat stupor coma temperature (catharsis), and the lethal temperature. The different patterns of the CO₂ release rate were established in averaging several replicates of the heating procedure with each species. The patterns obtained with different species, stages or strains were compared and discussed. Given our experimental conditions, the most heat tolerant species was the lesser grain borer *R. dominica* for which the mean lethal temperature was observed at 53.35°C. For *S. zeamais*, the lethal temperature (LT) was observed at 48.57°C and 49.98°C for a Portuguese and a French strain, respectively. The LT of the red flour beetle (*T. castaneum*) was observed at 49.83°C, when it was determined at 47.82°C for the confused flour beetle (*T. confusum*). Additionally, a very different pattern of the thermo-respirometric curve between these two related species was observed: *T. confusum* displayed a regular increase in the CO₂ production rate according to the temperature increase, while in *T. castaneum* the CO₂ release rate pattern changed considerably at different time intervals. In every case, the capacity to develop a physiological reaction (especially in the capacity to close the thoracic spiracles when oxygen uptake reached a potentially injurious level) to heat increase observed for the three “true” tropical species (*S. zeamais*, *R. dominica* and *T. castaneum*) may probably be the consequence of a more rapid start in the biosynthesis of heat shock proteins than for the last species (*T. confusum*).

Evaluation of carbon dioxide treatments at high pressure and at different temperatures against <i>Plodia interpunctella</i> (Hübner) (Lepidoptera: Pyralidae) and <i>Sitophilus oryzae</i> (L.) (Coleoptera: Curculionidae)	
<i>M. José Pons, Cristina Castañé, Jordi Riudavets</i>	321-326

Abstract: The application of CO₂ at high pressure has been used as an alternative treatment to methyl bromide for the control of insect pests on high value stored products. However, the application of high pressure treatments represents an important capital investment. On the other hand, heat treatments are also alternative treatments that are commercially available, although have high energy consumption and can affect the quality of the treated food product. In order to improve the efficacy of both treatments and achieve a reduction in the exposure time, we evaluated the possibility of the combined use of pressure and temperature treatment. We tested the effect of two pressures (20 and 10 bar) in combination with four different temperatures (50, 45, 40 and 25°C) on the mortality of *Plodia interpunctella* eggs and *Sitophilus oryzae* eggs and larvae. When CO₂ was applied at 20 bar and 25°C, total mortality was achieved after 10 minutes for *P. interpunctella* eggs and after 60 and 40 minutes for *S. oryzae* eggs and larvae, respectively. The reduction of pressure to 10 bar, that needs half the amount of CO₂ and implies a reduction of cost, increased the treatment time to 60 minutes for *P. interpunctella* and 240 minutes for *S. oryzae*. However, with the combined use of pressure and temperature, efficacy was achieved within a shorter exposure time, and for a pressure of 10 bar and a temperature of 40°C, only 10 minutes were needed for total mortality of *P. interpunctella* and 60 minutes for *S. oryzae* eggs and larvae.

Effect of sulfuryl fluoride fumigation on dried fig quality	
<i>Sen, F., Meyvacı, K. B., Aksoy, U., Tan, G., Buckley, S.</i>	327
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Laboratory evaluation of availability and level of resistance to phosphine
in five Bulgarian populations of *Trogoderma versicolor* Creutz.
(Coleoptera: Dermestidae)

Angel Obretenchev, Doncho Obretenchev, Evdokia Staneva, Svetla Maneva ... 329-339

Abstract: Five populations of *Trogoderma versicolor* Creutz. were established in Bulgaria from 1998 till 2006: in different wheat varieties in storage at Plant Protection Institute (PPI), which was bread under laboratory conditions 6 years long; in storage with packed wheat germs in confectionary factory in the town of Burgas; in wheat grain storage in Draganovo village; in storage with herbs in the town of Shumen and in storage with cocoons of *Bombix mori* L. in SVILA factory in the town of Haskovo. The resistance to phosphine in adult insects and 4th-5th instar larvae in these populations was investigated. The experiments were conducted in the laboratory for stored product insects at Plant Protection Institute. It was found that the highest resistance to phosphine showed the population from Haskovo. The LD₅₀ values for the adults and the larvae were 0.0358mg/l and 0.1180mg/l, respectively; the LD_{99,9} values 0.1350mg/l and 1.8810 mg/l, respectively. Resistance showed also the population from Draganovo – the LD₅₀ values for the adults did not differ from those in the laboratory population (PPI) (0.0058mg/l and 0.0041mg/l, respectively), while according the LD_{99,9} values their resistance was visible. The resistance in the larvae in this population was good expressed – the LD₅₀ and LD_{99,9} values were 0.0487mg/l and 1.0780mg/l, respectively. Susceptible to phosphine were the laboratory population and the populations from Burgas and Shumen. The larvae from all tested populations showed higher resistance to phosphine compared to the adult insects. The increased resistance to phosphine in the populations led to a longer larval development (68-97 days), lower weight of the female pupae (2,93-6,43mg) and lower reproductive potential (the number of laid eggs varied from 10 to 86) compared to the same parameters in the susceptible populations. The populations of *T. versicolor* from storages and foodstuffs which have been treated many times with phosphine without obtaining sufficient efficacy showed increased resistance.

