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Predator-Predator Interactions and the Ecology of Biological Control

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Biological control theory has long been based on the model of arthropod community structure first proposed by Hairston, Smith and Slobodkin, in which communities are built from three functionally discrete trophic levels (plants, herbivores, predators). Under this model, predator diversity is expected to have a uniformly positive influence on biological control success (i.e., the suppression of herbivore populations). I will describe a case study of a cotton arthropod community whose interactions are fundamentally incompatible with the three trophic level model. Generalist predators in this system eat not only herbivores but also each other. The result is a mixture of 3- and 4-trophic level behavior, and the failure of biological control. I conclude that a deeper understanding of predator ecology is needed to predict predator function, and highlight some recent attempts to understand why some predators function primarily as consumers of herbivores, while others function primarily as consumers of other predators.

Switches in Habitat Preference of Sand Dune Arthropods with Shrub Encroachment

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Over the last few decades coastal sand dunes in Israel have been subjected to various pressures which threaten this habitat and its resident species. In the Nizzanim area, local nomads who

practiced grazing and firewood collection have been excluded from the dunes, resulting in shrub encroachment. The effect of shrub encroachment on the arthropod community was studied. at two scales: at the dune scale, arthropod activity was compared between heavily vegetated (stabilized) dunes and sparse (shifting sand) dunes. At the patch scale, activity was compared between open patches and those under shrubs.

A strong interaction was found between the two scales for most species. Arthropods tended to switch their patch occupancy, opting for the rarer patch type. So while in the sparse dunes there was a preference for activity in the very few shrubby patches, in the vegetated dunes there was a preference for the relatively rare open patches. There are several possible mechanisms to explain this phenomenon and these are discussed. These findings have important implications for the conservation of psammophile (sand-loving) species. Shrub removal from the stabilized dunes may not result in the same community as that in the shifting sand dunes. This is because most species, regardless of their affinity to the stabilized dunes, will benefit from an increase in the area of the rare micro-habitat and species turnover will be delayed.

Age Related Variation in Sleep-Like Behavior in the Honeybee *Apis mellifera*

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Age-based division of labor in honeybees is associated with plasticity in circadian rhythms. Young bees typically care for the brood around-the-clock with no circadian rhythms, older foragers have strong circadian rhythms with a sleep-like behavior during the night. Similar ontogeny of circadian rhythms also occurs in bees housed individually in constant conditions. It is yet unknown if young bees, that are active around-the-clock, also show sleep-like behavior. We video recorded laboratory isolated young bees (3 days of age) and foragers over 24 consecutive hours and quantitatively analyzed the behavior of each individual bee. We defined and characterized six distinct behavioral states: three wake states and three sleep-like states. We assigned a behavioral state for every minute during the day, recorded the number of antenna movements in each sleep-like state and summarized the likelihood of transitions between behavioral states. We also measured the response threshold to a light stimulus for the different behavioral states. We found that the three sleep-like states differed in body posture, number of antenna movements, bout duration and in response threshold. The characteristics of sleep-like states were similar in young bees and foragers. However, young bees tended to pass more often between sleep-like states and between sleep and wakefulness. Total sleep duration and sleep distribution were greater in young bees. These findings suggest that young bees which are typically active around-the-clock, show a sleep-like behavior that is similar, but not identical, to the nightly sleep-like state of foragers.

Genetic Diversity in the Gall-Forming Aphid *Slavum wertheimae* Across an Ecogeographical Gradient in Israel: Speciation in Fragmented Population?

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Intraspecific genetic or phenotypic variations across an ecogeographical gradient can be generated by various evolutionary forces such as differential selection pressures, limited gene flow because of geographical barrier, genetic drift, or phenotypic plasticity. The aphid, *Slavum wertheimae* (Homoptera: Fordinae), makes coral-shaped ("cauliflower") galls exclusively on *Pistacia atlantica* (Anacardiaceae). The galls are developed on young buds in the spring by a single aphid that reproduces parthogenetically. Both *P. atlantica* and *S. wertheimae* have an Irano-Turanian distribution; in Israel their distribution is fragmented along different phyto/zoogeographic and climatic regions, a relict of their wider distribution in moister climate 10,000 years ago. We examined the genetic diversity of the aphid *S. wertheimae* between and within populations across Israel. Gall formation requires a very intimate relationship between the aphid and its host plant. Therefore, it is possible that the genetic structure of the aphids' populations is influenced directly by the habitat and or the characteristics of the tree (genetic or phenotypic). In summer of 2005 we collected aphid and leaf samples in nine sites, representing their distribution in northern Israel (Golan Heights, Hula Valley, Upper Galilee, Lower Galilee, Menashe Heights), and in the south (The Negev Heights). DNA was extracted and genetic variability was compared within and between sites by two molecular methods: AFLP (Amplified Fragment Length Polymorphism) and sequencing of the mitochondrial cytochrome oxidase gene. The ecogeographical gradient had no apparent affect on the level of polymorphism and heterozygosity within populations. The average heterozygosity within populations (He) was ~0.28 and the polymorphism levels vary between 71% and 88%. We detected a significant genetic difference between the northern group and the southern group ($p<0.05$), while there was no significant genetic difference within any group. The average genetic distance between the northern populations was 0.03 and between the southern populations it was twice as much – 0.06. The average genetic distance between the northern and the southern populations was 0.11. It seems that gene flow among the southern populations is limited (compared to the northern populations), and gene flow between the north and the south of Israel is considerably lower. The results suggest that the northern and the southern populations of *S. wertheimae* may be in a process of allopatric speciation. Analyzing the genetic structure of *P. atlantica* (in progress) should reveal the role of the host trees in this process.

The Effect of Coloured Shading Nets on the Risk for Invasion and Establishment of Insect Pests

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In recent years colored shading nets are used to cover crops for improving yields. Although some of these nets have colors that are known to attract insect pests their effect on the risk of pest infestation has not been studied. Whiteflies (*Bemisia tabaci*) thrips (*Thrips tabaci* and *Frankliniella occidentalis*) and aphids (*Aphis gossypii* and *Myzus persicae*) are the main pests of protected crops in Israel. These pests cause damage by sucking plants and transmitting viral diseases. We compared the risk for penetration and establishment of these pests on crop plants grown under colored shading nets (Chromatinet™) that are being developed by the Polysack Co. in Israel. Initial studies were done in small structures (1x1x1m) covered with yellow, blue, red or black 30% shading nets. Whiteflies prefer to land on the yellow net. Thrips prefer to land on the blue and yellow nets. Although these nets have large holes that allow free passage of small pests, the color of the net had a significant effect the pest's penetration and establishment. The infestation levels of whiteflies on tomato and cotton plants were significantly lower under the yellow net compare to the other colored nets. The infestation levels of thrips on chive plants under the blue net were not higher than under the black net. Further studies were done in walk in tunnels (6.0x6.0x2.5m) covered with black, pearl or yellow 30% shading nets in which bell peppers were grown (spring 2006; Besor experimental station). Infestation levels of whiteflies were significantly lower under the yellow net compare to the other colored nets. The incidence of an aphid born viral disease (cucumber mosaic virus or potato virus-Y) was significantly higher under the black net compare to the other colored nets. It appears that these pests remain for a long time on the nets having the color they prefer for landing (an arrestment response) and as a result they are less likely to infest the plants grown underneath these nets.

Quick Method for Screening the Efficacy of Different Poisonous Baits for the Control of the Little Fire ant (*Wasmannia auropunctata*)

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At the end of 2005, Vonshak Dayan & Hefez, from Tel-Aviv University reported the first finding of colonies of the little fire ant *Wasmannia auropunctata* in a number of settlements in the upper Jordan Valley of Israel. This ant species is considered as a dangerous intruder species all over the world as well as a medically important pest. Until this finding ants have been considered in Israel as a nuisance pest, and only a few insecticide formulations are registered for their control.

Control of social insects in general aims to destroy whole nests. Two main methods are employed against ants; direct nest treatment and poisoned broadcast bait.

In order to find quickly and efficiently, suitable insecticide for the control of these ants in Israel, we tested in the laboratory insecticides registered in Israel (active ingredients) as well as commercial baits known to be effective against this species in other parts of the world.

In the laboratory the tests were done on "mini" colonies comprising of a queen, about 200 workers and brood. In order to distinguish between lack of effect as a result of no feeding of the bait and no lethal effect of eaten bait, we developed a differential marking method based on coloring the baits with food dyes. The absorption of the colored bait was followed in the workers and brood. The most effective colors tested were green and blue. In 24 hours color can be detected in both the workers and the brood. The rates of absorption and disappearance of the color was determined employing sugary (non-poisoned) baits. The feeding on the different poisoned baits was followed using this method with the green dye.

The following active ingredients were tested: ready for use formulation containing: boric acid (2), avemectin (1) methoprene (2) hydramethylnon (2) thiomethoxam (1) spinosad (1). As well as baits prepared in the laboratory with the active ingredients hydramethylnon, thiomethoxam and spinosad.

Good results were obtained for three insecticides hydramethylnon, thiomethoxam and spinosad. Hydramethylnon was found to be the most efficient insecticide. Spinosad showed a relatively rapid effect but in several instances despite considerable mortality a small viable reproductive nucleus remained.

These tests preformed in a closed laboratory setup, enable to check the efficacy of a large number of insecticides in a relatively short time. Before large scale control applications are taken, it is imperative to test the promising baits on larger indoor and outdoor experimental scale.

Mating Behavior and its Effect on Reproductive Potential of the B and Q Biotypes of *Bemisia tabaci*

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Ecological interaction between species or sub-species (biotypes), such as reproductive interference, refers to the negative fitness consequences of behavior that disrupts reproduction. Interference may occur between species or biotypes if they have incompletely isolated mate recognition systems. Interspecific reproduction interference includes reduced female reproduction due to mating with heterospecific males, fertilization and aborted development, sperm competition and mate guarding. The whitefly *Bemisia tabaci* has two biotypes in Israel, B and Q. Although the biotypes exist side by side at many locations, accumulated data suggest them to be reproductively isolated. Recent crossing studies between the two biotypes have shown that interbiotype courtship behavior is common. The goal of this study was to check if interbiotype courtship behavior affects the reproductive potential of the B and Q biotyes.

We compared the courtship behavior using intra- (B male and B female or Q male and Q female)

and inter- (B male and Q female or Q male and B female) biotype pairs. Fecundity was studied using small populations of males and females from one biotype or populations containing females from one biotype and males from both biotypes. Differences were found in the courtship steps and the total courtship period between the intra- and inter- biotype pairs. We also observed reduction in the fecundity of Q females in the presence of B males. These results suggest that reproductive interference between the B and Q biotypes of *B. tabaci* exists in at least one direction.

