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Implications for integrated storage strategies of food contaminants legislation

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Abstract: Contaminants of grain in storage have been the subject of recent EU legislation and others are likely to come under scrutiny. Pesticide residues and mycotoxins are examples of the former and insects and mites are examples of the latter. Maximum residue levels may limit the efficacy of some pesticides and determine the mode of application. For instance, top-dressing may be questionable, which puts greater reliance on physical control. Regulatory levels for mycotoxins in food have focused attention on ochratoxin A (OTA) as the most important quality determinant for safe storage times for damp grain. This dictates how long it may be held in harvest backlogs before it is passed through a hot-air dryer or before a drying front is completed using an ambient air drying system. A UK project seeks to integrate an EU-funded model of OTA production with an established British drying model. This will determine under which conditions the new quality criteria can be achieved using current design parameters and how these may be improved. EU regulations for food hygiene require that farmers adopt procedures to minimise the risk of biological, chemical and physical contamination. Feed businesses must comply with specific microbiological criteria and adopt procedures to meet specific targets including a permanent written procedure based on HACCP procedures. This could be applied through national guides to good practice, such as HGCA's 'Grain storage guide'. However, determination of contaminants depends on accurate sampling and knowledge of distribution of the contaminants in bulks that requires further research.

Food safety and on-farm grain storage

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Abstract: An occasional survey in the German federal states of Brandenburg, Sachsen-Anhalt and Mecklenburg-Vorpommern, showed that 12 of 20 farms sold their grain directly after harvest. In farms storing grain, multi-purpose buildings often served for storage for periods of 3-12 months. These buildings posed no barrier to the immigration of insects, mites, and vertebrates. Grain was mostly not cleaned from dust, husks and other contaminants due to the lack of equipment. Cracks and crevices in walls and floors, wooden beams and high roofs with a multitude of dust collecting surfaces complicated cleaning prior to storing the new harvest. These conditions allow many pest species to establish permanently. Grain drying units, blowers and air ducts used in grain aeration facilities for cooling using ambient air, were found to be scarce. All grain samples taken were found infested at least with one insect species. Among the pests found in grain samples from on-farm storages were *Cryptolestes ferrugineus*, *Oryzaephilus surinamensis*, *Pyralis farinalis*, *Sitophilus granarius*, *Typhaea stercorea*, *Tenebrio molitor*, mites and booklice. Mouldy grain could be found close to walls, doors, openings, aeration ducts, in cracks or metal profiles. Poorest storage conditions were found in farms specialised on market crops other than grain and farms storing grain for feeding life-stock. It was concluded that on-farm storage may pose a risk to grain quality down the grain processing chain, that it may be advisable to define minimum storage quality standards, and to provide a better incentive for high-quality storage. A significant improvement could be the definition of a minimum standard of gas-tightness for European grain silo bins.

Insects in food in the Jewish religion as a motive for pest control

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Abstract: Judaism forbids the consumption of most types of animals with the exception of a restricted number of species which are specifically mentioned in the Bible. There is a strict injunction against eating insect-infested food, and this is a powerful motive for pest control operations in the whole system of food production acceptable by Judaism, particularly in Israel. The purpose is to supply food free from insects and insect fragments. Most of the public in Israel consumes kosher food, which has a rabbinic authorization according to Jewish dietary laws. Consequently these religious authorities are very powerful in controlling the food industry and the marketing system. In recent years, a monitoring system has been implemented using hundreds of religious inspectors who have been specially trained in entomology. This control system is mandate to permit food plants to obtain a "kashrut" certificate. Pest control is carried out mainly by monitoring: from the crops in the field, through post-harvesting procedures to the acceptance of the raw materials in the food factories, the objective being to prevent inclusion of insects into the food process. In the food industry, the insect monitoring is carried out throughout the production, packaging and storage procedures. The combination of monitoring by inspectors equipped with the essential professional knowledge and the motivation, from deep religious convictions, with the increasingly sophisticated monitoring systems, brings excellent results in achieving clean food with negligible infestation, acceptable by the "kashrut" authorities.

European network on biological control of pests in stored products

– COST Action 842, WG 4

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Abstract: In June 2005 the final meeting of the European COST Action 842 was held. COST (an intergovernmental framework for European CO-operation in the field of Scientific and Technical research) has made it possible for a group of researchers to meet on a regular basis during the 5½ years this action has been functional. Originally derived from two applications, COST 842 was entitled "Biological control of pest insects and mites with special reference to Entomophthorales". Working Group 4 dealt with "Biological control of arthropod pests in stored products". WG 4 had six meetings during its lifetime, most of the meetings with 20-25 delegates. The activities of WG 4 have been reported in written proceedings; they will become available on a website.

Insecticidal effect of diatomaceous earth applied alone or in combination with *Beauveria bassiana* and beta cyfluthrin against *Sitophilus granarius* on stored wheat

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Abstract: Three diatomaceous earth (DE) formulations, SilicoSec, PyriSec and Insecto were tested for their effectiveness against adults of the granary weevil, *Sitophilus granarius* (L.) (Coleoptera: Curculionidae) on stored wheat under laboratory conditions, at 25°C and 65% r.h. Three series of tests (bioassays) were carried out. In Test 1, 500 ppm of each DE was tested alone or in combination with 1000 ppm of dry conidia of the entomopathogenic fungi *Beauveria bassiana* (Balsamo) Vuillemin (Hyphomycetes: Moniliales). Mortality was assessed after 24 h, 48 h, 7 d and 14 d of exposure, while the treated substrate was also examined for progeny production, 45 d after the 14 d count. In Test 2, beta cyfluthrin, at 0.4 ppm was tested alone or in combination with each of the three DEs, at 500 ppm. In this test, weevil mortality was assessed after 7 d of exposure. Finally, in Test 3, beta cyfluthrin at the rates 0.2 and 0.8 ppm was tested alone or in combination with 500 ppm of SilicoSec, while mortality and progeny production counts were performed as in Test 1. In Test 1, the presence of DEs increased the effectiveness of *B. bassiana*, especially at exposures ≥ 7 d. Hence, after 7 d of exposure, *S. granarius* mortality was $>93\%$ on wheat treated with the fungal/DE combinations, but did not exceed 51% on wheat treated with *B. bassiana* alone. Furthermore, the presence of DEs decreased progeny production on the fungus-treated wheat. The additive effect on *B. bassiana* was the same for the different DEs. The same trend was observed in Test 2, where after 7 d of exposure DE increased the effectiveness of beta cyfluthrin. In this test, weevil mortality was 51% on wheat treated with beta cyfluthrin alone, but exceeded 75% when DEs were present. In Test 3, the presence of SilicoSec increased the insecticidal effect of beta cyfluthrin and decreased progeny production only in the case of the lowest dose rate. Hence, after 7 d of exposure, weevil mortality on wheat treated with 0.2 ppm of beta cyfluthrin with or without SilicoSec was 36 and 78%, respectively, while the respective figures for 0.8 ppm were 95 and 94%.