Susceptibility of *Stegobium paniceum* (Coleoptera: Anobiidae) to low and high
temperature at different life stages

Abdelghany, A., Awadalla, S. S., Abdel-Baky, N. F., El-Syrafy, H. A.,
Fields, P. G. 340

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Efficacy of heat to disinfect concrete grain silos

Edmond Bonjour, Carol L. Jones, George P. Opit, Randy L. Beeby,
Frank H. Arthur, Thomas W. Phillips 341-348

Abstract: Field experiments were conducted in 30.2m tall empty concrete silos. Three replications were completed, each on consecutive days, consisting of one heated silo and one silo under ambient conditions. A Mobile Heat Treatment Unit was used to introduce heat into the silos. When the average temperature in a heated silo reached 50°C, heating was continued only for the next 8h. Ventilated plastic containers with a capacity of 100g of wheat kernels held all life stages of *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) and *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). Polyvinyl chloride containers with a capacity of 300g of wheat held adults of two psocid species: *Liposcelis corrodens* (Heymons) (Psocoptera: Liposcelidae) and *L. decolor* (Pearman) which were contained in 35 mm Petri dishes within the grain. Containers were fastened to a rope suspended from the top of the silo at depths of just under the top manhole, 10.1, 20.1, and 30.2 meters below the top manhole. There was 100% mortality of adult *T. castaneum* at the lower three depths but 4% survived near the top manhole where it was slightly cooler, while ≥99% survived in the control silos. *T. castaneum* progeny were produced only near the top manhole in the heat treatments. For *R. dominica*, adult survival in the heat treatments averaged 39.3, 6.6, 0, and 1.0% at increasing depths, while survival was greater than 95% in the control silos. Progeny of *R. dominica* was produced at all depths in the heat treatments except where there was no adult survival. There was 100% mortality of

L. corrodens at all depths in the heat treatments but only 92.5% mortality for *L. decolor* with those surviving being located at the top manhole level. Wheat kernels had a strong insulating effect. Economics of heat treatment are evaluated.

Laboratory assessment of the influence of various structure materials
on the mortality of three cereal-flour insect pest species after various
exposure intervals to a temperature of 50°C

Francis Fleurat-Lessard, Bernard Fuzeau, Cecile Bezler, Rachid Benlafquih 349-355

Abstract: A laboratory test was conducted whereby three species of common insect species in cereal processing plants of different body size (*Tenebrio molitor*, *Oryzaephilus surinamensis* and *Tribolium confusum*), maintained on three different structure material (galvanized iron, thin wood plate, and ceramic tile), were exposed to a fixed temperature of 50°C during increasing exposure times. During heat exposure, the temperature at the surface of each material was monitored by flat shape temperature sensors. The insect mortality was assessed on four replicates of 25 individuals per kind of material immediately after the insects were withdrawn from the 50°C-heated chamber at the end of the exposure time. The definitive percentage of killing was confirmed after 48 h incubation in optimal conditions for insect survival. The mortality rate varied significantly both between the three species and between the different support materials. The lethal exposure was reached first on galvanized iron support, more slowly on ceramic tile, and very slowly on wood plate. The yellow mealworm (adult stage) was observed the most sensitive species to the heat treatment, preceding the saw-toothed grain beetle and the confused flour beetle. For this last species, a large part of adult stage population (about 50%) exposed to 50°C in the present experimental conditions was not killed by prolonged exposure time when maintained on the wood plate support. It was confirmed by temperature records that the temperature at the surface of wood plates was about one °C less than the temperature at the surface of the two others materials. Consequently, it is emphasized that even though 50°C is considered as the lowest temperature level to be achieved in flour mill heat treatment schedules, it seems insufficient to kill the less sensitive insect species when crawling on a woody surface. These results indicated that i/ for an economical heat disinfection schedule of flour mills, temperature must be carefully measured and controlled on the structural material with the highest insulating capacity (such as wood or brick); ii/ the preliminary identification of the current insect species is of prime importance to determine its intrinsic heat tolerance; iii/ the relative level of tolerance of all the target insect species to be killed by heat treatment must be well known. To feed this later requirement, a new laboratory test enabling a rapid discrimination between insect species and even strains was studied in order to accurately determine upper lethal temperature level (see related communication in these proceedings).