Worker Reproduction and Chemical Signaling in the Bumblebee *Bombus terrestris*

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Colony development in the bumblebee *Bombus terrestris* is typified by three social phases: The eusocial phase in which only the queen reproduce, the competition phase when workers compete with the queen over male parentage, and queen rearing phase at the end of colony cycle. All these phases are regulated by pheromones that are emitted by the queen and/or workers. In the present study we have investigated the chemistry and caste specificity of Dufour's gland secretion in this species. Queen Dufour's gland is typified by a series of saturated and unsaturated hydrocarbons ranging from heneicosane to tritriacontane and is rather constant through the colony social phases. The secretion of workers is more plastic and changes according to their social status. Workers from the eusocial phase, before the competition phase, have in addition to the above hydrocarbons also a series of octanoic acid esters that range from octyl dodecanoate to octyl stearate. Workers that enter the competition on the other hand gradually loose the ester components of the secretion and by that becoming progressively more queen-like. Inspection of the worker ovarian development showed a negative correlation between oocyte length and the amount of esters. However, in workers after the competition the glandular secretion is totally lacking the esters irrespective of their ovarian state. We propose that the esters signal sterility in workers. This is in sharp contrast to what is known in honeybees where Dufour's gland of queen have long chain esters that are absent in sterile workers but present in fertile workers and thus constitute a fertility signal.

The Characterization of the Pectinolytic Bacterial Community in the Gut of the Mediterranean Fruit Fly *Ceratitis capitata*, and a Possible Interaction between Fruit Maceration and Nitrogen Fixation

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Female Mediterranean fruit flies oviposit in fruits wherin the larvae develop. By performing a systematic study of the medfly's gut microflora, using both culture-dependent and culture-independent approaches we have found that populations of pectinolytic bacteria identified as *Pectobacterium spp*. and *Klebsiella oxytoca* are present in every individual and able to fix nitrogen. This pectinolytic community was larger in larvae and pupae than in adult flies. Accordingly, we suspect that maceration of fruit tissues induced by pectinolytic activity provides ample carbohydrates that fuel the dinitrogen fixation function within the rotting fruit, thereby providing nitrogenous compounds to the growing larvae in this nitrogen-deficient environment. Moreover, we propose that larvae get an "enterobacterial package" of pectinolytic and nitrogen fixing bacteria that establish during the fly's life and may play a significant role in the fly's development.

Molecular Analyses of Spider-Mites (Acari: Tetranychidae) in Israel

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Forty-five sequences of the second internal transcribed spacer (ITS2) of nuclear ribosomal DNA were obtained from 16 Israeli species of spider mites (Acari: Tetranychidae). The length of the ITS2 region was species-specific and ranged from 368–483 bp for members of the subfamily Bryobiinae and 473−542 bp for members of the Tetranychinae. Three species: *Eutetranychus orientalis, Panonychus ulmi* and *Panonychus citri*, showed extensive polymorphism in their ITS2 base composition (twelve, seven and five sequences, respectively), while eight species had only one ITS2 sequence. The interspecific variation ranged from 3.8−56.8%, and the intraspecific variation from 0.2 to 2% with the exception of *T. turkestani* which was shown to be closely related to the two-spottes-spider-mite *Tetranychus urticae*, morphologically and molecularly, with a genetic distance of 1% between them. The maximum parsimony (MP) and maximum likelihood (ML) phylogenetic trees supported the monophyly of the Bryobiinae and the Tetranychinae and that of their genera, with the exception of *Oligonychus*, where monophyly was rejected.

Our results indicate that ITS2 sequences of spider-mites are applicable for two different purposes: species identification and determination of phylogenetic relationships at the family level.

Occurrence of *Synanthedon vespiformis* (Lepidoptera: Sesiidae) in Stone Fruit Orchards in Israel: Development a Sex Pheromone Based Monitoring System

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During the last decade injury caused by caterpillars (Lepidoptera) boring into the roots, and root collar of stone fruit trees (*Prunus* spp.) has been observed in many plantations in Israel. Damage has been caused mainly to nectarine, peach and almond orchards. The infestation was associated with infestation by *Agrobacterium tumefaciens*. In heavily infested sites caterpillars and empty pupa cases could be easily detected in the top soil near the stem and close to the stem collar. The injured trees could be easily detected because of the exudation of large quantities of gum, usually at the root collar of the trees. Adult clearing moths that developed from these caterpillars in the laboratory were identified as *Synanthedon vespiformis* L. The identification was confirmed by Zdeněk Laštůvka (Czech Republic) and Franz Pühringer (Austria). Adult males of *S. vespiformis* were captured en masse in pheromone traps baited with 9:1 or 8:2 mixtures of E3,Z13−18:AC + Z3,Z13−18:AC. S. *vespiformis* was trapped in stone fruit orchards and oak stands. Dry funnel traps (IPS Type) captured more males than sticky delta traps. One-milligram baits impregnated in 'American' rubber (West Co.) and 'Israeli' improved rubber ('Yogev' Ltd.) dispensers (without sulfur) were equally effective, and both baits were active for at least 5 weeks during the summer. It is not yet clear whether the moth is the primary cause of the damage syndrome and/or whether the *A. tumefaciens* tumors facilitate the injury or enhance the damage.

Contribution of Gut Microbiota to the Reproductive Success of the Mediterranean Fruit Fly (*Ceratitis capitata*)

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In the Mediterranean fruit fly (*Ceratitis capitata*) enteric bacteria (*Enterobacteriaceae)* dominate the bacterial community inhabiting the adult alimentary canal. Nonetheless, very little is known about the nature of this association and the influence of these bacteria on their host's biology. We hypothesize that gut bacteria provide the fly with necessary nutrients, thereby contributing to its overall fitness. The purpose of this study was to establish the influence of gut microbiota on two fitness components of *C. capitata*: the copulatory success of males and fecundity of females. Flies were fed one of two antibiotic containing diets: sucrose only or a diet which provided all nutritional needs. Their performance was compared with that of flies fed the same diet, without antibiotics. Males of each dietary group were allowed to compete against each other for copulations and their latency to mate was recorded. The number of eggs laid by females served as an estimate of their fecundity. Additionally, the impact of diet and antibiotics on the gut microbiota was evaluated

using bacteriological and molecular methods. Several tests confirmed that flies did not suffer major deleterious effects caused by the consumption of antibiotics. On the other hand, both diet and antibiotics significantly affected the size and composition of the gut bacterial population. Males, whose gut microbiota was not disrupted, enjoyed a significant competitive advantage when fed on sucrose and were preferred as mates over their antibiotic fed counterparts. When given a full diet, males did not display this trend. Females, however, did not lay fewer eggs when fed with antibiotics. These results suggest that bacterial activity in the gut may contribute significantly to the reproductive success of males. The use of probiotic bacteria could improve the competitiveness of irradiated males used in mass rearing and release control operations. Additionally, unraveling the qualities of Tephritid-bacteria associations could lay the fundamentals for a new bio-control method of the fly, based on the disruption of the gut microbiota.

Regional Monitoring of Thrips to Determine the Risk for Infestation of Chive

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Chive (*Allium schoenopransum*; Liliaceae) is a major exporting crop for fresh herb growers in Israel. Chive is grown in naturally ventilated tunnels or greenhouses. It is harvested every 4–6 weeks over a growing cycle of 6–12 month. In recent years "silver spots", resulting from thrips feeding (both *Frankliniella occidentalis* and *Thrips tabaci*), significantly restricted the export of chive from Israel. Lately, the number of insecticides to control thrips in chive was greatly restricted. Also, we found thrips populations resistant to insecticides in chive. During 2006 we conducted a state wide phonological survey of thrips in order to determine the risk for infestation of chive. Blue sticky pole traps, 1m high, were placed at 5 geographical regions in Israel. In each region we had 4 traps in various locations adjacent to where chive was grown. Traps were changed weekly as long as catches were above 20 thrips per trap per day. When catches decreased below this level traps were changed every 2 weeks. The overall number of thrips caught decreased from Yavne'el in the North to Ramat Ha'Negev in the South. At Ramat Ha'Negev, Jordan valley and Bet Shan regions the peak of catch was in late April, while in Yavne'el it was in late June. The period of time with catches above 20 thrips per trap per day, chosen as the threshold for high risk of infestation, increased from south to north. Catches went below this threshold at Ein HaBesor on mid May, at Jordan valley and Bet Shan on mid June and at Yavne'el only at mid August. At almost all sits, the highest numbers of thrips were caught on the eastern side of the poles (40–50%) and the lowest numbers were caught on the western side (10–20%). During the Spring and the Fall similar numbers of *T. tabaci* and *F. occidentalis* were caught. While in the Summer, 90% of the thrips caught were *T. tabaci.* This information may be used in a national plan to reduce thrips infestation of chive.

Mating Behavior and Mate Choice in the Mountain Pine Beetle *Dendroctonus ponderosae* Hopkins (Coleoptera: Scolytidae)

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The Mountain Pine Beetle (*Dendroctonus ponderosae* Hopk.) is the most destructive biotic agent of mature pine forests in western North America. We examined the mate choice behaviour in the Mountain Pine Beetles, both in Banff National Park, and in the lab. We found that there is mutual mate choice in this monogamous mating system. Females are the pioneering sex, which establish breeding sites, to which the males are subsequently attracted. Males in poorer condition were more likely to enter a gallery, contrary to what would be predicted by female choice. This may indicate that males in better condition are being more choosy and not accepting the first female they encounter. Female condition did not influence whether a male entered, but males were more likely to enter if the female gallery was larger and if tree defenses (resin flow) was lower. For males that entered, the time to enter depended on both male and female condition. For males in relatively good condition, time to enter decreased as female condition increased, as expected by male choice. However, for males in poor condition, time to enter increased as female condition increased, suggesting that females in better condition were more choosy when looking for a male for copulating.

Dynamics of *Bemisia tabaci* Biotypes in Field Crops

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The whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) is a serious pest and virus-vector in many agriculture systems. The species *B. tabaci* is defined as host races or biotypes complex. In Israel, The most widespread biotype is the B-type, which is character by high vitality, broad host-range and resistance to pyrethroids. The Q-type, which is characterized with resistance to some insecticides groups such as Neo-nicotinoides or Insect growth regulators (IGR) has been also confirmed to occur, but in more restricted range. Reproductive incompatibility between those types has been reported. Biotypes have been distinguished largely on the basis of biochemical or molecular polymorphism, so the identification was made with RAPD-PCR, SCAR and CAPS techniques. A multiple field survey, at the Arava region, Ayalon valley and at the Carmel coast was established in the years 2003−2006 to examine the interactions between biotypes under different variables,

such as climate areas, hosts preference and chemical or organic pesticides control. Analysis of field samples collected during the season from organic and conventional fields indicated that the Q-type has higher tolerance to various insecticides than the B-type and the latter exhibits higher fitness in untreated fields. Under non-insecticidal regimes, such as in organic agriculture, B-type was apparently more competitive than the Q-type. Use of chemical control promotes selection toward the Q-type. In climate and host preference aspects, the B-type in favored of warm climate and cotton, while the Q-type seem to prefer temperate climate and sunflowers.
Studying the distribution and interactions among *B. tabaci* biotypes is needed in order to design and improve effective crop protection and IRM strategies.

Female Remating in the Medfly – Towards a Fast and Simple Quality Control Test

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Female remating in Medflies is a key factor affecting the efficiency of the sterile insect technique (SIT). The ability to inhibit female receptivity to remating is a major component of male sexual performance. Accordingly our objective is to develop a reliable Quality Control test that accurately measures this component.