The importance of food supplements for parasitoids of stored product pests: the case of *Venturia canescens* (Hymenoptera: Ichneumonidae).

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Abstract: Laboratory studies were conducted on the effect of honey-feeding on progeny production and longevity of adults of *Venturia canescens* Gravenhorst (Hymenoptera: Ichneumonidae) parasitizing larvae of the Mediterranean flour moth *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae). Experimental adults lived under various temperature regimes with access to hosts. Provision of adult parasitoids with honey resulted in a significant increase in production of total offspring at all temperatures. Highest mean fertility of honey-fed wasps was recorded at 20°C, followed in decreasing order by 25, 30 and 15°C. At all temperatures honey-fed wasps lived significantly longer (almost three times) than their starved conspecifics. The experimental findings are analyzed with the objective of improving the effectiveness of *V. canescens* as a biological control agent of stored product pests.

Amylase inhibitor is without any adverse effect on parasitoid *Venturia canescens*

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Abstract: The amylase inhibitors (AI) are suitable candidates for transgenic plants to increase their resistance to insect pests. Detail study of suppressive effects of AI on target and non-target insects is necessary before their incorporation into GMO plants. Therefore, we tested the effect of selected AI inhibitor (acarbose) on pest flour moth (*Ephestia kuehniella*) and its parasitoid wasp (*Venturia canescens*) in laboratory experiments. Various concentrations of AI were incorporated into diet for larvae of *E. kuehniella* and their mortality was observed to find sublethal doses of AI. The larvae influenced by sublethal concentrations of AI (0.001 and 0.0001%) were parasitized by the wasp. The morphological parameters of the wasps treated by AI and control were compared. The AI in the range from 0.1 to 0.01% caused 100 % mortality of *Ephestia kuehniella* larvae, the concentration AI 0.001% suppressed larval weight increase and prolonged developmental period. We did not observe any suppressive effect of AI on *Venturia canescens*; but we found differences in morphological parameters between wasps treated on (i) control larvae and on larvae fed on 0.001 %AI and (ii) 0.0001%AI. Measured parameters of the wasp influenced by AI 0.0001% were in most cases significantly higher (i.e. weight, hind tibia length and wing size). These results demonstrate the possibility of the combination of biocontrol and AI that would provide higher pest control efficiency than these methods used individually.

Age specific fecundity and survivorship of *Cephalonomia tarsalis* (Ashmead) (Hymenoptera: Bethylinidae) at different temperatures

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Abstract: The effect of temperature on fecundity and survivorship of *Cephalonomia tarsalis* (Fabr.) was studied at 5 constant temperatures (21°C, 24°C, 27°C, 30°C and 33°C) in temperature-controlled chambers. The adult longevity was temperature and sex dependent. Adults lived longer at lower temperatures and females lived longer than males. Mean longevity of males was 4-8 days over temperature range of 21°C- 33°C, females mean longevity increased from 43 days at 30°C to 82 days at 21°C. Egg production was non-linear, temperature dependent. Highest mean fecundity of 110 eggs per female was recorded at 27°C, lowest mean fecundity of 32 eggs per female was found at 21°C. The rate of egg laying was highest at 30°C and lowest at 21°C.

Control of *Sitophilus granarius* in grain using a combination of parasitoids and entomopathogenic fungi – preliminary results

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Abstract: Several studies have investigated the potential of larval parasitoids for control of *Sitophilus granarius* (L.) (Coleoptera: Cucurionidae) in stored grain. However, as the longevity of the adult weevils, and thus the oviposition period, is very long, efficient control of *S. granarius* necessitates a strategy that will target both the adult weevils and the larvae. The presentation will report on preliminary results of a “semi-field” study involving a combination of larval parasitoids and entomopathogenic fungi against *S. granarius*.

A wide range of isolates of entomopathogenic fungi have been screened for their impact on *S. granarius* imagines. An isolate of *Beauveria bassiana* has been selected for further studies. Two species of larval parasitoids have been included in the study: *Lariophagus distinguendus* Förster and *Anisopteromalus calandrae* (Howard) (both Hymenoptera: Pteromalidae). A trial was set up to simulate an infestation in a grain store using plastic containers each containing 9 kg of wheat infested with *S. granarius*. The trial involved the following: i) addition of *L. distinguendus*, ii) addition of *A. calandrae*, iii) addition of *B. bassiana*, and combinations of the natural enemies. The trial ran for a total of 24 weeks.

Interpretation of pheromone monitoring programs for stored-product insects

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Abstract: Effective integrated pest management programs are needed for food processing and storage facilities and this requires improvements in our ability to monitor pest populations and use this information to target interventions in both time and space. The use of pheromone traps to monitor pests is increasing in the food industry, but adoption has been hampered by lack of information on how to effectively implement and interpret pheromone-monitoring programs. In this presentation, how factors such as landscape structure, and pest behavior and ecology, impact pheromone trapping and the targeting of pest management will be discussed. Critical factors include determining temporal dynamics of pest populations, spatial distribution of subpopulations in the landscape, and pest movement patterns. How these factors can be assessed in the field will be discussed and their impact illustrated using data collected in and around food processing facilities.

Mating disruption of stored product moths: toward commercial development

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Abstract: Mating disruption (MD) of the Indianmeal moth was suggested and proven on a small scale in the laboratory more than 30 years ago, but no commercial scale treatments have been demonstrated. We studied mating disruption of *Plodia interpunctella* in a controlled field situation in which ZETA was loaded into high release-rate bags that were distributed throughout the test site to disrupt male orientation and mating. A „switching” experiment was done using two similar chicken houses in which adult moths were released weekly and monitored by trapping with virgin females. Reproduction was monitored with oviposition dishes. MD was implemented in one house while the other remained as an untreated check during the 4-week treatment period. Male responses to females and reproduction were significantly suppressed by MD. Mean male trap catch during MD was 1.6 (± 7.2 SE) vs. 44.6 (± 5.3 SE) in non MD checks. The mean larval count in oviposition dishes during the four week period before the MD was 181.8 (± 26.3 SE), whereas the mean larval count during MD was 82.5 (± 35.4 SE). Subsequent experiments to test efficacy in commercial food facilities were conducted in warehouses located around the U.S. Each location had pairs of non-mating disruption (control) and mating disruption (treatment) buildings. Infestations of almond moth, *Cadra cautella*, and Mediterranean flour moth, *Ephestia kuehniella*, were also studied. Most treated locations displayed significant decreases in moth activity after on set of MD, while untreated buildings showed typical seasonal increases. Migration of moths into treatment facilities from other areas may account for lower treatment effects. Testing continues on deployment density of MD lures while commercial partners pursue government registration.