Microwave treatments and mortality in *Callosobruchus maculatus* (F.) and
Acanthoscelides obtectus (Say) (Coleoptera: Bruchidae)

Sauro Simoni, Elisabetta Gargani, Riccardo Frosinini, Luca Tirinnanzi,
Francesca Ciudici, Andrea Maestrelli, Marcello Della Campa, Nicola Diaferia,
Valerio Rosito, Pio Federico Roversi 357-362

Abstract: The cowpea weevil (*Callosobruchus maculatus*) and the bean weevil (*Acanthoscelides obtectus*) can cause serious pulse infestations. Due to the cryptic habits of these Bruchids for most part of their life cycle, monitoring and control are difficult, especially during the ensilage period. Here, the control of these pests, with the use of a microwave (MW) apparatus – the metallic reverberating chamber, “Misya” (EMitech Society) – is evaluated. On both species, the trials were performed on eggs, larvae and adults. Seed lots of biological chickpeas were put into small propylene boxes, MW transparent. In each box, a nonwoven sachet containing seeds, infested by different development stages of *A. obtectus* and *C. maculatus* was introduced. Every sample was treated in the “Misya” chamber. MW power was applied with different exposure times. After the application, the MW treated sachets were put into a climatic cabinet at 25°C, RH 50% and 16:8 photoperiod. With regard to the test of preimaginal stages, weekly observations were performed till adult emergence. Physical and organoleptic analyses were carried out on

seeds to check even quality modification in all treated samples both infested and non infested. The evidences acquired suggested interesting perspectives concerning the adoption of this technique.

Effect of ultra violet irradiation on egg hatching of *Callosobruchus maculatus* (F.)

(Coleoptera: Bruchidae)

Roshanak Sedaghat, Ali Asghar Talebi, Saeid Moharamipour 363-368

Abstract: The cowpea weevil, *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae) is a serious cosmopolitan pest of stored products, especially seeds of Leguminosae, and is to be found throughout the tropics and subtropics. In this research, the effect of ultraviolet irradiation (UV) on egg hatching of *C. maculatus* was evaluated at temperature of $25\pm 5^{\circ}\text{C}$ and a photoperiod of 10:14 (L:D), without humidity control. Three age groups of eggs (1-, 2- and 3-day old eggs), were exposed to UV-irradiation (254nm wavelength). In each group 120 eggs were irradiated for 2, 4, 8, 16, 24, 32, 40 min. The results indicated that all exposure periods of UV-irradiation, reduced the hatching of eggs in comparison to control. An increase in time of exposure to irradiation caused a gradual decrease in percentage of hatching of eggs in all age groups of eggs. However, for each exposure duration, the hatching rate was decreased as the age of irradiated eggs increased from 1 to 3 days. The percentage of egg hatching was determined to be 95% in control treatment. In one-day-old eggs, egg hatching was 71.93, 64.92, 37.72, 28.95, 22.81, 10.53 and 7.89% at 2, 4, 8, 16, 24, 32 and 40 min exposure time, respectively. Irradiation of 2-day-old eggs at 2, 4, 8, 16, 24, 32 and 40 min exposure duration resulted in 43.86, 18.43, 9.65, 5.27, 7.03, 6.15 and 5.51% egg hatch, respectively. Irradiation of 3-day-old eggs at the same exposure duration resulted in 40.36, 21.93, 9.65, 7.89, 5.27, 2.64 and 1.86% egg hatch, respectively. The 1-day-old eggs were less sensitive to irradiation than 2- and 3-day old eggs. It may be concluded that UV-irradiation is a safe and clean method for stored product preservation and pest control. However, much more comprehensive studies on demographic parameters of *C. maculatus* are needed.

Mortality effect of elevated temperatures on adult German cockroach,

Blattella germanica (L.) (Dictyoptera: Blattellidae)

Tunaz, H., Isikber, A. A. 369

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Session 6: Chemical control and inert dusts

Are phenylpyrazole insecticides alternatives for organophosphate insecticides to control storage pests?

Stejskal, V., Aulicky, R., Kucerova, Z., Novakova, M. 373-377

Abstract: We have tested a new surface spray formulation of fipronil (Attricide 26 SC; fipronil 26g/l) for its ability to control two species of storage beetles (*Sitophilus granarius* and *Tribolium castaneum*) on four types of surfaces (paper, concrete, glass and wood) that can be encountered in grains stores and food industry premises. We used permanent exposure on the surface treated 1% concentration of Attricide 26 SC. The mortality after 96 hours exposure was as follows: *S. granarius* (concrete – 100% glass – 100% and wood – 100%) and *T. castaneum* (concrete – 92%, glass – 63 % and wood – 78%). The results showed a high efficacy of the tested fipronil formulation on *S. granarius* while the sensitivity of the *T. castaneum* was substantially lower.