Virgin females were mated with virgin males from different sources: wild males, laboratory reared-males and sterile males. Males were fed on one of two diets: sugar and protein or sugar only. One hour after the end of the first mating, mated females were given the opportunity to remate. We chose to focus on this time frame, because females who mate in the field are likely to encounter males immediately after mating, and, we suspect, their "window of receptivity" is wide open at this time. Overall, female remating rates were above 50%. These rates varied according to the strain and diet of the first male to copulate and the condition and strain of the second male offered to the female.

Ongoing and future experiments will determine the optimal post-teneral environment for sterile males that best promotes female refractory behavior.

Finally, we suggest that this female remating test can be standardized and incorporated as a SIT quality control procedure.

Mating Behavior in the Schistopterini (Diptera: Tephritidae)

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The tribe Schistopterini comprises about 60 described species and at least another 150 undescribed species, the biology and behavior of which are almost entirely unknown.
We report here on the reproductive behavior of *Schistopterum moebiusi* (from Israel), and on two additional species of *Schistopterum* and *Brachiopterna ornithomorpha* (from Kenya), with emphasis on mating trophallaxis. In these species courtship and mating consist of stereotypical dancing, wing-waving, and secretion of a white foamy substance from the male's proboscis onto the substrate, followed by the female starting to feed on this secretion, thereby signaling her receptiveness to the male, who then mounts the female, and copulation takes place while the female is feeding. During copulation the male will usually stop several times to replenish the secretion while the female waits to the side, after which the couple resume copulation

We detail here the observed differences in courtship, copulation and oviposition among the studied species, as well as their common denominators.

The Effect of Outbreeding Opportunities on the Breeding Strategy of the Palm Stone Borer Beetle.

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Inbreeding and adaptations to inbreeding are often found either at the periphery of the species' range or in isolated areas such as islands. Inbreeding may predominate in these environments because it provides reproductive assurance when availability of mates is limited. I studied the mating strategy of the palm stone borer beetle, *Coccotrypes. dactyliperda* which develops in date palm *Phonix dactylifera* seeds. Seed colonization takes place individually but in high beetle densities, several females may colonize a single seed. Mating can occur between (1) unrelated individuals (2) siblings and (3) mother-son. I examined the genotypic structure of nine populations of *C. dactyliperda* under a wide range of geographic conditions and found significant departures from the Hardy-Weinberg equilibrium and excess of homozygosity. These indicate high levels of inbreeding. The results suggest that all populations are highly inbred with only occasional outbreeding events. In order to clarify the extent of inbreeding as a reproductive assurance strategy

a lab experiment was conduced in which females were presented with either kin or non-kin males as potential mates. The results reveled that females wait longer before mating with kins. I suggest that according to the reproductive assurance theory, a high level of inbreeding occurred due to low male availability.

Israel: Small Country – Small SIT projects

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Few years after the EastMed project was declared in Vienna (1994), aiming to eradicate the Mediterranean fruit fly *Ceratitis capitata* (Wiedemann) (Medfly) from the whole Middle East, it became clear that for the time being large scale SIT projects in the region are not feasible. However, the success of the Arava Medfly Eradication Project (AMEP) to reduce significantly the Medfly population in the Arava encouraged further use of this technology in Israel.

In the beginning of this year (2006), after the establishment of the Israeli factory producing sterile Mediterranean fruit flies, Bio-Fly, Israel have initiated two small scale SIT projects in commercial fruit groves: The "West Negev" and the "Ruins of Batra" projects. Both were initiated after the end of the winter of 2006, when the wild fly's population was minimal, by twice weekly ground releases of sterile flies at a rate of 250- to 300 flies/ dunam/ week.

The first project is carried out in the Negev, which is the major desert of Israel occupying more than 50% of the country. The semi-arid plane along its west, bearing some water for irrigation, is cultivated fairly intensively with non-irrigated fields (cereals) and irrigated crops such as citrus. From cost benefit reasons, most of these citrus orchards are clustered in compound orchards, each is approximately 1,000 dunam. These clusters, surrounded by desert with no host trees, are seamed most adequate for effective SIT. The West Negev project is carried out over 9,330 dunam of citrus and two neighboring villages, Kibbutz Gevulot and Kibbutz Ze'elim. Releases were started on February 2006.

The second project is carried out in the north of Israel, in the ruin of "Batra", north east to the Sea of Galilee. Again it is a complex grove, approximately 160 ha, consisted mainly of mango and surrounded by a 1 km wide belt with no hosts, which may serve for some extent as a barrier for the fly. Releases were started on March 2006.

Single Mating – Several Biological and Ecological Consequences

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A female medfly may lay hundreds eggs and infest many fruit during her life span. When applying the Sterile Insect Technique (SIT), remating may increase the chance of a female to mate with fertile flies and thus decrease the overall success of the technique.

This study examined how that remating affects the reproductive capabilities of the female. Virgin females were mated once and divided to two groups: one without males and one with fertile males. The number of the oviposited eggs and their fertility (egg hatch) were recorded. The results indicated that a single copulation is enough for female Medflies. The quantity of sperm stored then is sufficient for a few weeks fertilizing hundreds of eggs. Multiple copulations did not increase fertility in the first two weeks compared with single mated females although the data suggests that multiple matings may extend her fertility period.

What does this mean in ecological terms? The priority for a virgin female, once sexually mature, is to find a mate to assure the conception of largest part of her progeny. It is unlikely that she would forage for fruit and risk her reproductive potential by not finding a mate. Likewise the male's priority is to also maximize reproductive success, and will seek, primarily, for receptive (virgin) females rather than by seeking for ripe fruit and courting pre-mated, ovipositing females.

In the real world there are continuously shifting spatial patterns of fruit maturity according to crop species and variety, we expect the first flies coming to an orchard to be mated females. If they find susceptible fruit it will take at least 20 days (in summer, from egg to adult) for virgin females to emerge and a week until they will become sexually mature. So, while all Medfly populations have an overall sex ratio of 1:1, at orchard level spatial resolution the sex ratios may be highly variable. For example, each newly mated female will emigrate to a site of ripe fruit thereby increasing the proportion of males at the previous site. The paper predicts the temporal succession of immigration, emergence and emigration for each sex (and their sexual status) for a notional orchard which has just become susceptible to Medfly oviposition.

The Effect of Jasmonic acid Signalling Pathway on Tomato Defense to Broad Mite Behavior

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Broad mite (BM), *Polyphagotarsonemus latus* (Acari: Tarsonemidae), is a minute polyphagous mite that causes severe damage to many greenhouse crops. Being wingless, BM exhibits a specific phoretic relationship with whiteflies that helps its dispersal. Although knowledge on plant resistance to BM is poor, it was found to induce multiple defense genes pathways in cucumbers. In order to evaluate the possible involvement of the jasmonic acid (JA) signaling pathway in plant defense against BM, we compared wild type (wt) tomato, *Lycopersicon esculentum* Mill cv. Castlemart, with the JA pathway mutant *def-1* that is impaired in JA biosynthesis. We evaluated the effect of BM infestation on plant growth and leaf anatomy, along 5 weeks. To determine the involvement of JA pathway on host recognition by BM we compared wt and *def-1* leaflets in two behavioral bioassays: 1. "Detachment bioassay", comparing the rate of BM disembarking from its phoretic vector, the whitefly *Bemisia tabaci* onto tomato leaflets; 2. Leaflet choice assay by free- moving mites.

BM feeding did not affect growth and leaf development in the wt plants, but did cause a 50–60% inhibition in *def-1*. BM progeny-counts after three week infestation indicated that mite population developed only on *def-1* plants. Leaflet tissue of *def-1* revealed complete loss of epidermis, accumulation of phenolic compounds in the cell walls and an increase in mesophyll cell size and number. On the other hand, wt infested tissue appeared normal. Free moving BM preferred the *def-1* mutant over wt (87% of the total choosing free moving mites selected *def-1* while only 13% selected the wt). Moreover, BM detachment from its phoretic vector occurred faster on *def-1*, compared to wt leaves. Treatment of *def-1* leaflets with methyl jasmonate (MeJA) reduced the detachment rate to a level comparable to that of wt.

It therefore appears that JA signaling pathway plays a role in the resistance response against BM. On the other hand, BMs are able to actively discriminate between resistant and susceptible plants, preferring the JA-defective mutants. Host derived cues essential in host recognition and mites are yet to be disclosed.

Integrated Pest Management in Tomato Cultivars Resistant to Tomato Yellow Leaf Curl Virus (TYLCV)

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The limiting factor of tomato cultivation in Israel is the tomato yellow leaf curl virus (TYLCV) that is transmitted by the whitefly, *Bemisia tabaci*. TYLCV- resistant cultivars offer a novel opportunity to initiate IPM programs in greenhouse tomatoes. These cultivars are more tolerant to the virus, and thus enable the use of natural enemies. Our objective in this study has been to integrate mirid bugs and predatory mites along with soft pesticides (as needed) that will be applied

in tomato screen-houses against tomato pests.

Two mirid bugs (*(Nesidiocoris tenuis* and *Macrolophus caliginosus*) and four predatory mites were reared under controlled room conditions and tested for their effectiveness against *B. tabaci* nymphs. In addition, the effect of high temperature on the mirid species was determined. In other experiments, the development of predatory mites on tomato plants, and the effectiveness of these mites on tomato russet mite were examined. Field trials were conducted during September to March in the 'Besor' Experimental Station (SW Israel) in 15 tunnels.

N. tenuis nymphs and adults survived in temperatures as high as 38°C for at least 6 h, and were more tolerant to warm climate conditions than *M. caliginosus.* Under plastic tunnel conditions, both treatments (where mirid bugs had been released) reduced *B. tabaci* levels, especially *N. tenuis*. During the hot months of September and October *N. tenuis* adults increased to a very high level as compare with *M. caliginosus* whose population stayed very low. While other pests such as spider mites and leafminers also were affected by *N. tenuis,* russet mites were not. Although, the predatory mites tested were effective on russet mites, they did not develop satisfactory on tomato plants.

Our results demonstrate the high potential of *Nesidiocoris tenuis* for controlling whiteflies and spider mites in greenhouse tomatoes.

Banana moth, *Opogona sacchari* (Lepidoptera:Tineidae), new in Israel

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Presence of Banana moth, *Opogona sacchari*, in Israel was first confirmed in November 1999. The moth was found on exotic palm, in greenhouse and since in number of nurseries around the country. The moth was probably introduced on a plant of ornamental palm. Pest status of the moth in Israel at time of its introduction to the country was: Quarantine pest.

Monitoring attempts by means of pheromone traps or light traps showed no success. The only way to detect infestation is by visual examination of plants. All stages are hidden inside plant therefore detection of infestation is difficult and accidental distribution of the pest is expected.

A national survey in ornamental palm nurseries was carried out by Plant Protection and Inspection Services (PPIS). Observations were made on life cycle, host range and damage to host plants.

Feeding damage of the larvae, up to 30 per plant, in trunk and root area can cause plant mortality yet larvae can complete life cycle on the dead plant. Therefore big effort is needed for phytosanitation and chemical treatment to control the moth. Attention is made to possible infestation of banana plantations.