The influence of environmental structure on trap efficacy in food industry pests: preliminary study

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Abstract: The effect of structural complexity on the dispersion behaviour of food industry pests was estimated by means of sticky traps. The German cockroach, *Blattella germanica* L., was used as a model of a highly mobile pest species frequently associated with food facilities. The experiments were performed in an isolated chamber (3x2m) with controlled temperature and dark-light regime that contained sticky traps arranged in a grid pattern. Cockroach shelter was located at the edge of the chamber. The increasing complexity of environment was simulated by installation of wooden boards-barriers between trap area and cockroach shelter. The catch of cockroaches in traps was recorded for 24 hrs. It was found that increasing complexity decreased the cockroach catch dramatically. In structurally complex environment, all traps falsely indicated zero presence of cockroach pest thereby generating an alarming message: the results of pest monitoring by traps may be completely misleading under certain conditions. We discuss the possibility of using fractal geometry for the description of an irregular surface and for modelling insect dispersal in a complex, food industry environment.

First evaluation of the efficiency of a pheromone trap as a monitoring tool

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Abstract: The foundation of a successful integrated pest management (IPM) program is an effective monitoring system that supplies accurate information on the size and changes in pest populations over time. For many important stored-product insects, pheromones have been isolated and traps are now commercially available. However, many questions remain about the use of these traps as a monitoring tool, from the very practical issues such as how many traps are needed and which types work best, to the fundamental issues concerning the relationship between pheromone trap captures and actual pest population density, distribution, and level of product infestation.

In this communication we present for the first time preliminary data evaluation of pheromone trap efficiency under controlled laboratory settings. In order to achieve controlled conditions a 170 x 65 x 45cm olfactometer was designed and built with a vent producing a 0.1-0.3 m/second wind velocity. The traps were attached to the wall below the vent.

Two insect species were tested: the cigarette beetle (*Lasioderma serricorne* F.) and the tropical warehouse moth (*Cadra (Ephestia) cautella* (Walker 1863)) using three commercial pheromone traps. For the moth we used "Gachon[®]" from "Fuji" and "Biostop[®]" traps and for the cigarette beetle we used "New Serrico[®]" from "Fuji" traps. The preliminary results indicate that the capturing efficiency of the traps in a mixed population of 100 females and male tropical warehouse moths after 24 h. averaged about 10% and after 72 h. it increased to 30%. In all tests, male and also females were captured in a ratio of 2:1 up to 5:1 males to females. For the cigarette beetle the capturing efficiency was about 25% on average after 72 h. Different levels of capturing efficiency were obtained when the position of the cigarette beetle traps was changed. The capturing efficiency increased to about 40% when the traps were located on the floor 30 cm from the vent wall and decreased to about 10% when the traps were hanging in the air 30 cm from vent.

These preliminary results indicate that additional studies are needed to evaluate the efficiency of available commercially traps in order to use them effectively as a monitoring tool in for the reliable indication of size and changes of a pest population over time.

Pheromones and kairomones for detection and control of indoor pyralid moths

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Abstract: Three pyralid moths, the Mediterranean flour moth (*Ephestia kuehniella*), the almond moth (*Ephestia cautella*) and the Indian meal moth (*Plodia interpunctella*), infest food products all over the world and cause severe problems in factories, shops and households. For health and environmental reasons chemical control becomes more and more restricted. We here present some promising results offering efficient detection and control of these species based on semiochemicals. The pheromone mating disruption technique (MD) was employed in three mills, a chocolate factory, a pet shop and in a pet food warehouse during 7-21 months, including localities with infestations of all three species. Catches of monitoring traps decreased instantaneously and measured air concentrations of the main pheromone component, released from the MD-dispensers, increased immediately. Fewer moths were observed in the localities and the number of complaints from customers of mill products decreased. In the chocolate factory, it was possible to use traps baited with water to obtain an additional and independent measurement of the *E. cautella* population level. Catches in these traps showed a decrease in population density. From the MD-experiments we can conclude that this technique has a large potential for controlling all three moth species. For more efficient monitoring and evaluation of control measures, we have done a series of studies to improve pheromone traps and to make trapping of *E. kuehniella* and *P. interpunctella* females possible (*E. cautella* females are readily caught by water traps). Improved pheromone baits for *E. cautella* and *P. interpunctella* and blends potentially attracting females will be presented.

Contribution of spatial analysis for precision Integrated Pest Management of beetle pests in a semolina-mill

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Abstract. By utilizing food-bait traps we evaluated the presence and the spatio-temporal distribution of insect-pests in an industrial semolina-mill, with particular attention to the adults of *Tribolium confusum* J. du Val, *Typhaea stercorea* (L.) and *Tribolium castaneum* (Herbst). The confused flour beetle was collected on all the sampling dates, with two main peaks in the second half of June-beginning of July and in the first half of August. The hairy fungus beetle was most abundant from the second half of May to the beginning of July and in the first half of September. The presence of the rust-red flour beetle had a main peak in June. After the annual fumigation of the mill, carried out in the second half of August utilizing methyl bromide, only a small number of captures of the two *Tribolium* species occurred until the end of the sampling period. In contrast *T. stercorea* remained to colonize the mill until the end of November. The contour maps drawn to represent the spatial distribution of *T. confusum* before the fumigation treatment showed that the highest abundance foci of adult population were confined to the corners of the milling area and in the base of the adjacent walls of every floor, where a large amount of dust and debris usually accumulate. Adults of *T. stercorea* were confined in the I and the II floors, the main moisture areas of the mill contaminated with mould. Almost the same distribution as *T. confusum* was found for *T. castaneum*, but this species was observed only in the upper floors of the mill, especially in the VI floor. The indications obtained by spatial analysis and representation of spatio-temporal distribution were used in pest management procedures (precision IPM) after the fumigation, based essentially on the improvement of good sanitation practices. Furthermore, the initial monitoring plan was adapted, decreasing the number of food-traps (from 85 to 66) and optimizing the trap positions in the structure.

Insect populations in a feed mill for horses in Portugal

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Abstract: Trials were carried out in a feed mill for food horses from 7 January 2004 to 20 January 2005 in order to identify the insect species and to study pest populations. Several type of unbaited traps and traps baited with pheromones and food lures were used: Dome traps for crawling insects, Thinline, funnel traps and Lasiotrap for flying insects, probe and pitfall traps for insects developing within the stored products. Following surveys, 47 insect species were identified. Some of them were caught throughout the year, others were seasonal. Considering that the products after the micronizer, to transform cereals and beans to flakes, were free of insects, probes were used for sampling horse-bean stored as micronized product, stored in bulk, and the non micronized black oat which was stored in big bags.