Residual efficacy of the insect growth regulator pyriproxifen for control of stored product insects

Frank H. Arthur, Thomas W. Phillips ... 379-383

Abstract: The insect growth regulator pyriproxifen is registered in the USA as an aerosol and as a surface treatment to control stored product insects. Field trials with the aerosol show that residues from an application of pyrethrin + pyriproxifen gave residual control of *Tribolium*

castaneum Herbst for at least 10 weeks. Laboratory tests with pyriproxyfen alone as a surface treatment gave greater residual control compared to hydroprene, even though the application rates for pyriproxyfen were 5 to 10 times lower than the label rate for hydroprene. Results show that pyriproxyfen could be incorporated into management programs to control stored product insects.

Insecticidal effect of spinosad dust against three stored-grain insect species:

effect of strain, commodity and combination with diatomaceous earth

Chintzoglou, G., Athanassiou, C. G., Arthur, F. H., Kavallieratos, N. G.,

Markoglou, A. N. 385-386

Abstract only

Development of a non-toxic, ecologically compatible, natural-resource based insecticide from diatomaceous earth deposits of South Eastern Europe to control stored-grain insect pests

Athanassiou, C., Kavallieratos, N., Vayias, B., Tomanovic, Z., Petrovic, A.,

Trdan, S., Adler, C., Korunic, Z., Rozman, V. 387-388

Abstract only

Insecticide potential of diatomaceous earth from Croatia

Zlatko Korunic, Vlatka Rozman, Josip Halamic, Irma Kalinovic, Darka Hamel 389-397

Abstract: Diatomaceous earth (DE) is a geological deposit consisting of the fossilized skeletons of numerous species of siliceous marine and fresh water one-cellular organisms, particularly diatoms and other algae. The skeletons are made of amorphous silicon dioxide. DE is probably the most effective natural inert dust used as an insecticide. DE is a low toxicity, natural insecticide. Several formulations of DE are registered and used as stored product protection insecticides around the world. The objective of the research was determination of the potential insecticide effectiveness of Croatian DE against stored products pests and the comparison of their effectiveness with the effectiveness of standard DE sample. One sample of the Croatian DE was selected and investigated. As a standard DE sample, the German fresh water DE SilicoSec was included into the experiment. SilicoSec formulation is registered as a grain protectant and belongs into a group of the most effective DEs in the world. The effectiveness of particle size fractions of the Croatian DE from most to least effective is: 0-20 microns (μm), 0-45 μm 0-150 μm , 20-45 μm and 45-150 μm . The Croatian DE sample applied at 600mg/kg containing particle size 0-45 μm showed with over 90% mortality after 1 day for *Cryptolestes ferrugineus*, after 3 days for *Sitophilus oryzae*, after 7 days for *Rhyzopertha dominica* and after 25 days for *Tribolium castaneum*. SilicoSec caused 100% mortality these insects at the same or shorter time periods. The effectiveness of the Croatian DE containing particles smaller than 45 μm was equally effective against the progeny if compared with the effectiveness of the standard DE.

The authors conclude that Croatia has potential sources of DEs for ecological acceptable insecticide production and it is important to find new localities with even better sources of DEs. It can be a new safe and natural insecticide product from Croatia.

Laboratory examination of the efficacy of sodium selenite rodenticide against wild populations of Norway rat (*Rattus norvegicus*)

Goran Jokić, Marina Vukša, Mirko Draganić, Ivan Čović, Suzana Đedović 399-403

Abstract: Laboratory feeding tests were carried out to determine the efficacy of sodium selenite as a rodenticide against individually caged wild male and female Norway rats *Rattus norvegicus*. The experiment was conducted on 20 animals (10 males and 10 females) captured at two milling facilities near Novi Sad, Serbia, and in compliance with the recommended OEPP/EPPO procedure. Individual animals were acclimated to cage (120x90x45cm, l, w, h) and laboratory conditions for 7-10 days after catching. Over the period, they had free access to unpoisoned baits, made on the same recipe as poisoned ones, only without the active ingredient. The rats were offered 20g of unpoisoned bait per individual and the portions were measured and refilled on a

daily basis. After the period of acclimation, rats were given portions of 20g of bait containing 0.1% sodium selenite. The consumed amounts of poisoned bait were measured daily and refilled with fresh bait of identical weight. During the experiment, water was available ad libitum. Males, having 259.8±12.12g average weight, died after 8.9±0.85 days, while females with average 179.1±12.65g weight died after 7.9±0.86 days. Palatability of sodium selenite was very good.