To date, pest status in Israel is declared: Quarantine pest, present in protected cultivation, subject to official control. PPIS official control includes ongoing surveillance, observations on host range and ability to complete life cycle under different conditions.

First Evidence to the Little Fire Ant's Impact on Local Fauna in Israel

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Humans frequently transport plants and animals to new habitats. The few propagules that survive and establish in their new environment sometimes pose a serious threat to local flora and fauna as well as to agriculture and economy. One of the most significant impacts of invasive ants is on local ant species; in some cases they were found to displace up to 90% of local species. Since ants have many and complex rolls in the ecosystem, affecting their species composition may impact other organisms as well.

The little fire ant (LFA, *Wasmannia auropunctata* Roger, 1863), discovered in Israel on November 2005, is known worldwide for its devastating impact on biodiversity and on economy, as well as on quality of life. Thus it is listed in the IUCN's "one hundred of the world's worst invasive alien species" list. The ant's natural range is in South and Central America, and it is now spreading in West Africa and in Pacific and Caribbean islands. We believe that the ants were imported to Israel with wood logs from Gabon to Kibbutz Afikim, five to eight years ago. Following their establishment, the ants spread within Israel, with chopped wood, logs, and potted plants as vehicles of spread.

In order to study the ants' impact on local fauna, we sampled ground dwelling arthropods using pitfall traps and baits. We compared samples from different LFA densities between three villages, an open landscape, and a nature reserve.

Preliminary results of the pitfall traps from Kibbutz Afikim show a substantial impact on the local ant species in plots with high densities of little fire ants. In these plots other ant species were very rare (for example – 1 individual compared to 3,518 LFA in 16 traps). At low LFA densities or in their absence we found higher numbers of other ant species (mean ± SE: 17.37 ± 1.36 and 24.12 ± 1.39, respectively). There was also a considerable impact on the diversity of beetles and spiders.

Thus, the spread of the little fire ant in Israel endangers local biodiversity and urgent measures must be taken to stop its spread.

Myiasis in domestic animals in Israel

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Myiasis is the phenomenon of infestation of tissues of living animals with fly larvae. The phenomenon is known in humans, but is rare in developed societies. Myiasis was recorded in Israel in the past mainly from sheep and goats. In a survey of Jerusalem and its surroundings in 2005, 51 dogs and 1 cat were found to be infested with larvae of *Wohlfahrtia magnifica*, one dog was infested with both *Lucilia sericata* and *Chrysomya albiceps* and 2 cats with *L. sericata*. One sheep was infested with *L. sericata*, 2 goats with *Przhevalskiana silenus* and 3 goats, 2 camels

and a horse with *W. magnifica*. All larvae were removed manually and the wounds were cleaned and disinfected. The animals were treated with antibiotics and an anti-inflammatory agent and most animals recovered. 90% of all the infestations were with *W. magnifica* which is the common species causing myiasis in animals and humans in Israel. This species is larviparous, depositing larvae in animal wounds, including very small wounds such as those from tick bites. At least 5 of the dogs with myiasis were also infested with the dog tick *Rhipicephalus sanguineus*. *W. magnifica* is distributed all over Israel and deposits from 120 – 170 larvae in each laying. The number of larvae extracted from a single dog wound was up to 150. The developing larvae may cause great damage to the host tissues and can even be fatal without suitable treatment. In some cases, larvae of different ages were found suggesting that more than one infestation occurred in the same wound. Most of the infested dogs were guard dogs or outdoor dogs. Some dogs had wounds infested after dog fights. The infestations were mainly in areas not heavily covered with fur: 32% in head and neck, 32% in the genitalia, 19% in legs, 8% on the tail. There was one infestation on the back and one in a mammary tumor. In several dogs there was more than one focus of infestation. The species *Chrysomya albiceps*, which was found on one dog together with *Lucilia sericata*, is known to cause secondary myiasis in the tissues already infested with the primary species. Myiasis in cats is rare, probably because of grooming. This is the first report of *W. magnifica* and *L. sericata* on cats. The camel infestations occurred in the jaw and the vagina, and the horse was infested in the foot. The species *Przhevalskiana silenus* has been reported as a pest in goat herds in Western Galilee. This species may cause much damage to the goats especially when the level of treatment is low. *L. sericata* is known in Israel and elsewhere as causing significant damage to sheep.

Anobium punctatum (Coleoptera, Anobiidae), a New Pest to Books in Israel and Other Beetle Pests Imported to Israel with Dry Wood

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The powder-post beetle, *Lyctus* sp., was known in Israel until recently as the only beetle pest of dry wood or books printed and bound with paper and cardboard produced from wood and stuck with starch glue. In 2004, *Anobium punctatum* was found to be causing a very serious infestation of books stored in one of the largest libraries in Israel. It was estimated that between some tens of thousands and some hundreds of thousand books were infested. Most of these books are very specialized, old and irreplaceable copies. They are valued not according to monetary value but according to their national and scientific importance as well as their emotional value. The damage caused is characteristic to the lifestyle of *A. punctatum*. This species is distributed in temperate climates, is common in Europe and North America and is considered to be the main pest of dry wood, its products and in libraries. It was recorded in Israel in the past from imported wood infested with larvae and in 1995, several books were found infested with this species in one of the religious libraries in Israel. However, in these cases, the damage was small and the population did not become established nor spread to other libraries in Israel. It is assumed that the dryness

and high temperatures in Israel prevent the egg-laying activity of the adult beetles in nature. These small (2−3mm) brown beetles live in the internal space of buildings. The females live for 2−3 weeks and lay 20−60 eggs. After hatching, the larvae immediately penetrate into the wood or books where they feed, and by moving and gnawing they create tunnels and an impressive amount of saw-dust which proves that the books are infested. Under optimal conditions, the larvae pupate after one year near to the surface. Under less than optimal conditions, this may take up to two years. The adults emerge from the wood or books producing a regular hole of over 2mm in diameter. The larvae ingest cellulose and also gnaw the starch glue of the book-binding causing the book to disintegrate. It is assumed that in the case of the severe library infestation, the first infestation foci were of books brought from abroad. The level of infestation and the long period of development indicated that the infestation had developed over many years. Two control operations are necessary in order to exterminate the beetles: fogging of the library to kill the adults and treatment of the books to kill the larvae and pupae. This treatment may be either by methyl bromide, freezing of the books to –30ºC, or anoxia methods. In the last year, 3 cases of imported beetle pests of dry wood have been recorded: *Sinoxylon* sp. from a wooden sculpture from Zimbabwe; *Heterobruchus* sp. in a wooden crate from the USA and *Dinoderus minutus* in barbeque sticks from the Far East. These cases show that stricter controls should be made on old books and wood and wood products imported to Israel.

New Identification Approach of Mites (Acari) and Insects

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The major increase in international agriculture trade and agreements between plant protection & inspection services all over the world obligates fast identification of insects and mites in the ports and gateways of each state. All over the world the community is faced with a decrease in number of taxonomists. The conventional identification methods of insects and mites are: 1. Classic method – base on the morphology difference between organisms. 2. DNA method – base on adjustment of DNA sequence to cDNA data base. In both methods proficiency and equipped laboratory is needed.

Our proposition is to use the technological progress of digital photography and unique computer applications to solve this issues .In our search for suitable application we found a biometric system for identification of criminals by finger prints. The system is based on vectorial picture identification application and data base that contain large amount of finger prints. The experiment took place in the facility of Israel police department – the finger prints identification department. The experiments include the following elements: Microscopic facilities of insects and mites, microscopic digital pictures of insects and mites.

The pictures was scanned into the automated fingerprints identification system (AFIS) in jpeg format and indexed into the application. After the scanning we characterize the picture by "sperms" .The "sperms" are vectors that characterize the most unique organ of the Acari. We saved the vectorial picture into the application data base. The experiment included scanning of 10 pictures of mite (species). After the scanning, the AFIS system was used to find the most similar vectorial picture from the data base. In the experiment we have got positive result and the computer gave the result in a very high probability for each sample of Acari.

This is the first step for computerize scanning method. Still we have a lot of work ahead and the vision is: An inspector sitting by a computer in the state ports .The computer include a grate amount of Acari /insects/other organs in the data base. By an agreed protocol, the inspector will prepare a microscopic facility and will picture and scanned it to the application. The computer will give the inspector an answer including the result by probability. This method we can get a fast identification in source and we won't need a proficient for each taxonomic group. The preparation of the organs data base and the building of appropriate protocol for vectorise/ to vectorise? each group picture is seeking a proficient work and can take a long time. The decision of making this experiment to a real project is in the hand of the plant protection & inspection services and the Israel agriculture ministry.

Early Reports of a Predator-Released Kairomone Affecting Mosquito Oviposition Site Selection and Ability to Quantify Predation Risk

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Previous studies found that two common species of mosquitoes (*Culiseta longiareolata* and *Culex laticinctus*) avoid ovipositing in pools containing the aquatic predatory backswimmer, *Notonecta maculata*. Detection of the predator by the gravid mosquito females is achieved through chemical cues released by the predator (kairomones). Testing the kairomones composition and influence on oviposition habitat selection could have practical importance in biological control and ecological dynamics.

Gas Chromatography Mass Spectrometry in the Solid Phase Micro – Extraction (GCMS-SPME) mode, identified volatile chemicals from predator-conditioned water. We are presently testing their individual and interactive effects on ovipositing females.

In outdoor artificial pool experiments, we found evidence that females are able to quantify risk of predation and oviposit accordingly when given various pairwise combinations of predator densities.

Development of Winter form Morph in the Pear Psylla, *Cacopsylla bidens*

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The Pear psylla (*Cacopsylla bidens*) is a key pest in pear orchards in Israel. *C. bidens* appears in two distinct phases: a summer form and a winter form, differing morphologically mainly in body size and coloration, with the winter form bigger and darker than the summer form. In order to examine the morphological and physiological characteristics of the winter form, adult *C. bidens* were sampled during 2002–2004 in three separate pear orchards in different regions in northern Israel: Bar'am (+700m), in the eastern upper-Galilee, Ha'hula Valley (+70m), in the northern Galilee and Rosh-Pina (+300m), located at the southern basalt barrier of Ha'hula Valley. The morphological parameters evaluated were: the length of the front wing and wing melanization. In females mating status and ovarian development were also determined. Additionally, a laboratory experiment was conducted in order to evaluate the influence of temperature and photoperiod on development of the winter form characteristics and presumptive existence of reproductive diapause. The experiment consisted of five treatments: two of them schematically simulating the winter phase (a short day with a low temperature) and the summer phase (a long day with a high temperature), and two manipulations: a long day treatment at a low temperature and a short day treatment at a high temperature. A fifth treatment tested the influence of the equinox conditions, where the day-night period is equal (L:D,12:12). The experimental results indicated the potential for reproductive diapause in the winter form that is dependent on photoperiod. The field data showed that the transition from summer form to winter form in the population is gradual, beginning in early autumn around the equinox, as a consequence of decreasing photoperiod. The body darkness first, wing pigmentation occurs later and the average wing length increases. Within the three sampled populations, there is a time-shift of two weeks in the expression of the winter form characteristics, with that in Bar'am preceding the population in two other locations. Wing melanization continues to increase through January, indicating that the photoperiod is the primary factor to phase induction but that low temperature is a contributing factor. Average wing length also increases, suggesting either the existence of several generations during this time frame, or a distribution in development time with the generation. Concurrent to the morphological changes, the percentage of females in reproductive diapause, in the field population collected at the three locations, gradually increases from the beginning of autumn, as evidenced by reduced ovarian development and decrease in mating occurrences. The duration and intensity of diapause differs in the three sites examined, whereas its termination occurs simultaneously at the three sites and ends in early January, perhaps synchronized by photoperiod, induced at the winter solstice.