The results demonstrated that the feed mill suffered important infestations of several insect species. High populations of *Ephestia* spp. were present throughout the year. It appeared the major risk should be their development within the machinery than attacking the stored products. Although the micronizer can provide a product free of insects, the horse-bean stored in bulk, after a while presented populations of several stored insect species. The most important insect pests caught in the stored products were *Oryzaephilus surinamensis* and *Sitophilus zeamais*. Eight species of parasitoids were also identified and the existence of these natural enemies may enable the development of a biological control program.

Insect fragments in flour: Relationship to Lesser Grain Borer (Coleoptera: Bostrichidae) infestation level in wheat and rapid detection using near-infrared spectroscopy

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Abstract: The grain milling industry routinely checks wheat flour for insect fragments to determine whether the number found is below the U.S. Food and Drug Administration (FDA) defect action level of 75 fragments/50 g flour. However, the standard chemical extraction method used to detect insect fragments in flour is costly and time-consuming; thus, a rapid detection method is desirable. In addition, little is known about differences in the number of fragments produced from different stages of different insect species. In this study, we determined that wheat infested with a single pre-emergent adult lesser grain borer, *Rhyzopertha dominica* (F.), contributed 28 times and 10 times as many fragments as wheat infested with a single larva or pupa, respectively. Using regression models that we developed from these data, we predicted that 1-kg samples of wheat with more than 20 kernels infested with pre-emergent adult borers would be above the FDA defect action level for insect fragments. Similarly, it would take an infestation level of 380-640 kernels (in a 1-kg sample) containing larvae or pupae to exceed the defect action level. We also determined the accuracy and sensitivity of near-infrared spectroscopy (NIRS) for detecting insect fragments in flour using three different NIR-spectrometers. The number of insect fragments predicted by NIRS was correlated with the actual number of fragments in test samples. NIRS was less precise than the standard flotation method, but it has the advantages that it is rapid, non-destructive, does not require extensive sample preparation, and can be automated for a more sophisticated sampling protocol for flour.

Monitoring of bruchids (Coleoptera: Bruchidae) in stored broad beans (*Vicia faba* L.)

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Abstract: Samples of threshed dried broad beans (*Vicia faba* L.) were collected in different places of Portugal, and bruchids (Coleoptera: Bruchidae) found infesting those seeds were identified. Independently of the geographical location, *Bruchus rufimanus* was the dominant species in Portugal. Parasitoids were also found inside the seeds. The percentage of attacked seeds in eight varieties of broad beans was compared. No differences in infestation levels were detected among the tested seed varieties.

The application of immunochemical methods in detection and traceability of arthropod contaminants in stored food

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Abstract: HACCP (Hazard Analysis and Critical Control Point) needs methods for the detection, identification and quantification of food contaminants, not only of living pests, but also of their products (like allergens, and quinone secretions). The main benefit of molecular methods consists in their ability to detect not only current infestation but also the residues of past infestations. These methods are applicable not only to whole arthropods or their fragments, but also to their metabolites (toxins or allergens). We reviewed the published results of application of antibodies on detection of 4 stored-product mites, 4 stored-product beetles and 1 cockroach species or their allergens. ELISA techniques were demonstrated to have a potential to detect stored product arthropods as well as their hazardous products. The immunological approach in combination with antibodies-based microarrays, based on highly parallel simultaneous analyses, has shown its potential for large-scale analyses. Such a screening technology would allow simultaneous detection of contaminants like allergens of microbial and arthropod origin as well as mycotoxins and pathogens.

Evaluation and characterization of damage produced in packaging films by insect pests

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Abstract: Packaging of food products has an important role as a barrier for insect pest and plastics films are among the most effective materials. In this work, the penetration ability of *Rhyzopertha dominica*, *Sitophilus oryzae* and *Oryzaephilus surinamensis* into different plastic films was assessed. The plastic films studied were polypropylene, polyethylene, and polyester, and a multilayer film (Paper, Polyethylene, Aluminium and Polyethylene). Damages observed in each material were evaluated under a binocular microscope. All three species were able to penetrate the films tested. *Rhyzopertha dominica* was the species with the highest penetration ability. The number of damages produced by all three species were higher in polyethylene than in polypropylene and polyester. In the multilayer film, *R. dominica* showed a similar penetration ability notwithstanding the film side exposed to the insect, since the Aluminium foil was the layer acting as a barrier to avoid the penetration of this species.

The comparison of population growth of stored product mites (Acari: Acaridida) under various temperatures

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Abstract: Stored product mites are of economical and medical importance, their feeding damaged grain and their allergens are dangerous for farmers, food industry workers and also for urban population. The pest potential of stored product mites depends on their population density and their reproduction rate. Temperature is one of the most important abiotic factors influencing reproduction rate. In this study we compare of population growth of three species (*Acarus siro*, *Tyrophagus putrescentiae*, *Aleuroglyphus ovatus*) under temperatures in the range from 5° to 35°C at 85% humidity. The start population was 20 individuals and final population was recorded after 21 days or after 42 days. The experiment was terminated by extraction of mites in modified Tullgren-Berlese funnels and counting the final population density. The population growth was influenced by the temperature, the response was Logan curve with broad optima from 20° to 30°C and the curves were similar for all tested species. The population growth was minimal at temperatures of 32.5° and below 15°C. These results indicate that for multiplication of mite population in stored grain are the most critical temperatures in the range from 20° to 30 °C.

Kernel-kernel communications and behaviour of *Sitophilus zeamais* Motschulsky

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Abstract: To assess the influence of mechanically damaged, insect damaged, and intact maize kernels on the behaviour of adults of *Sitophilus zeamais* Motschulsky in the laboratory, kernel-kernel interaction experiments were carried out. Three series of experiments (with olfactometer assays in arena) were conducted. In the first, mechanically damaged kernels, insect damaged kernels, and intact kernels were placed in traps containing arenas (three-choice tests) . In this experiment, the kernels were conditioned in a plastic box with two caps: one cap containing 2 g of a certain “kernel status” (mechanically damaged, insect damaged, or intact kernels), and the other cap with 2 g of whole kernels. Five types of conditioning were assessed: 0, 1, 2, 7 and 14 days. In the second experiment, two trap-devices were placed in the arenas, containing each of the aforementioned conditioned whole kernels in all possible combinations. The conditioning duration tested in this case was 1 and 7 days. In the third test, two choice tests were placed in the arenas, containing fresh or stored conditioned whole kernels, or mechanically damaged kernels, or insect damaged kernels in pairs. Conditioned tests were carried out as above in boxes with plastic capsules containing 2 g of fresh maize (~ 8 months after harvest) or 2 g of stored maize (~ 20 months after harvest). Adults of *S. zeamais* are strongly attracted by the insect damaged kernels or by the conditioned kernels damaged by insects, in comparison with the other two-conditioned kernel categories considered. In addition, the conditioned mechanically damaged kernels are more or less attractive than the conditioned intact kernels. Conditioned whole kernels by allelochemicals coming from mechanically damaged kernels revealed less attractiveness if compared to the conditioned insect damaged kernels or to the conditioned intact kernels.