The effect of rodenticide baits containing 0.1% sodium selenite against commensal rodents *Rattus norvegicus* and *Mus musculus* at a flour mill facility
Goran Jokić, Marina Vukša, Suzana Đedović 405-408

Abstract: Despite their highly detrimental effect on the environment, humans and animals, and an evolution of resistance to them which was observed in the EU as far back as in the 1970s, anticoagulant rodenticides have continued to be the most widely represented means of controlling populations of commensal rodents. In Serbia, potential rodent resistance to those compounds has not yet been thoroughly researched. In keeping with global trends of introducing more environment-friendly products, a rodenticide based on sodium selenite has been used in Serbia to control commensal rodents. The mechanism of activity of sodium selenite is based on an exchange of SH-S-S groups of functional enzymes. Experiments were conducted at a flour mill facility in Serbia (GPS.: 44°45'N, 20°44'E), following a standard EPPO procedure, to test the efficacy of baits containing 0.1% sodium selenite against *Mus musculus* in facilities for wheat milling and flour packaging and storing, and against *Rattus norvegicus* around the mill, in wheat storage rooms and outbuildings. Baits were laid in boxes, at 1-3m intervals and in 30g portions for *Mus musculus*, and 150g portions appropriately positioned for *Rattus norvegicus*. Additionally, 100g baits were laid in active holes of *Rattus norvegicus* found in the mill's vicinity. The numbers of commensal rodents were evaluated based on the highest and lowest daily bait take over a 10-day experimental period, divided by the daily required amount of feeding, and using a census method before and after treatment. The results showed that the efficacy of sodium selenite baits, calculated from the ratio of required daily diet and daily bait take, and by census method, was 89.38% and 81.48% for *Mus musculus*, and 82.12% and 78.57% for *Rattus norvegicus*.

Effect of Serbian-originated diatomaceous earths on *Acanthoscelides obtectus* (Say) adults on treated beans
Petar Kljajić, Goran Andrić, Milan Adamović, Mirjana Marković,
Marijana Pražić 409-414

Abstract: Based on current IPM programs for the protection of stored products, as well as general food safety concerns, a preliminary study was conducted to test the potential of natural diatomaceous earths originating from Serbia (roughly purified at the Institute of Technology of Nuclear and Other Raw Materials, Belgrade) in protecting beans against *Acanthoscelides obtectus* (Say). Using modified methods OEPP/EPPO (2004), three dust products with different SiO₂ contents, i.e. DE S-1 with 79.8%, DE S-2 with 63.2% and DE S-3 with 46.5%, were tested against *A. obtectus* in the laboratory at 24±1°C and 55±5% r.h. All three diatomaceous earths were applied at the rates of 0.5, 1.0 and 1.5g/kg of beans. Lethal effects on weevils were determined after three and seven days of contact with treated beans. The effects of dusts on progeny production/reduction in F₁ generation were also determined. *A. obtectus* mortality after three days of exposure was not significant, while maximum mortality after seven days was 52.5 and 57.5% on beans treated with the highest rates of DE S-1 and DE S-2, respectively. However, progeny reduction after three days of parent exposure to beans treated with all three rates of DE S-1 and DE S-2, and with 1.0 and 1.5g/kg rates of DE S-3 achieved a high level of 97.5-100% and 100%, respectively. Progeny reduction after seven days of parent contact ranged 86.8-100% (DE S-1), 72.8-99.3% (DE S-2) and 17.6-97.1% (DE S-3). The results indicate that the tested diatomaceous earths have weak direct insecticidal effect on bean weevil adults, but a high impact on progeny production.

Laboratory evaluation of the efficacy of diatomaceous earths against *Plodia interpunctella* (Hübner) larvae on treated broken and unbroken maize kernels