The source of significant differences in wing melanization and ovarian development between the populations is not clear, but could be a result of genetic isolation.

Pheromones for Commercial Control of Leopard Moth (*Zeuzera pyrina*) in Pome Fruit and Olive Orchards in Israel

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The decline in usage of organic phosphorus insecticide sprays in pome fruit and olive orchards, and increasing implementation of IPM strategies has lead to a substantial increase in Leopard Moth (LM) damage in these orchards throughout the Mediterranean basin. The LM larvae attack the branches and trunk of the trees, weakening the tree and causing its decline. The severity of

the damage varies according to the age of the tree and the intensity of the infestation. A one-year-old tree may be killed by a single caterpillar. In established orchards trees may lose main branches. In addition the orchard may become very vulnerable to wind damage and to secondary infestation by other xylophagous pests. The female LM lays egg masses on the rough bark in the tree tops (usually on the same tree from which she emerged, as the female has limited flying ability). The newly hatched larvae burrow leaf axils causing their death. Consecutive stages of the larvae descend to lower thicker branches causing death of parts or of the entire tree. In Israel the life cycle of the pest is one year. Control of the emerging larvae with convention insecticides requires repeated applications during the entire emergence period (3−4 months). This treatment is expensive and may damage the natural predator population in the orchard. The larvae may be mechanical controlled by hand with flexible wire. This treatment is time consuming, costly and not always effective. The female LM emits pheromones which attract the male. The use of pheromones for monitoring and mass trapping of the LM has been reported since the early 1990's. In 2001 the Agricultural Department of Agan Chemical Manufacturers in co-operation with researchers and field advisors began field trials in orchards for LM control using pheromone rope dispensers manufactured by Shin-Etsu, Japan. The pheromone ropes are distributed evenly throughout the orchard (about 2 meters off the ground) in the spring, at a rate of 450−600 ropes/Ha (27 – 45.5 gram/Ha pheromone). The pheromone is released uniformly over a period of 80 days. In the pheromone-treated orchard the males have difficulty locating the females and the result is a reduction in mating. Commercial applications of pheromone ropes over two consecutive years gave significant reduction of LM damage. Following three years of pheromone treatments in a severely infested orchard, the LM infestation rate was reduced to below the detection level. In the fourth year, after the pheromone treatment was discontinued a significant level of new infestation was recorded. Field trials are underway to determine of a low application rate of pheromone ropes can maintain low levels of LM infestation after the initial infestation level has been decreased. Leopard Moth Ropes received registration in 2006, for use in apple, pear and olive orchards in Israel, for both conventional and organic agriculture.

Secondary Symbionts in Israeli Biotypes of the Sweetpotato Whitefly *Bemisia tabaci*

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The sweetpotato whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae), is a sap-sucking insect that harbors the essential primary symbiont *Portiera aleyrodidarum*, as well as several secondary symbionts (SS) whose function is unknown. *B. tabaci* is actually a species complex consisting of many biotypes which may differ in host range, insecticide-resistance and ability to transmit plant viruses. All Israeli *B. tabaci* tested to date belong to either the B or the Q biotype.

In this work we have studied the association of *B. tabaci* SS composition and frequency with the biotype and host plant. 28 laboratory- and 18 field- populations collected between 1987 and

2005 from various host plants and geographic regions in Israel were sampled. SS and biotype were identified using PCR with specific primers. Four SS were found. *Hamiltonella* was detected only in the B biotype whiteflies (100% infection) whereas *Wolbachia* and *Arsenophonus* were detected only in biotype Q individuals (33% and 87% infection respectively). 45%−100% of both biotypes harbored *Rickettsia.* B biotype was dominant in field populations sampled from sweet pepper, cucumber, squash and eggplant, while biotype Q dominated in cotton and *Salvia* plots. No differences were found with regards to SS prevalence among host plants within the B biotype, but whiteflies collected from *Salvia* (Q) recorded a significantly higher infection rates with both *Rickettsia* and *Arsenophonus* from all other samples. The localization of *Hamiltonella* in *B. tabaci* was studied using Fluorescence *in-situ* Hybridization**.** *Hamiltonella* was found to be localized inside the bacteriocytes confined with *Portiera* during all developmental stages, as opposed to the *Rickettsia* distribution in the haemolymph, previously reported.

The high incidence of SS in *B. tabaci* may suggest they play a vital role in the biology of the host and the deviation in SS composition between biotypes might be related to the differences in host range, insecticide resistance and development rate.

Wheat Stem Sawflies Damages in Israel and Development of Means to Reduce Them

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Wheat is a major winter crop at the Yizrael valley and the northern Negev regions of Israel. In recent years the wheat stem sawfly (Hymenoptera: Cephidae) damages are increasing in those regions. Similar damages were last reported at the early 80's. Our observations indicate that currently the main pest species is *Cephus pygmaeus* (L.) and the minor pest is *Trachelus tabidus* (F.). These sawflies are univoltine species, whose over-summering adults emerge from mid February until mid March. Mated females lay a single egg between the third and fourth nodes of the stem, usually before the head of the wheat has emerged. Larvae feed and develop inside the stem. This often results in small and light colored kernels with reduced protein level. The larval phase lasts for about one month, after which the mature larva prepare for hibernation at the base of the plant. During this process it cuts a groove at the base of the stem which often causes it to break and lodge before harvest. Sawflies larvae hibernate in the wheat stubble. Currently, yield loses due to sawflies reach 30 to 50% in infested fields. Damages are especially high in fields where wheat is grown a second year in a row, and minimum tillage is practiced. We are developing management tools to reduce sawflies damages and minimize the use of insecticides. These include developing pest monitoring system, phenological models and an economic action threshold. We also study the spatial distribution of the pest in order to make monitoring and control more efficient. We evaluate solar heating and sheep grazing as means to reduce the survival of the over-summering larvae.

Interactions Among a Key Pest of Liliaceae, the bulb Mite *Rhizoglyphus robini*, Soil Fungi and Symbionts

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The Bulb mite, *Rhizoglyphus Robini,* (Acaridae: Astigmata) is a key soil pest of Liliaceae. Its capacity to subsist on substrates of minimal nutritional value may be an indication that symbionts are involved in supplementing its diet. In the field, bulb mite infestation is usually associated with soil fungi. While it is known that these mites, (and other astigmataids), are attracted to fungi, it is not known whether the bulb mite is able to distinguish between different fungi species. To determine whether bulb mites are equally attracted to soil fungi associated with lily and onion we evaluated their attraction to seven pathogenic fungi and one non pathogenic species (to Liliaceae), *Verticillium dahliae*. Experiments were conducted in Petri dishes containing two discs of potato dextrose agar (PDA) infested with one species of fungi and two discs with PDA serving as controls. Mites were attracted to seven out of the eight species of fungi evaluated but the degree of attraction varied. The most attractive species were *Colletotrichum dematium* followed by *Fusarium oxysporum*. Attraction to the non pathogenic fungus *V. dahliae* was similar to the latter species. Mites were more attracted to the purple mycelium strain of *F. moniliformae* than to the more virulent white strain. Mites were not attracted to the pathogenic fungus *Pythium oligandrum*. It appears that bulb mite attraction to fungi is not affected by the degree of fungal pathogenicity to onion or lily.

To identify and characterize bacterial symbionts present in the bulb mite, PCR was conducted with specific primers to the 16S rDNA gene. Two species of Bacteria belonging to the class Proteobacteria were found in parents and eggs. Experiments are now conducted to assess the effect of these symbionts on mite fitness and degree of attraction to fungi .The implications of fungal, symbionts, mite interactions on the pest status of the bulb mite will be discussed.

The Spatial Dynamics of Omnivore-Prey Association: Scale Differences between Adults and Nymphs

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Whereas many field studies have estimated the numerical response of predators to their prey, the numerical response of omnivores is yet to be explored. The goal of the present study was to

describe the relationship between an omnivore and its prey at different spatial scales. Toward this end, populations of omnivorous bugs of the genus *Orius* and their thrips prey were sampled in *Verbesina encelioides* flowers at three hierarchical spatial scales; a flower, small patch (2m dim.) and large patch (6m dim.). Population densities of the omnivore and its prey were correlated using a hierarchical statistic model.

Results indicate that the intensity of omnivore-prey association changed with spatial scales. Density of adult bugs was positively correlated with that of the prey only at the largest spatial scale. The density of omnivore nymphs, however, was positively correlated with that of their prey at all spatial scales.

We tested the aggregative and oviposition responses of *Orius* females to their prey in a laboratory choice experiment. Results show that female bugs aggregated and laid more eggs in artificial flowers that harbored an increased number of prey. These results suggest that aggregation is an important component of the numerical response of these omnivores to their prey in the field. Different mobility rates of adults and nymphs may therefore underlie the recorded differences omnivore-prey dynamics at different spatial scale. Future studies are needed to explore the effect of plant material, such as pollen, on the aggregative response of omnivores to prey density. Such data would provide mechanistic underlying of the numerical response of omnivores to their prey.

Biological Control of *Polyphagotarsonemus latus* by the Predaceous Mite *Amblyseius swirskii*

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The broad mite, *Polyphagotarsonemus latus* (Acarina: Tarsonemidae), is a major pest on many crops in tropical and subtropical regions and in greenhouses world-wide. Damage caused by broad mites is expressed by leaves curving downward, plant growth is stunted and blossoms aborted. Fruit may become distorted and get a silvery cast upon it. Due to growing consumer demands for healthy and green produce, non-chemical solutions, foremost among which is biological control, are being sought. The phytoseiid predatory mite, *Amblyseius swirskii* Athias-Henriot, is a type III predator, able to feed on pollen and small arthropods. Originally found in citrus groves in Israel, laboratory research in Europe has demonstrated its ability as an effective biological control agent against *Bemisia tabaci* and *Frankliniella occidentalis*. However, its ability to control populations of *P. latus* is yet unknown. The object of this research was to determine the ability of *A. swirskii* to feed on broad mites in the laboratory. Female predatory mites were isolated and starved before being placed on a leaf disc with different numbers of *P. latus*. After a period of 24 hours broad mite mortality was determined. We found that *A. swirskii* demonstrates a type II functional response to varying population sizes of *P. latus*. Based on these positive results we will explore *A. swirskii* as a biological control agent against broad mites by 1) determining their ability to develop on a diet exclusively of broad mites (life table) and 2) their ability to control the pest on sweet pepper in the field. *(L)*

Effect of Novaluron Against Stored Product Insects

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Wide use of conventional fumigants and protectants was resulted in increasing the insect pest resistance and negative public reaction on their use. As a result of these trends a strong accent is given on the searching for save and environmentally friendly alternatives. One of them is Insect Grows Regulators (IGRs), Novaluron is a novel chitin synthesis inhibitor from benzoyl phenyl urea's group of IGRs with a broad-spectrum activity on various insects, but with very low toxicity to mammals.