The comparison of allergen classes in stored-product and house-dust mites (Acari: Acaridida)

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Abstract. Nowadays, 483 different proteins inducing IgE antibody in human have been investigated from all groups of allergen producing organisms. The allergens derived from the arthropods cover about 25 % of these compounds. Among arthropods, mites are the serious producers of allergens covering about 10 % of total allergens. Up to the present time, 20 classes of allergens and 49 IgE binding compounds have been described in house dust (*Dermatophagoides pteronyssinus*, *D. farinae*, *D. siboney*, *Euroglyphus maynei* and *Blomia tropicalis*) and stored product mites (*Glycyphagus domesticus*, *Acarus siro*, *Lepidoglyphus destructor* and *Tyrophagus putrescentiae*). The dual functionality of allergenic proteases increasing their importance has been discovered recently. Except passive allergen reaction, the cysteine (Der p 1, Blo t 1, Der f 1) and serine (Blo t 3, Der p 3, Der f 3, Eur m3, Blo t 6, Der p 6 and Der p 9) proteases are able to provoke allergic reaction due to their enzymatic activity. These enzymes participate in mite digestion of both groups of stored product and house dust mites and accumulate in faeces in a high amount. In the faeces, proteases are still active and stable, because their decomposition rate is very low during time in the house conditions. The spectrum of mite species occurring in stored products is substantially wider than in house dust. Apart from the named species, the protein fractions of many other species are known to bind IgE of sensitive patients. Although biochemical characterization of their allergens is lacking, the unique IgE epitopes for their allergens most likely exist. It increases the medical importance of stored-product mites.

The bacteria as food for stored-product mites (Acari: Acaridida)

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Abstract: Stored product mites have been considered as grammi or fungi-vorous, feeding on grain debris, fungi, and yeasts growing in the grain ecosystems. The bacteriophagy (e.g. feeding on bacteria) represents an alternative feeding strategy in the grain ecosystems. However, it has not been reported in stored product mites yet. We analyzed whether bacteria could serve as a food source for stored-product mites. The analyses were based on the (i) activity of lysozyme and (ii) increase of population growth of mites on diets enriched by bacteria. Lysozyme (EC 3.2.1.17) is an enzyme catalyzing the hydrolysis of cell walls of many bacteria, causing cell death lysis, cell wall degradation and enables digestion of bacterial cells. The increase of population growth was observed on the control (rearing) diet and the diet enriched by *Micrococcus lysodecticus* (5% in the diet). Among tested species the lysozyme activity was highest in middle acid pH (optima from 4 to 5). Based on the observed enzymatic activity we distinguished three levels: (i) high lysozyme activity: *Caloglyphus redickorzevi*, *Tyroborus lini*, *Tyrophagus brevicrinathus*, *Acarus gracilis*; (ii) intermediate lysozyme activity: *Aleuroglyphus ovatus*, *Glycyphagus domesticus*, *Tyrophagus putrescentiae*; (iii) low lysozyme activity: *Carpoglyphus lactis*, *Acarus siro*, *Lepidoglyphus destructor*. The population growth of *Tyroborus lini* and *Caloglyphus redickorzevi* was higher on the diet enriched by *Micrococcus lysodecticus* in comparison to control, while we observed no differences in population growth of *Acarus siro* and *Lepidoglyphus destructor*. We conclude that species with high lysozyme activity (*Tyroborus lini* and *Caloglyphus redickorzevi*) are able to utilize bacteria as a food source and bacteriophagy seems to be another alternative feeding strategy in stored grain ecosystem.

Nymph's morphology of *Dorypteryx domestica* (Psocoptera)

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Abstract: *Dorypteryx domestica* is an expansive psocid often occurring in synanthropic localities. So far only, adults and eggs have been possible to identify since the description of nymphs has not been available. The morphological study reported here deals with overall appearance and size measurements of particular instars. Five developmental instars are distinguished and described. Morphological characters include mainly number of flagellar segments, number of ommatidia in compound eyes, and level of wing development. Morphological details are illustrated with scanning electron microscope micrographs and macro photos.

***Sitophilus granarius* (Curculionidae): outdoor occurrence in vicinity of a grain store**

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Abstract: The aim of this work was to explore the frequency and abundance of *Sitophilus granarius* occurring outside a grain store. Wheat bait-traps were used for pest monitoring. Bait-traps exchange was carried out monthly throughout the year. Exposed bait traps were analysed in the laboratory and stored for subsequent adult incubation (27°C, 75% r.h.) for 1 month. The long-term outdoor occurrence of *S. granarius* was documented in the Czech Republic for the first time. This highly mobile internal grain feeder was the dominant pest in comparison to 8 other species of Coleoptera found outside the grain store. The weevils were captured in grain baits almost throughout the year. There were differences in weevil's abundance and frequency depending on bait trap location. The population of granary weevil in baits from hidden infestation (eggs) increased 10 - 50 times after one month of incubation period compared to primary infestation.

The secretory cells of digestive tract of *Tribolium castaneum* (Coleoptera, Tenebrionidae) larvae

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Abstract: The red flour beetle, *Tribolium castaneum* (Herbst, 1797), is widely distributed and is a secondary pest of grain and cereal products. In the Czech Republic, it belongs to the most abundant and frequent storage pest that is hard to control by pyrethroid insecticides due to tolerance to them. This is why the new insecticides against this pest are developed. They are target against midgut (*Bt* toxins, inhibitors of insects amylases and proteases). To understand the effect of insecticide on the midgut in this study, we explored and described the structure of secretory cells of midgut of *Tribolium castaneum* larvae using optical microscopy.

The larvae, approximately 3 weeks old, were fixed in Bouin-Dubouque-Brazil fluid, embedded in paraplast, sectioned (thickness 5-7 µm) and stained in Masson's triple stain. The histological prepreparates were observed under Axioskop Zeiss.