Petar Kljajić, Goran Andrić, Milan Adamović, Mirjana Marković, Marijana Pražić

415-421

Abstract: Inert dusts have been increasingly used to control stored-product insects, and diatomaceous earth products are the most important of them. Their efficacy is significantly affected by dust origin, environmental conditions, type of cereal grains and degree of grain damage. In laboratory experiments at $24\pm 1^\circ\text{C}$ and $60\pm 5\%$ r.h., we conducted preliminary testing of the efficacy of two Serbian diatomaceous earth products, DE S-1 (with 79.8% of SiO_2) and DE S-2 (with 63.2% of SiO_2) (roughly purified at the Institute of Technology of Nuclear and Other Raw Materials, Belgrade), against L_3 - L_4 larvae of Indian meal moth *Plodia interpunctella* (Hübner), and compared the results with those of the registered product Protect-Ittm (Hedley Technologies Inc., Canada). Maize containing 14.99% broken grains and maize without any broken grains were used in efficacy tests that employed modified methods OEPP/EPPO (2004). The Serbian dust products were tested at 0.6, 1.0 and 1.5g/kg rates, while Protect-Ittm was applied at the recommended rate of 0.6g/kg. Lethal effects were evaluated after 7 and 14 days of larval contact with treated maize grains. Depending on the application rate, larval mortality after 7 days of contact with treated broken grains was found to range: 50.0-73.3% (DE S-1), 8.3-51.7% (DE S-2), and 45.0% (Protect-Ittm), while dust efficacy on treated unbroken grains was significantly higher: 83.3-100% (DE S-1), 81.7-98.3% (DE S-2) and 91.7% (Protect-Ittm), respectively. After 14 days of larval contact with broken maize grains, the efficacy of Protect-Ittm and DE S-1 applied at 1.0 and 1.5g/kg exceeded 95%. All three diatomaceous earth products achieved high efficacy in treatments of unbroken grains: 91.7-100% (DE S-1), 80.0-96.7% (DE S-2), and 100% (Protect-Ittm). The results indicate that the two tested Serbian diatomaceous earth dusts, especially DE S-1, have high insecticidal potential for control of Indian meal moth larvae.

Laboratory evaluation of the efficacy of inert dusts against adults of rice weevil *Sitophilus oryzae* (L.) and red flour beetle *Tribolium castaneum* (Herbst) in treated wheat

Petar Kljajić, Goran Andrić, Milan Adamović, Mirjana Marković, Marijana Pražić

423-429

Abstract: Inert dusts have a prominent place in *IPM* programmes for protection of cereal grains from stored-product insects. The intention in this study was therefore to conduct preliminary tests of the insecticidal potential of several inert dusts in protecting wheat from *Sitophilus oryzae* and *Tribolium castaneum* adults, namely: (a) natural zeolite originating from Serbia (Minazel and Minazel plus with 63-68% SiO_2), (b) bentonite originating from Bosnia and Herzegovina (Bentonit, with 48.4% SiO_2), and (c) diatomaceous earths originating from Serbia (DE S-1 with 79.8% SiO_2 , and DE S-2 with 63.2% SiO_2) (roughly purified at the Institute of Technology of Nuclear and Other Raw Materials, Belgrade). The efficacy of dusts was tested in the laboratory ($24\pm 1^\circ\text{C}$ and $60\pm 5\%$ r.h) by exposing insects to wheat treated with 0.75g/kg of each product, using modified methods OEPP/EPPO (2004) and Collins (1990). Mortality was determined after 7 and 14 days of insect contact with treated wheat, while total mortality after 7 more days of recovery on untreated wheat. After seven days of exposure and the additional seven days of recovery of *S. oryzae* and *T. castaneum*, the highest efficacy was observed in treatments with DE S-1: 72% and 47%, and 78% and 61%, respectively. The highest efficacy after 14 days was achieved by DE S-1 (96%) and DE S-2 (91%) against *S. oryzae*, and DE S-1 (94%) and DE S-2 (89%) against *T. castaneum*. Total mortality of rice weevils reached 100% after contact with DE S-1 and DE S-2 dusts, while the highest mortality of red flour beetle reached 94% and 91%, respectively. Total mortality of both insects in wheat treated with Minazel was 86-89%. Under the trial conditions and application rate, none of the bentonite treatments achieved efficacy exceeding 15%, while Minazel plus reached a maximum of 53%, which indicates that higher application rates would be required to secure significant efficacy.

Insecticidal efficacy of three insect growth regulators (IGRs) against larvae of three European populations of *Tribolium confusum* (Col.: Tenebrionidae)

B. J. Vayias, D. N. Mylonas, C. G. Athanassiou, C. T. Buchelos 431-438

Abstract: The effectiveness of three Insect Growth Regulators (IGRs) was evaluated in the laboratory to control 1-3 instar larvae of three European populations of *Tribolium confusum* (Col.: Tenebrionidae) originating from Greece (GR), Germany (GER) and France (FR). The tested IGRs were diflubenzuron, fenoxycarb and pyriproxyfen and applied on hard wheat at three dose rates; 1, 5 and 10ppm. The effectiveness of the tested IGRs was evaluated after 14d of exposure of larvae on the treated commodity at 25°C. The most effective of the tested IGRs was diflubenzuron since it controlled 82.7% of the treated larvae, on average, while the less effective was fenoxycarb. Significant differences between pyriproxyfen and diflubenzuron or pyriproxyfen and fenoxycarb were not always recorded. The strain from Germany appeared to be more susceptible to the tested IGRs in comparison with the strains from France or Greece. However, between FR and GR strains significant differences in susceptibility to the tested IGRs were not always recorded. Increase of dose rate significantly enhanced efficacy of all three IGRs. Thus, the most effective dose was 10ppm, since it provided control against more than 90% of the treated larvae, in all of the tested cases.