The objective of this study was to evaluate the efficacy of Novaluron on the main stored product insect pests as possible alternative to standard pesticides for stored pest control.

In laboratory conditions, at a concentration of 1.0 ppm total mortality of external *T. castaneum* and *T. granarium* third-instar larvae and total prevention of the adult emergence of *P. interpunctella* were recorded. Novaluron significantly influenced on the hatchability of the eggs. At 1.0 ppm the numbers of F_1 internal feeders *S. oryzae* and *R. dominica* were reduced by 95% compared with the control. Survived insects completely died after 3–4 months with no progeny**.** The activity of Novaluron against *S. oryzae* was maintained at least 1 year. In field studies, the efficacy of Novaluron at 2 ppm against both *S. oryzae* and *R. dominica* was enough high during at least 9 months: 82−90%.

The Effects of Alkaloids in *Nicotiana glauca* Nectar on Ants

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Ant-pollination is relatively rare and in many cases ants are considered as "nectar thieves" i.e., consuming floral nectar without serving as pollinators. Ants may reduce floral attractiveness to legitimate pollinators and may also damage sexual organs and interfere with pollen germination and growth. Toxic nectar might have evolved as defense against ants and other nectar robbers. Only limited research effort has been devoted to the influence of repellent compounds in floral nectar on ants.

In a series of field and lab experiments we investigated the influence of the alkaloids nicotine and anabasine which are found in *Nicotiana glauca* nectar, on ants. More specifically we addressed two aspects: a) The effect of pyridine alkaloid concentration on food preference of six ant species that visit *N. glauca*, and b) The effect of pyridine alkaloid on water consumption and food preference of *Tapinoma simrothi*.

In the field, the ants have not been deterred by the natural alkaloids concentrations (0.5−5 ppm) in the nectar but 500 ppm was highly deterrent. Hence, foragers were deterred only from

concentrations that were one hundred or one thousand times higher than naturally occurring concentrations of anabasine and nicotine in floral nectar, respectively. These concentrations are significantly higher than those that deterred bees and birds visiting *N. glauca's* nectar. In non-choice feeding experiments, laboratory colonies of *T. simrothi* fed and survived on 500 ppm alkaloid solutions. This species can consume high concentrations of anabasine and nicotine for long periods without water dilution. Moreover, colonies that fed on higher alkaloid concentration developed tolerance to lower alkaloid dosages.

Finally, in laboratory experiments *T. simrothi* covered liquid drops that contained high alkaloid concentrations (500 ppm) with mud. The more the colony was deterred by the alkaloid, the more they tend to cover the drops. It appears that ants can handle high alkaloids concentrations. We suggest that covering liquid with mud might be a way of dealing with noxious materials.

The Effect of Octopamine on Nestmate Recognition in the Ant *Camponotus fellah*

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Nestmate recognition is a major mechanism which enables the colony of social insects to maintain its insularity. This ability in ants is achieved using hydrocarbons as recognition cues. These hydrocarbons spread on the cuticular surface or stocked in the post pharyngeal gland admix with nest odors and food materials to create a uniform colony odor called the gestalt. In addition, octopamine is believed to mediate the recognition process by affecting the discrimination threshold. We hypothesize that in the ant *Camponotus fellah* the queen produces primer pheromone that affects the levels of brain octopamine, enhancing colony territoriality and aggression. In order to test this hypothesis we used merging experiments using ants reared under different social regimes and drug treatments. Merging two 6-months-queenless (QL) alien colonies was followed with high level of trophallaxis and low level of aggression between alien ants. After 3 days the two colonies merged creating a single colony. Chronic exposure of such colonies to octopamine resulted in a high level of aggression and a lower level of trophallaxis. Merging two alien queenright (QR) colonies resulted in high level of aggression and low level of trophallaxis. Chronic exposure of such colonies to phentolamine, an octopamine antagonist, lowered the level of aggression and elevated the level of trophallaxis. Reuniting two colony fragments, one QL and one QR generally progressed with little aggression even after 6 months of separation. However, feeding the QL workers with octopamine resulted in increase aggression and decrease in trophallaxis between the QR and the QL ants. Hydrocarbon profiles of QL colonies were distinct before the merging, but became congruent after 3 days of the merging. However, the hydrocarbon profiles of QR colonies remains distinctively different before and after merging. These results lend credence to the hypothesis that octopamine is involved in the nestmate recognition system in *C. fellah*, and that it may acts by lowering the discrimination threshold between nestmate and alien ants.

Pheromones as a Chemical Weapon for Establishing Hierarchical Status and Advertising Fertility in the Honey Bee (*Apis mellifera)*

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The honeybee (*Apis mellifera)* constitutes a classical example of reproductive skew whereby a single queen is the major egg layer, while workers are mostly sterile. This reproductive division of labor is maintained through extensive use of pheromones. However, under queenless (QL) hopeless conditions cooperation collapses in favor of worker-worker reproductive competition through aggressive behavior and mass egg-laying, as well as biochemical shift in pheromone biosynthesis from worker- to queen-like chemical bouquet. In this study we investigated the behavioral, reproductive and pheromonal plasticity in workers, and their possible role in queen-worker and worker-worker competition. To assess worker-worker competition we observed the behavior of callow workers reared as QL groups for two weeks. Soon after establishment, aggression among the workers erupted, directed towards workers with developed ovaries mainly by workers with undeveloped ovaries. Analyses of Dufour's and mandibular gland secretion revealed that the attacked workers had higher levels of queen-like secretion compared to the attacking workers. This indicates that either or both pheromones disclose the fertility and perhaps hierarchical status of the attacked workers. Next, we assessed how powerful is the queen influence on worker reproductive decision by investigating whether worker fertility and royal pheromone production are reversible. To that effect we induced ovary activation and queen pheromone production in workers by rearing them as queenless (QL) groups, and subsequently reintroducing them into queenright (QR) micro-colonies for one week. Such workers if reintroduced into queenright, but not queenless colonies showed a clear regression in ovary development and reverted from queen-like to worker-like pheromone production. These results emphasize the powerful effect of the queen and her pheromones on worker physiology and behavior.

Pre-Penetration Events of Two Isolates of the Entomopathogenic Fungi *Metarhizium anisopliae* against Ixodidae Ticks

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Entomopathogenic fungi are promising biocontrol agents against arthropod pests. In recent years it was found that they are also highly efficient in controlling ticks. The present study focused on the pre-penetration events of tick-fungus interaction: attachment, germination and appressorium formation. For this purpose we compared the virulent of two subspecies of the fungus *Metarhizium anisopliae*: *M. anisopliae* var. *anisopliae* (MAan) and *M. anisopliae* var. *acridum* (MAac). MAan was highly virulent to eggs, larvae and adults of *Boophilus annulatus* and to most stages of

Rhipicephalus sanguineous and *Hyalomma excavatum*, while MAac demonstrated low virulence to almost all stages and species tested. We developed a new quantitative method for removing adhered spores from ticks' cuticle using organic solvents and found that conidia of high and low virulence fungi adhered equally to ticks-cuticle. What's more, no correlation was observed between the tick susceptibility to fungus and number of adhered spores. Fungi germination and appressorium formation was tested on ticks' cuticle extracts. The lipids extracts from the most susceptible tick, *B. annulatus,* stimulated spore germination of high virulent MAan, but not of low virulent MAac. Only extracts from engorged *H. excavatum* females, the most resistant tick tested, inhibited MAan development. Low virulent fungus MAac did not germinate or formed appressorium on any ticks' extract.

The pathogenicity process of MAan was investigated in details toward *B. annulatus* eggs. The histopathology investigation of *B. annulatus* eggs infected with MAan demonstrated all fungi developmental phases. In conclusion, adhesion is a non-specific process while germination and appressorium formation depends on cuticle compounds. Understanding the mechanism of infection on all of its stages is highly important for the use of fungi against ticks and other pests.

Biological Control of *Oligonychus perseae* on Avocado by Indigenous Predators

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The persea mite, *Oligonychus perseae*, was first discovered in Israel in 2001 in avocado orchards of the Western Galilee. All immature life stages live within and are protected by nests of dense webbing located on the lower leaf surface. High populations of this mite can inflict severe foliar damage. The objective of this ongoing study is to develop a biological control program for the persea mite based on indigenous natural enemies. Phenological data from 2003–2006 suggest a negative correlation between populations of the pest and the local predatory mite *Euseius scutalis* (Phytoseiidae). Preliminary evaluations on leaf discs showed that this predator was not able to enter the nests of the persea mite but did prey upon mites that moved between nests. Trials conducted in environmental chambers at L14:D10 31/21 °C and L11:D13 24/14 °C simulating summer and fall conditions, respectively, demonstrated that the predator lowered pest populations by 40% in the summer and 31% in the fall regimes.

Sequential sampling of persea mite revealed a high frequency (63%) of torn nests, implying the involvement of additional predator species in pest predation. With the aim of identifying these species, generalist predators were collected bi-monthly in beating tray samples, in the spring and summer of 2006, in conventional and organic avocado orchards. Candidate species were exposed to 1 day-old nests on leaf discs and predation was evaluated 48 hrs later. Nests were torn and life stages fed upon by larvae of the green lacewing (C*hrysoperla carnea*) and of a dusty wing fly

(*Conwentzia* sp.), and by the spider *Chiracanthium mildei*. Because population of the predatory mite *E. scutalis* were high in these orchards, we propose that predation efficacy of the persea mite is enhanced by the intra-guild facilitation exerted by these generalist predators.

Response of Soil Arthropods and Herbaceous Vegetation to Woody Plant as Ecosystem Engineers in a Semiarid Environment

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Woody plants are ecosystem engineers that create landscape mosaic by the process of patch formation. These patches determine the filtering of species from the regional species pool to the local species pool and consequently, the species richness and productivity of the ecosystem. We studied the engineering effect of woody vegetation as ecosystem engineers on species diversity, abundance of soil animals and herbaceous plants in the northern Negev. In order to examine the effects of woody plants on species diversity, abundance and species richness, we manipulated woody plant by reducing canopy cover. The experimental design encompasses four treatments: clear cutting of woody plants canopy; grazing by goats; clear cutting with grazing and natural vegetation. We recorded species diversity and abundances of soil arthropods, spiders and herbaceous vegetation. Since these groups are relatively immobile, we expect them to be sensitive to scale of patchiness that is created by the woody plants. Woody plants increased the species richness of soil arthropods under the woody plant canopy, although they decreased the species richness of herbaceous vegetation. We conclude that woody plants as ecosystem engineers have different effects on the species richness of primary producers and consumers.