The digestive tract of the larvae of *T. castaneum* is composed of 3 parts: stomodaeum (foregut), mesodaeum (midgut), and proctodaeum (hindgut). Stomodaeum forms short and dilated pharynx and narrow oesophagus extends towards the swollen mesodaeum. Mesodaeum of the larval *T. castaneum* is rather simple tube, without any caeca or diverticula. Proctodaeum is divisible into 3 sections. Very small and conical „pyloric chamber“, at the anterior end followed by the ileum which forms an S-shaped bend and spindle-shaped rectum. In the middle part of mesodaeum there are the cylindrical cells. Short middle zone secretes no enzymes. Multi-layer peritrophic membrane is present. The secretory cells were localized into (i) anterior mesodaeum and (ii) posterior mesodaeum. The anterior part of mesodaeum contains tall and columnar cells and the membrane on the luminal side forms microvilli. The apical extrusions at the apical parts of the cells release into gut lumen. The cells of posterior mesodaeum create multicellular crypts and apical extrusions can be also observed here. Both the cells in anterior and posterior mesodaeum contain large nuclei and they are strongly vacuolized indicating strong secretory activity. The described situation corresponds to model species *Tenebrio molitor*. The function of secretory cells as well as the potential for suppressive compounds is discussed.

Development of *Araecerus fasciculatus* De Geer (Coleoptera: Anthribidae) on *Panax ginseng* C. A. Meyer roots

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Abstract: *Araecerus fasciculatus* De Geer is a beetle of considerable economic importance. Its occurrence is cosmopolitan, though it is more common in tropical and subtropical countries.

The aim of this experiment was to study the development of coffee bean weevil on two different kinds of ginseng roots, compared with data obtained on corn grains and coffee beans. Tests were carried out under laboratory conditions at a constant temperature and relative humidity.

It was observed that the time of development is the shortest on spindle-shaped, bipartite ginseng roots and the number of emerging adults is higher on corn grains and coffee beans. *A. fasciculatus* do not develop on secondary ginseng roots.

Susceptibility of *Triticum polonicum* L., *T. durum* Desf., *T. spelta* L. to post-harvest infestations by *Sitophilus zeamais* Motschulsky (Coleoptera: Dryophthoridae, Rhynchophorinae)

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Abstract: *T. polonicum* L. (Polish wheat) is a tetraploid wheat, with a high content of protein, lipids and minerals. Moreover, it is less allergenic than other wheat species and for these reasons it is increasingly cultivated in Italy.

The development of *Sitophilus zeamais* Motschulsky on Polish wheat was examined in laboratory trials at a fixed temperature and relative humidity. These results were compared with the development on *T. durum* Desf. (durum wheat) and *T. spelta* L. (spelt wheat). Tests were carried out with 100 adults of mixed sex in 30 g of kernels, removed from jars after 5 days. New generation adults were checked every day, counted and removed. A greater number of emerged adults was observed on *T. durum*, the lowest on *T. spelta*. The beginning of emergence started earlier on *T. durum* and *T. polonicum* as compared to *T. spelta*.

Susceptibility of different kinds of powdered milk to the attack of Pyralid moths

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Abstract: Tests were carried out to determine the susceptibility of four different kinds of powdered milk, used in human nourishment to attack by *Cadra cautella* (Walk.), *Corcyra cephalonica* (Staint.), *Ephestia kuehniella* (Zell.) and *Plodia interpunctella* (Hbn.). One hundred eggs, 24-48 h old, were placed on substrates (50g); in a thermostatic room (26±1°C; 70±5% r.h.; 16:8 L:D). For each substrate, three replicates were carried out.. At the end of each test the mean adult number emerged, the mean developmental period and the mean susceptibility index was calculated. Results were subjected to ANOVA and to Duncas' multiple range test (SPSS 11.5 for Windows).

Test species were able to complete their development on soya milk. On this substrate, emergence of 50-60 adults were observed except for *C. cephalonica* where there were 19.0±1.00 emerged adults. *C. cautella*, *E. kuehniella*, and *P. interpunctella* were not able to complete their development on the human nourishment milk (powdered whole milk, powdered reconstituted milk and powdered baby milk). *C. cephalonica* adults were observed not only on powdered soya milk but also on the whole milk, numbers of adults that emerged were: 17.0±1.00 from powdered baby milk: 40.7±3.84 from reconstituted milk: 32.0±2.00 from other substrates. *C. cephalonica* showed the ability to use lactose, as an energy source. This sugar, in fact, for the most part is toxic to the moths and beetles of stored products.

Injury capability of pests to stored legumes in Namibia

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Abstract: It is recognized that in developing countries the stored product pests endanger both food safety and food security. However, there is a controversy over the extent of weight losses caused by pests to various stored food products. In this work we report unusually high pest related losses (i.e. losses >95%) to stored legumes (*Vigna unguicula*, *Arachis hypogea* - Leguminosae) in Namibia. In the inspected samples and stores we found: (i) 100% infestation of legume kernels; (ii) 100% injury of legume germs; (iii) the weight loss of internal content of kernels of *Vigna unguicula* was >95%. Symptoms of combined injury caused by pyralid moth (*Corcyra cephalonica*) and bruchid beetles (*Callosobruchus subinnotatus*) are described and photo-documented.

Use of biogenerated atmospheres of stored commodities for quality preservation and insect control, with particular reference to cocoa beans

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Abstract: Preliminary data for insect control and for quality preservation of stored cocoa beans is presented, as a methyl bromide alternative, by employing a novel approach through the use of biogenerated modified atmospheres. The respiration rates of fermented cocoa beans from Makassar, Sulawesi, Indonesia, were determined under laboratory conditions. Initial insect populations found in these cocoa beans samples consisted of *Carpophilus* spp., *Ahasverus advena*, *Cryptolestes* spp., and Psocids. Respiration rates of cocoa beans at equilibrium relative humidities (r.h.) of 59, 68, and 73% were determined at 26°C in hermetically sealed 1 L capacity jars containing 500 g commodity. At the equilibrium r.h. of 73%, the respiration of the cocoa beans depleted the oxygen concentration to <1% and increased the carbon dioxide concentration to 23% within six days. To obtain a similar oxygen depletion for cocoa beans at 68% equilibrium r.h, a duration of 23 days was required, while for the sealed cocoa beans in equilibrium with 59% r.h. the oxygen concentration after 23 days had only decreased to 10.8%.

Under field conditions in a cocoa bean storage facility in Makassar, Indonesia, a hermetically sealed flexible structure containing 6.7 tonnes of cocoa beans at an initial moisture content of 7.3% (70% equilibrium r.h.) was monitored for oxygen concentration and quality parameters of the beans. The measurements showed a decrease in oxygen concentration to 0.3% after 5.5 days. No insects survived the oxygen depleted biogenerated atmosphere. These encouraging results reveal the possibility of utilizing biogenerated atmospheres in integrated pest management (IPM) for the quality preservation (by preventing the development of FFA, molds, and mycotoxins), and insect control of cocoa pests.