Efficacy of five Slovenian natural quartz sands admixed with wheat grains against *Sitophilus oryzae*

Helena Rojht, Aleksander Horvat, Stanislav Trdan 439-444

Abstract: The efficacy of Slovenian quartz sands admixed with stored wheat was examined against rice weevil (*Sitophilus oryzae*) in laboratory conditions. Five different samples of quartz sand of different age were tested: from location Raka-Ravno (with admixture and clean), location Moravče (with admixture and clean) and commercially available cleaned quartz sand (Plantella) from Puonci locality, each at six concentrations: 100, 300, 500, 900, 1200 and 1500ppm. The amount of SiO₂ in all sand samples is high and varied from 91.52 to 99.24%. For each dose rate, the treated wheat grains were placed at two temperatures (25 and 30°C) and at 55% relative humidity level. Dead adults were counted after 7, 14 and 21 d of exposure. After 21 d counts all the exposed adults were removed and progeny production on treated grains was estimated after 60 d. All samples showed some insecticidal effect on adults of rice weevil. Commercial quartz sand formulation showed the most promising results with approx. 90% mortality of rice weevil adults at 1500ppm and at 30°C. At this conditions the progeny production was the lowest (7 adults per treatment) in experiment.

Session 7: Integrated Pest Management, pest prevention and legislation

Combination of diatomaceous earth, deltamethrin, and artificial cooling for insect management in paddy rice in subtropical climate

Flavio A. Lazzari, Sonia M. N. Lazzari, Fabiane C. Ceruti 447-453

Abstract: Paddy rice in southern Brazil is usually stored in metallic silos waiting to be milled for storage periods as long as 16 months. The longer the storage period the higher is the pressure of insects. The main problem has been large infestation of coleopterans on the top layer of the grain mass due to the head space effect – high temperatures and fines. The objective of this study is to provide the rice industry with a program for insect management in large scale facility using a combination of physical and chemical methods to safely protect the paddy rice against insects for at least one year. In this program 40 silos with capacity for 3500 tons/silo of paddy rice were treated as follows. Two portions of about 60 tons of rice were treated with a combination of 300ppm of diatomaceous earth (DE) (commercial name KEEPDRY) plus 30ppm of powder deltamethrin (K-obiol 2 P a.i. 2%) per ton of rice. The treatment was applied as the grain was transported to the silo by a system of bucked elevator, screw, and conveyor belt. After the bottom portion was filled into the silo it was levelled and the silo filled with untreated grain. The top layer was filled with the other portion of 60 tons treated rice, and levelled. After the silo was

completely filled, cold air produced artificially was insufflated throughout the aeration system at 0.12m³/min/t to bring the temperature of the grain mass down to 12-14°C. Temperature monitoring of the grain mass was made with thermocouples installed in each silo. As the temperature increased, new cycles of chilled aeration or natural cold air from the cold fronts were used to keep the grain temperature at a safe range to avoid insect infestation. The combination of DE with pyrethroid plus chilled aeration is a novel approach to manage paddy rice for long term storage, reducing food and environmental contamination, personal exposure at competitive cost.

The future of the pest control management for professionalism and European legislation: A new A.N.I.D. and C.E.P.A. commitment

Urizio, S. 454
Abstract only

Integrated Pest Management of rice for consumption: EUREKA project

Carvalho, M. O., Adler, C., Arthur, F. H., Athanassiou, C. G., Navarro, S., Riudavets, J., Trematerra, P. 455-466

Abstract: The EUREKA project “Integrated Pest Management of Rice for Consumption” was carried out integrating environmentally sound and sustainable technologies to replace conventional chemical treatments needed for protecting the quality of rice at different phases of post-harvest handling and storage to meet European standards. It started in June 2006 and ended in January 2009 with partnership of research institutions, industries and farmer associations from Portugal, Spain, Italy, Germany, Greece, Israel and the USA. The implementation of sampling programs using manual and electronic traps in storage facilities and premises showed to be an important tool for risk assessment (in time and space) and helped in decision-making as an IPM strategy. Consumer and regulatory agencies for environmental protection demand for chemical-free and contamination-free products. This is a general tendency that industry finds difficult to conform with because insecticides are often necessary to prevent economic damage. In addition, in many countries insects have been developing resistance to contact insecticides and to the fumigant phosphine. The most common non-chemical alternative identified in the rice storage and processing industry was using aeration to reduce the temperature of stored paddy rice. In summer, use of refrigeration units provided good solution for quality maintenance of paddy. During this project, rice mills applied modified atmospheres in silos and hermetic big bags as alternative control methods. The gas used (CO₂) is comparatively safe and environmentally friendly and showed to be effective against key pests on both paddy and polished rice. The implementation of these strategies was reflected in the significant decrease of the number of rejected units of polished rice from 111 tons of packaged polish rice before the project (2006) to 7 tons until the end of the project (January 2009) and continued decreasing to reach only 500kg in June 2009, which may be interpreted as an increase in consumer satisfaction.