Evidence for Superparasitism and Asymmetrical Larval Competition in a Natural Population of a Polyembryonic Parasitoid

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Parasitoids are insects that lay their eggs on or in the bodies of other arthropods. The young

parasitoids consume the still-living host, eventually killing it. In polyembryonic parasitoid wasps, a clone of genetically identical embryos develops from each egg. In several species, some embryos develop into soldier larvae that attack competitors inside the host. In the encyrtid *Copidosoma koehleri* (Blanchard), only female clones produce a soldier, suggesting higher competitive abilities for females than for males. Does this competitive asymmetry allow females to out compete male rivals under field conditions? To address this question, we determined the frequency of male-female broods in a natural population, and sought evidence for asymmetrical competition between males and female larvae. We collected 103 parasitized hosts in South Africa, and reared them to pupation. We counted and sexed the emerged parasitoids, and measured the head width of a sub-sample of individuals per host. 40% of the broods contained both male and female wasps. A negative correlation between individual head width and brood size indicated strong competition for host food resources. Mixed-sex broods were highly female biased. In these broods, head width was larger for females than for males. These results support the hypothesis that competition between male and female larvae is common under natural conditions, and that the asymmetry between male and female larvae affects its outcomes.

The Effect of Colony Genetic Makeup on Worker-Worker Competition over Reproduction in Queenless Honeybee Workers

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Polyandry in honeybees results in the presence of many worker patrilines that leads to worker policing under queenright (QR) conditions and contributes to colony harmony, but can also lead to nepotism during queenless (QL) workers competition over male production. We hypothesized competition among half sisters and nepotism among super sisters, and examined the effects of such genetic variability on worker behavior, ovarian development and pheromone production in Dufour's gland as related to the above two parameters.

To create known patrilines we inseminated queens with a single drone. Micro-hives housed with 30 workers were kept as SL (single line) or ML (mixed lines; 10 workers of 3 different lines). Control hives were made of workers taken from a colony with a naturally mated queen (fertilized with 7−10 males), wild type (WT).

Behavioral observations during 14 days showed a preference for throphallxis between patrilines over that within a patriline. The ensemble behavioral pattern for each patriline (throphallxis, vibration, head probing, and eating) was typical of patriline and not affected by the genetic makeup of the group (single vs multiple patrilines). At the end of the observation period all workers were frozen and their ovarian development was determined. Of ML workers 43% had eggs in their ovaries, as compared to 52% of SL and WT workers. The pattern of ovary development for a specific patriline remained constant regardless of the genetic makeup of the group. Head probing (a measure for policing) tended to be greater in workers with little ovarian development (small eggs < 0.25mm without vitellogenin) and in worker with ready to lay-eggs. We propose that workers exhibit a competition threshold. The greatest competition was found when few patrilines were housed together resulting in strong mutual inhibition. In contrast, in the SL and WT there

was only weak inhibition of ovary development, probably due to higher cost than benefit. We will further investigate the effect of colony genetic makeup on queen-like ester production in Dufour's gland, in particular whether it deviates from the expected positive correlation between ester production and ovarian development.

Control of Phlebotomine Sand Flies (Diptera: Psychodidae) In and Around Human Habitation

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Sand flies can transmit viral diseases as well as leishmaniasis and their bites can constitute a serious nuisance and health hazard. Control of Phlebotomine sand flies is problematic because the breeding sites of their immature stages are unknown and/or inaccessible. We are developing and testing several approaches for controlling biting female sand flies by means of A. construction of insecticide-treated physical barriers, is aimed at reducing the over all numbers of sand flies approaching human habitation; B. *Geraniol*® ($C_{10}H_{18}O$) based area repellent placed inside houses should reduce the numbers of female sand flies biting indoors; C. treating the reservoir-host (rodents) of the leishmania parasite by self-dusting with insecticide is aimed at reducing the number of infected female sand flies. Preliminary results indicate a significant decrease in sand fly abundance inside barrier-treated enclosures versus open field controls in the Jordan Valley. On the other hand, Geraniol-based area repellent results demonstrated only a slight reduction between the number of flies before and after intervention. Geraniol had little effect on blood engorging of female sand flies. Rodent experiments on self-dusting with insecticide indicate practical use of carpet-lined plastic tubing, and a fur holding capacity of 0.3−0.7 g for powder-insecticide. *Opigal*® (ABIK™, 10% carbaryl and 0.2% permethrin) appears to be a suitable candidate for testing self-dusting in the field. It is anticipated that acceptable levels of control can be achieved using integrated strategies combining two or more of these measures, coupled with personal protection.

The Involvement of Glutathione S-Tranferases from *Bemisia tabaci* (Hemiptera: Aleyrodidae) in Plant-Insect Interactions

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Polyophagous insects like *Bemisia tabaci* are capable of feeding on a wide range of plant families. As a result, they have to cope with a tremendous diversity of plant defense secondary compounds. In many cases, resistance to these compounds is achieved by the activity of metabolic enzyme families like Glutathione S-Tranferases (GSTs), which are capable of detoxifying (among other substrates) glucosinolates (GLS), produced mainly by plant species belonging to Brassicaceae.

Here, we compared the expression level of three GST genes previously isolated from *B. tabaci*. Throughout our experiments, *B. tabaci* individuals were subjected to two Brassicaceae hosts (mustard and cabbage) and one non-Brassicaceae host (cotton).

When *B. tabaci* adults were transferred from cotton to mustard or cabbage, the expression level of all three GST genes increased (1.7−2.74 fold). When adults were returned back to cotton, all three genes showed reduced expression level but only one gene (designated GST2) showed a significant decrease (1.84 fold in transition from mustard to cotton). In order to examine the possibility the *B. tabaci* individuals are capable of switching on and off their GST genes in response to their plant host, the expression level of the three genes was examined for nine generations. In each generation, adults were allowed to choose between three host plants: cotton, mustard or cabbage and RNA was extracted from each sample. For producing the next generation, we continued only with offspring that chose the same plant species as their female parent (developed on cotton and chose cotton or developed on mustard and chose mustard). Significant increase and decrease in gene expression after switching and switching back between Brassicaceae and cotton was observed only for GST2. AFLP analysis revealed that the mustard and cotton lineages were genetically similar (only 2.8% variation among populations from the two plant species), suggesting that no selection occurred in nine generations. When *B. tabaci* adults were fed on artificial diet that contained different glucosinolates degradation products, the highest elevation in GST2 expression was observed when nitriles were added. All together, these findings suggest that GST2 is involved in the response of *B. tabaci* to plants from Brassicaceae and that the insect has the ability to increase the expression level of this gene only when required.

Evaluation of Arid Adapted Strains of the Predatory Mite, *Neoseiulus californicus*, for Spider Mite Control on Cucumber, Strawberry and Pepper

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The goal of this study was to identify a strain of the predatory mite *Neoseiulus californicus* (Acari: Phytoseiidae) that is tolerant to low humidity and has high efficacy against spider mites. This goal was attained in two sequential tasks: (1) identification of the most dry adapted strains of *N. californicus* from eight strains collected from South and North America and different regions

in Southern Europe, by evaluating selected life history parameters at low humidities, and (2) determining the most efficacious on whole plants. We hereby present the details of task 2. At the Agricultural Research Organization (ARO) in Israel and University of Natural Resources & Applied Life Sciences (BOKU) in Austria we conducted experiments on the population dynamics and suppression efficacy of the predators on singly potted plants of three species (cucumber, strawberry and pepper) infested with the two-spotted spider mite *Tetranychus urticae* or the carmine spider mite *T. cinnabarinus* in walk-in growth chambers. We compared the performance of two *N. californicus* strains, originating from California, USA and Sicily, Italy, to a standard commercial *Phytoseiulus persimilis* strain at 50±5 %RH, 25±0.6 °C and 16:8 h L:D photoperiod. Under these arid conditions predators' performance was very different on each host plant. On cucumber spider mite population levels were highest on plants treated with *P. persimilis* and lowest on the *N. californicus* Californian strain plants for weeks 2 and 3 (post predator release), plants with the *N. californicus* Sicily strain taking an intermediary position. Despite these differences none of the predator treatments succeeded in controlling spider mites and by week 4 plants were 'burnt out'. On pepper beyond week 2 spider mite populations were highest on plants with the *P. persimilis* release and lowest on the two *N. californicus strains*. From week 5 *N. californicus* began to invade the *P. persimilis* releases and by week 7 spider mite populations dropped to zero on most plants. On strawberry, all predators satisfactorily suppressed spider mites; however, they differed in short term efficacy and persistence. *Phytoseiulus persimilis* suppressed the spider mites more rapidly than did the Californian or Sicilian strains. Both *N. californicus* strains persisted longer than did *P. persimilis*. The Californian strain was superior to the Sicilian strain in population density reached, efficacy in spider mite suppression. Implications for biocontrol of spider mites using phytoseiid species under arid conditions are discussed.

Hybrid Cotton seed Production by the Bumblebee *(Bombus terrestris)*

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In order to produce hybrid seeds, pollen from the fertile-male line must transfer to the sterile-male line. Hybrid cotton seeds production is accomplished by expensive hand pollination. The alternative for hand pollination is insect pollination. Several studies have shown that honey bees do not pollinate hybrid cotton efficiently. Sporadic observations of bumblebees (*Bombus spp*.) visiting cotton flowers and collecting nectar and pollen, raised the hypothesis that they could be used for cotton pollination for hybrid seed production. However, the results of field trials with bumblebees (*Bombus terrestris*) were disappointing. The bees hardly visited the flowers from the male-fertile line and foraged on wild flowers and flowers of other crops. The aim of this study was to explore the factors that attract or repel bumblebees from the cotton plant. In laboratory trials, the bees were offered two honey solutions diluted to 40% (w/w) sugar concentration, one from citrus honey and one from cotton honey. The bees showed a strong preference to the citrus honey. Chemical analyses revealed high concentration of potassium in the cotton honey in comparison

to its concentration in the citrus honey. The effect of cotton pollen on the foraging behavior of bees was examined in semi-field trials. Bees collected nectar also from flowers that had stamens loaded with pollen, but they did not collect any of the pollen. Together, the results show that cotton nectar is not very attractive to bees, and that there is no pollen collection at all, maybe because of difficulties in collecting it or in packaging it into pollen pellets. Cotton breeders should consider developing new cotton lines with more attractive nectar and pollen. Moreover, bee pollination in cotton is likely to be more efficient in isolated cotton fields, where there is little competition with alternative bloom.

Rhynchitidae and Attelabidae (Coleoptera: Curculionoidea) of Israel

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Fourteen species of Rhynchitidae are reported from Israel. Ten species are reported for the first time, two of which are newly described. Five species are associated with oaks (*Quercus* spp.), and have no agricultural importance. Seven species are associated with wild and cultivated Rosaceae, primarily damaging fruits, and one species is associated with olives (*Olea europaea*). They are known as pests of orchard tree crops, in Europe, the Middle East and Central Asia, and are potential pests of orchard tree crops in Israel. One of them was reported as a pest of pears in Israel about fifty years ago. The Attelabidae, represented by one species that is associated with oaks, are reported from Israel for the first time. The distribution of the two families in Israel is restricted to the northern and central regions.