Effectiveness of gaseous ozone alone and in combination with low pressure or carbon dioxide against *Ephestia kuehniella* (Zell.) (Lepidoptera: Pyralidae) at short exposure time

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Abstract: Toxicity of initial concentration of 300 ppm gaseous ozone either alone or combined with a low pressure of 100 mm Hg and 92% CO₂ against all life stages of *Ephestia kuehniella* (Zell.) at short exposure time (2 hours) was studied. Results indicated that a remarkable difference in corrected mortalities of the treatments for each life stage. For the larvae, adults and pupae, treatments of ozone alone and all in combination with vacuum and CO₂ resulted in complete mortalities except ozone treatment in combination with CO₂ for the pupae by the mortalities ranging from 79.3 to 91.4%. However, although ozone alone had a higher mortality on the eggs by 85.1% than all other treatments any of the treatments did not give complete mortality. Clearly it indicated that the adults and larvae were the most easily killed, followed by the pupae and finally the eggs, which were the most tolerant to ozone treatments. There were very limited mortalities of all stages except the adults (21.9% to 100%), when exposed to either 100 mm Hg or 92% CO₂ for 1, 2 and 4 hours. Ozone alone was found to be effective against all the life stages of the common stored-product insect, *E. kuehniella*, at high initial concentration (300 ppm) and short exposure time (2 hours). However, the use of a low pressure of 100 mm Hg, or 92% CO₂ did not cause synergistic effect on this species as evidenced by no significant decrements in mortalities for all life stages. These results indicate that ozone alone is sufficient to have potential alternative to methyl bromide fumigation for rapid disinfestation of commodities.

Control of *Sitophilus oryzae* (Coleoptera: Curculionidae), *Rhyzopertha dominica* (Coleoptera: Bostrichidae) and *Tribolium castaneum* (Coleoptera: Tenebrionidae) by modified atmosphere created by paddy husk combustion

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Abstract: The smoke generated from paddy husk combustion, was evaluated for its toxicity against adults of Rice Weevil *Sitophilus oryzae* L., Lesser Grain Borer *Rhyzopertha dominica* F. and Red Flour Beetle *Tribolium castaneum* (Herbst.) under laboratory conditions. Adults of these species were put into cloth sacks hung in sealed bottles which were later filled with smoke generated from paddy husk combustion. Insects prepared in the same manner were kept as the control without being exposed to smoke. After different periods of exposure to smoke, response of insects was evaluated in terms of mortality.

A significant lethal effect of the paddy husk combusted gas was observed on the adults of all three insect species tested compared to the untreated control. Adult mortality of 100% was achieved for *Sitophilus oryzae*, *Rhyzopertha dominica* and *Tribolium castaneum* at 14, 13 and 18 hours of exposure respectively, compared to 5-6.6% mortality in the relevant controls.

The experiments were conducted by changing the carbon dioxide and carbon monoxide concentrations separately. It was revealed that carbon monoxide was directly related to the mortality of the target insects. The recorded mortality was brought about by 5000- 6000 ppm of carbon monoxide. This study shows the application of smoke enriched with carbon monoxide generated from the partial combustion of paddy husk as an insect pest management strategy for the insect pests of stored paddy instead of complete combustion and thus saving energy.

Improving the reliability of heat treatments in food industry

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Abstract: A German flour mill was heat treated in August 2005. Heated air was blown into different parts of a 40 m high flour mill building through air hoses. The building consisted of a flour mill built in 1989 and a new mill built in 2002 adjacent to it. Connected to both mills was a packaging area, with just a first floor included as a loft into the 7 m high hall where finished products such as flour, food pellets, and bran were stored.

Bioassay samples containing caged adults and all developmental stages of *Rhizopertha dominica* were distributed in 50 locations of the building. The cages were placed into sealed cotton bags and every other bag was supplied with a data logger recording temperature and moisture contents in 15 min intervals. Infrared (iR)-thermographs were used during the treatment from outside and inside the building to detect areas of heat loss or cold bridges, respectively.

Temperatures achieved in most of the open space and in all of the machinery tested were sufficient to control insects. However, not all test insects were killed during the treatment, the topmost floor in the older mill, as well as several upper floors in the new mill and areas in the cellar did not reach temperatures above 50°C. Another obstacle to the treatment was that the mill had not been emptied and cleaned prior to the treatment, but contained bag stacks with flour, wooden beams, garbage bags with dust and husks and a bucket with water. Some of these materials allowed the survival of insect samples as well as a portion of the natural infestation with *Tribolium confusum* and *Cryptolestes ferrugineus* beetles. In conclusion, it is crucial for the success of a disinfestation to make food industry management aware of the prerequisites of a heat treatment. iR-thermographs, data loggers, manual temperature measurements and a bioassay with insect samples were found to be good and complementary tools to determine the efficacy of a treatment.

The use of controlled atmospheres for stored product pest control

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Abstract: Insects and other pests in commodities need to be controlled to meet customer requirements. Methyl bromide (MB) and Phosphine fumigants that have been widely used as disinfestation agents have well-documented environmental and other problems. These problems have been overcome in the Netherlands through the commercialisation of controlled atmospheres, heat, and heated controlled atmospheres. These treatments that can be accommodated within the logistical requirements of many import products are safe, affordable, effective, residue-free, and environmentally-friendly alternatives to MB. These treatments have been developed in the Netherlands, and are now being replicated in other locations in Europe and elsewhere, to meet the safety and quality requirements of the regulatory authorities for disinfestation of food and non-food items.

Insect pest management in stored products using reduced-risk insecticides

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Abstract: In recent years there has been increased interest throughout most developed countries in replacing older conventional neurotoxic insecticides used in pest management programs, including those used for stored products. Registrations for older compounds are being either withdrawn completely or altered to be applied in reduced application rates in combination with other insecticides. During the last decade in the United States, there have been several new or revised registrations for insecticides used on raw grain and in food storage facilities. Examples of these insecticides include inert dusts, insect growth regulators, bacterial pathogens, and new insecticides that affect metabolic pathways and receptors specific to insects.

Research today includes not only the identification of potential new insecticides that can be used in stored-products, but also a thorough examination of the factors that can affect efficacy of these new insecticides. Physical and environmental factors, differences among target insect species, insecticidal formulations and methods of application, and the economics involved in determining effective application rates are just a few examples of these factors. In addition, some of these new insecticides can be combined for increased effectiveness, and can be specifically targeted for a particular insect species.

Data from personal research studies will be used to illustrate concepts and ideas relevant to the diverse stored-product environments, from raw grain to urban storages. Topics for discussion include physical and environmental factors that affect insecticidal efficacy, methods of targeted applications, research with new insecticides, and new directions for insect pest management programs.