Integrated Pest Management of insect pests in a past factory in Portugal

Maia, A., Barros, G. 467
Abstract only

Traceability for stored wheat and maize

Fabiane C. Ceruti, Sonia M. N. Lazzari, Flavio A. Lazzari 469-478

Abstract: To whom does it interest the identity preservation and traceability of grains? Obviously, to the processing industry and to the final consumer. It interests to the industry because it will process better quality grain with low contamination and at lower costs. It also interests to the consumer because he will be taking safer and better quality food. Despite the difficulties of implementing traceability programs for grains, there are some systems working satisfactorily in Brazil for meat production, seeds and fruits. In the grain production chain, technology is available; however, many challenges need to be overcome, from the field to storage and processing, for successful grain traceability programs. There are limitations on storage infrastructures (too large grain pits and dryers), lack of methodology and equipments for

measuring quality, lack of trained personnel and adequate silos for grain segregation. We designed a decision support system for recording the procedures for wheat and maize production from the field to the consumer. All the important steps for quality maintenance of stored wheat and maize were evaluated for one year. Monitoring of insect pests and control measures, including application of diatomaceous earth and artificial grain cooling, were carried out during the storage phase. Based on a detailed documentation of the procedures, a database was generated and information can be recovered along the process. The decision support system is a very simple and valuable tool for traceability of grains, adding value to products and increasing food safety.

The influence of the herb sage and wormwood on the migrational activity of saw-toothed grain beetles *Oryzaephilus surinamensis* L. (Coleoptera, Cucujidae) populations

Malgorzata Klys 479-484

Abstract: The object of this study was the saw-toothed grain beetle *Oryzaephilus surinamensis* (L.) The aim of the study was to determine the effect of the sage (*Salvia officinalis* L.) and wormwood (*Artemisia absinthium* L.) herbs on migration activity and mortality in saw-toothed grain beetle populations. The experiments were conducted in laboratory conditions in a thermostat, the temperature of 30°C and 70 ± 5% relative humidity (r. h.). In the experiments a set of culture vessels was used which enabled adult insects to migrate from the original population. The herbs were powdered and added to oat flakes in the proportion of 0.5g herbs to 40g oat flakes. The population of the saw-toothed grain beetles was controlled monthly for a period of five months in order to check if used the plants restrict the development and at the same time reduce the size of this pest. The results obtained allow for the conclusion that for *O. surinamensis* the wormwood is a repellent, because it causes a very considerable migration of insects from food to which this plant has been added. Saw-toothed grain beetles do not invade oat flakes to which some wormwood has been added. The wormwood has a toxic effect on the insects, resulting in a high mortality rate among them. The sage neither limits proliferation in the *O. surinamensis* population nor increases the mortality rate.

Application of ascorbic acid and gluten for improving of baking properties and quality in damaged wheat grains by *Eurygaster integriceps*

Askarianzadeh, A., Rajabzadeh, N., Abdollahi, A. 485

Abstract only

Moulds and insects affecting libraries and archives, ecological and applied issues: the use of entomopathogenic fungi to control library infestations

Flavia Pinzari, Mariasanta Montanari, Piero Colaizzi 487-497

Abstract: The use of entomopathogenic fungi to control pest infestation in libraries and archives to our knowledge has never been considered, until now. The problems that can occur in an eventual application of fungal commercial formulates against museum and library pests regard the efficacy on one side, and the possible activity against materials, or humans. In this paper, an experimental study on the possibility of utilising some entomopathogenic fungi in libraries and archives to control pests' populations is presented. Data on the metabolic profile, paper spoiling attitudes and pathogenicity to some pests of a strain of *Metarhizium anisopliae* (Metsch.) Sorokin (Deuteromycotina: Hyphomycetes) are presented. The metabolic profiling has been performed with a Biolog™ phenotype microarray method for filamentous fungi (FF^R-plates).

Life table parameters and thermal requirements of *Oryzaephilus surinamensis* (Coleoptera: Silvanidae) on different wheat cultivars

Shafaghi, F., Fathipour, Y., Kamali, K. 498

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