Ovicidal activity of various essential oils against Confused Flour Beetle, *Tribolium confusum* Jacquelin duVal (Coleoptera: Tenebrionidae)

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Abstract: In this study, the ovicidal activity of vapour of essential oils from laurel (*Laurus nobilis*), fennel (*Foeniculum vulgare*), oregano (*Origanum dubium*), onion (*Allium cepa*), yarrow (*Achillea millefolium*), peppermint (*Mentha piperita*), juniper berry (*Abies balsamea*), eucalyptus (*Eucalyptus globulus*), fir needle (*Juniperus communis*), garlic (*Allium sativum*), nutmeg (*Myristica fragrans*), citronella (*Cymbopogon winterianus*), pine (*Pinus sylvestris*), anise (*Pimpinella anisum*), rosemary (*Rosmarinus officinalis*), turmeric (*Curcuma longa*) were evaluated against eggs of confused flour beetle (*Tribolium confusum* Jacquelin duVal). Eggs of *T. confusum* were exposed to a dose of 100 µL/L air of all essential oils for periods of 24, 48 and 72-h. Vapours of laurel, yarrow, peppermint, juniper berry, eucalyptus, fir needle, nutmeg, citronella, pine, rosemary and turmeric essential oils were found to have a low ovicidal toxicity to eggs of *T. confusum* at all exposure times by <20% of corrected mortality. Whereas, garlic, onion, fennel, anise and oregano essential oils indicated a strong ovicidal activity by varying from 42.2% to 100% of corrected mortality at 24-h exposure time. Probit analysis data on eggs of *T. confusum* resulted in LT₉₀ values of 1.1, 22.1, 22.4, 13.8 and 51.1-h at a dose of 100 µL/L air for garlic, onion, anise, oregano and fennel respectively. On the basis of LT₉₀ values, toxicity of vapour of essential oils to eggs of *T. confusum* in descending order was: garlic < oregano < onion < anise < fennel. Essential oil from garlic with 0.12 g h/L of Ct product was found to be the most promising one by a closer Ct product value to the most commonly used commercial fumigant, methyl bromide (0.05 g h/L).

Efficacy of *Plectranthus glandulosus* and *Steganotaenia araliacea* leaf powders from Cameroon as post-harvest grain protectants against *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae)

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Abstract: Powdered leaves from *Plectranthus glandulosus* and *Steganotaenia araliacea*, collected in the Adamawa province of Cameroon, were tested under laboratory conditions for their ability to protect stored maize from attack by *Sitophilus zeamais* Motschulsky. Maize grains were admixed with the powders at four rates (0.5, 1, 2 and 4% (w/w)) for the assessment of mortality over a 32-day period, as well as for F_1 progeny production, population increase and damage evaluation. Weevil mortality increased over time for the two plant powders at all content levels. A maximum 100% mortality was recorded only for *P. glandulosus* at contents of 4 and 2% at 16 and 32 day post exposure, respectively. 16-day LD_{50} s were 0.86% for *P. glandulosus* and 1.72% for *S. araliacea*. The two powders considerably reduced F_1 progeny production, population increase and grain damage, with complete protection of the grains provided by *P. glandulosus* at contents of 1% or higher. These results suggest that powdered leaves of *P. glandulosus* and *S. araliacea* may be of high value in grain storage against *S. zeamais*, especially in subsistence agriculture where the plants are locally available to farmers with little resources to meet the high cost of pesticides.

Comparative efficacy of different grain protectants against *Tribolium castaneum* under two sets of temperature and humidity

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Abstract: Experiment was conducted to compare the efficacy of different grain protectants viz. cypermethrin, deltamethrin, neem leaf extract and *Acorus calamus* oil at the concentrations of 100, 100, 1000 ppm and 30 μ L/L, respectively against *Tribolium castaneum* under two sets of temperature and humidity viz. 28°C and 35°C at 55% and 68%. Mortality of *T. castaneum* was observed for exposure periods of 24, 72 and 168 h. Results showed that maximum mortality was observed against deltamethrin at 28°C and 68% r.h. at exposure period of 168 h followed by cypermethrin. *Acorus calamus* oil was proved to be least effective at 35°C and 55% r.h. at an exposure period of 24 h. Results further showed that overall effect of humidities were non significant on the mortality of *T. castaneum*.

Fumigant activity of monoterpenoids against the rice weevil, *Sitophilus oryzae* (L.)

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Abstract: Results of the assays on fumigant activity of 6 major monoterpenoid constituents of essential oils from aromatic plants grown in Turkey namely, carvacrol, 1,8-cineole, menthol, γ -terpinen, terpinen-4-ol and thymol against adults of the rice weevil, *Sitophilus oryzae* (L.) are presented. Doses between 5.8 and 184.8 mg/L air and exposure periods of 24-96 h were used. All 6 constituents showed fumigant activity in varying degrees against adults of *S. oryzae*. The most active constituent was γ -terpinen which achieved 100% mortality at 46.2 mg/L air and an exposure of 96 h. This was followed by thymol and carvacrol which achieved 99.2 and 96.4% mortalities, respectively, at the same dose and exposure period. While terpinen-4-ol caused mortalities of 99-100% at 184.8 mg/L air and exposures of 24-96 h, the constituents 1,8-cineole and menthol achieved mortalities of up to 95 and 61%, respectively, at any dose and exposure time.

Influence of deltamethrin on *Cephalonomia tarsalis* (Ashmead) (Hymenoptera: Bethyridae)

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Abstract: The contact insecticide deltamethrin is broadly used in stored product pest management against saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.) (Coleoptera: Silvanidae) in Czech Republic. *Cephalonomia tarsalis* is an ectoparasitoid of *O. surinamensis*. In a dose response experiment with *C. tarsalis* we have studied its sensitivity to deltamethrin. We found that males and females of *C. tarsalis* were not equally sensitive to deltamethrin. Males were significantly more sensitive than females. The LC₅₀ values at 24 h after exposure to deltamethrin were 0.758% for males and 1.201% for females.

Antifungal activity of plant extracts

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Abstract: The use of natural products with therapeutic properties is as ancient as human civilisation. Nowadays, there is a growing concern and awareness by public opinion regarding the use of synthetic pesticides and to the presence of their residues in food. These facts have lead to a search for new forms of food protection against contamination by microorganisms. In this work we evaluate fungistatic activity of six aqueous extracts namely: French lavender (*Lavandula stoechas* L.), ginger (*Zingiber officinale* Roscoe), malva (*Malva sylvestris* L.), oregano (*Origanum vulgare* L.), pau D'arco (*Tabebuia impetiginosa* (Mart.) Standley) and rosemary (*Rosmarinus officinalis* L.). They were tested against *Aspergillus candidus*, *A. niger*, *Penicillium* sp. and *Fusarium culmorum*. Results are presented and discussed.