Management of Sunn pest *Eurygaster integriceps* and Improvement of Wheat Quality in Israel

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In 2003−2006, 5−10% of the wheat grain yield in Israel was disqualified for flour milling because of the pure gluten index (less than 40%) which is acceptable parameter for gluten quality evaluation. The gluten quality is depending on many factors, such as wheat variety, soil and whether conditions and agrotechnical measures. One of the most serious factors affected the gluten quality is sunn pest *Eurygaster integriceps* Put. (Heteroptera: Scutelleridae). Bug damaged

wheat contains enzymes, which degrade gluten proteins, causes rapid relaxation of dough and results in the production of bread with poor volume and texture.

The object of this study was to develop the strategy and tactics for management of sunn pest *E. integriceps* and improvement of wheat quality in Israel. Systematic observations and field experiments were conducted for studying the biology and harmfulness of sunn pest and evaluation of control measures.

Suitable sites and biotopes for sunn pest diapauses were found. The influence of *E. integriceps* on the level of the gluten index was studied and the degree of its damage was established. Bet Hashita, Negev and Ariel were determined as strong gluten cultivars. Athir and Galil were classified as weak gluten cultivars. The intercultivar differences on the gluten index did not depend on the level of wet gluten and protein content. In Gedera cultivar a clear tendency to decrease the gluten index volume with increasing of the bug damage level was recorded.

Cymbush and Titan treatments decreased the bug numbers to zero and increased the gluten index to 84–93% compared to 8–26% in the control. One treatment against *E. integriceps* by one of the mentioned insecticides in the period from flowing to milk and wax stages of wheat allows control the bug population, decrease drastically the percentage of damaged kernels resulting in improved wheat quality, especially high gluten index.

Gall Destruction and Aphids Predation by Great Tits

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Several aphid species (Homoptera: Fordinae) form galls on *Pistacia palaestina* in Israel. The galls that are formed in the spring provide food and shelter to the developing aphids until the fall. Within the galls, the aphids are well protected from natural enemies, benefiting from the physical barrier and chemical composition of the surrounding plant (gall) tissue.

Nevertheless, Great tits (*Parus major*) are known to attack some of the Fordinae galls. In the field, we observed for the first that the large banana-like galls of the aphid *Baizongia pistaciae* are also attacked in high rates by the tits. We analyzed the gall defense (of *B. pistaciae,Paracletus cimiciformis*, *Geoica* sp and *Forda formicaria*) traits against avian attack with twelve captive great tits. The caged birds recognized the aphids within these galls as a food source puncture the galls and consume the aphids.

All birds deterred from a 5% gall tissue (dry weight) in an artificial diet, and clearly chose the control (gall-free) food. To rate the deterrence effects of the four galls, we performed multiple food-choice experiments between pairs of species (galls) in all combinations as described above. *Paracletus cimiciformis* was remarkably deferrable to the tits while no clear differences were detected between the other species. We found high tannin concentrations in most of the gall species whereas the concentration in *P. cimiciformis* was the highest. No correlation between repelling rank and conspicuousness (size, shape and color) traits was found; not supporting the hypothesis that some galls are aposematic. In conclusion, although aphids posses chemical and mechanical defenses via the surrounding gall tissue, birds (e.g., great tits), can still open the galls and consume the aphids.

Antimicrobial Peptides in *Drosophila melanogaster* Female Reproductive Tract

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Successful fertilization requires maintenance of an optimal microenvironment in the female reproductive tracts. Antimicrobial peptides (AMPs), a part of the innate immune system, are likely to play a role in maintaining this optimal microenvironment via their function in keeping the reproductive tract free from microbial infection. Using DNA microarrays we identified AMPs in the Drosophila female upper reproductive tract. We found that mating induces a striking increase of cecropin and attacin in female upper reproductive tract at 3 hours post-mating. To confirm the differential expression and to refine the spatial expression pattern of AMPs within the female reproductive tract we subsequently assayed AMP expression using transgenic flies and *in-situ* hybridization. We found that cecropin expression was localized to specific regions in the lateral and common oviducts and in the sperm storing organs of the female reproductive tract. Moreover, measurements of cecropin expression in mated vs. unmated females via relative fluorescence intensity levels revealed significantly increased expression only in specific regions within the common oviduct. Additional spatial mapping of AMPs indicated similar localized expression AMPs within specific regions and tissues elsewhere within the female reproductive tract. Currently we are utilizing several transgenic lines that express a single AMP to identify the role of AMPs in female fertility and fecundity as well as other processes critical to reproductive efficiency.

Wide Area Control of the Codling Moth in Israel

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The codling moth (CM) *Cydia pomonella* L. is a key pest of apple and pear orchards in Israel. In orchards in which integrated pest management is implemented, CM control is based on the mating disruption (MD) technique with IsoMate-C ropes ("Shin Etsu" Ltd.) or ChackMate CM-WS patches ("Suterra" LLC). Perennial use of this technique reduced the CM population and the number of applications of organophosphorus compounds (OPs). The main reason for recovery of the CM population level is the immigration of fertilized females from neighboring orchards, in which MD is not applied. To prevent this situation application of wide-area control is necessary. The commercial MD products (ropes and patches) could form a good solution for wide-area control, but their distribution and use by growers is limited because of the expense factor (their use costs more than twice that of OPs) and the lack of cooperation among neighbors. In this study two new MD products were found to control CM efficiently, and they might be more suitable for wide-area application. The Exosex™ ("Exosect" Ltd.) technique is based on the dispersal of pheromone

by males. With this technique the amount of synthetic pheromone required for efficient MD is dramatically reduced. One advantage of this would be to delay the possibility of the CM evading the sex pheromone. The second new MD technique, based on the CM-F pheromone microcapsule ("Suterra" LLC.), offers easy application with a commercial sprayer. Dispersal of pheromone microcapsules by aircraft is an option that enables the use of MD over a wide area, independently of neighboring growers who may not apply pheromone exactly according to the timing of the CM population development during the season.

Pollination Efficiency of the Carpenter Bee *Xylocopa pubescens* (L.) (Hymenoptera: Apidae: Anthophoridae): Social and Solitary Nesters

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Many agricultural greenhouse crops suffer reduced yields due to insufficient pollination. This problem can be alleviated by introducing efficient pollinating insects into the greenhouse. The bee *Xylocopa pubescens*, a candidate for domestication as an agricultural pollinator, is unique in its facultative social organization. Females either nest solitarily, or together with a second female (a non-reproducing guard). Social nesting occurs when food and nest sites are limited, and carries fitness benefits and costs to the bees as compared to solitary nesting. We investigated the implications of *X. pubescens*' social organization for crop pollination.

We grew honeydew melons as a model crop in a small greenhouse. The non-crop plants *Portulaca oleracea*, *Solanum Rantonnetii, Lavandula angustifolia* and *Ocimum basil* supplemented the bees' diet. We introduced social and solitary *X. pubescens* nesters into the greenhouse in alternation. We recorded their daily activity pattern, the frequency and duration of visits to each flower species, and the run-lengths of consecutive visits to each flower species. We also recorded the melons' fruit set, and determined the fruits' mass and seed number.

Social nesters visited *P. oleracea* more frequently than solitary bees when this species was in bloom. After *P. oleracea* finished blooming, socially nesting bees visited melon more often than solitary nesters. Social bees spent a longer time at the melon patch, but spent less time per flower than solitary nesters. Solitary and social bees did not differ in their daily activity patterns, flower visitation rates, and constancy to melon flowers. Pollination by both types of nesters resulted in similar fruit set, fruit mass and fruit seed numbers. The dissimilarities in foraging behavior may reflect differences in the dietary demands of solitary vs. social nests. The similarity in fruit sets and flower constancy suggests that both nest types provide pollination services of similar quality.

Examinations of Various Tactics for Managing Pyriproxyfen Resistance in Biotypes of *Bemisia Tabaci* under Laboratory Conditions

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The whitefly *Bemisia tabaci* (Hemiptera: Aleyrodidae) is a serious pest damages many agricultural crops. *B. tabaci* consists of several biotypes whose biological significance is still unclear. In Israel we have recently detected two biotypes of *B. tabaci*: "B", that has been the predominant in the past, and "Q" – a new biotype.

Pyriproxyfen (insect growth regulator) exhibits juvenoidal activity by disrupting normal hormonal balance, resulting in the suppression of embryogenesis, metamorphosis and adult formation. Pyriproxyfen use against *B. tabaci* start in 1991, however, resistance to this insecticide in cotton field was found five years later on. (Susceptible and moderate resistant)

The dynamics of resistance to pyriproxyfen in *B. tabaci* was investigated by detecting resistance to pyriproxyfen in two field populations: one was collected from sweetpotato field in the western Negev (Revivim strain, defined as B biotype) and the other collected from south Israel (Kfar Menachem, defined as a mixture of B and Q biotypes). The main objective of this study was to examine various tactics for delaying resistance development to pyriproxyfen in *B. tabaci*.

Under laboratory conditions simulate field insecticide applications were done; check treatment (no insecticide applications); periodically treatments with pyriproxyfen (Tiger); alternation treatment (rotation with pyriproxyfen, diafenthiuron and acetamiprid, insecticides with different mode action). Generally, in the check treatment we observed increase of susceptibility as result from B biotype predominance in the population and discontinuation of pyriproxyfen applications. The treatments with pyriproxyfen caused increase of resistance to the insecticide even in the biotype B. The alternation treatments, using insecticides with different modes of action revealed to decrease of resistance to pyriproxyfen in the *B. tabaci* population.

This research suggesting the alternation tactic as the best one may assist in establishing resistance management programs for pyriproxyfen, which will lessen the development of resistance in *B. tabaci* to this leading insecticide.

Feeding on Plant or Prey Foods Similarly Reduces Cannibalism in an Omnivorous Bug

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Cannibalism involves several disadvantages, including risk of injury and reduced fitness from kin predation. Studies show decreased cannibalism when other food sources are available. This effect has been quantified for carnivores and herbivores, but the effect of food availability on cannibalism in omnivores is unclear. Because plants are of lower nutritional value than prey, we hypothesized that feeding on plants would reduce cannibalism less than prey availability does. This was tested in the omnivore *Orius laevigatus* Say (Heteroptera: Anthocoridae). Starved adult female bugs were held individually with five second-instar nymphs and offered one of four diet treatments: 1) *Helicoverpa armigera* eggs (prey), 2) pollen (plant), 3) *H. armigera* eggs and pollen (prey+plant), and 4) no eggs or pollen. Time spent feeding on prey, pollen and nymphs, and number of adult: nymph encounters in two hours were recorded. Availability of pollen and prey caused similar reductions in cannibalism. Fewer cannibalistic events and shorter feedings were observed in the presence of pollen and/or prey than in their absence, suggesting that cannibalism involves costs which are mitigated by feeding on alternative foods. Omnivory enables predators to sustain themselves in the absence of prey without resorting to cannibalism, a desirable trait among biological control agents.

Female Choosiness in the Mediterranean Fruit fly, *Ceratitis capitata* Wiedemann (Diptera: Tephritidae)

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In the Mediterranean fruit fly *Ceratitis capitata* Wiedemann (Diptera: Tephritidae) female mate choice largely determines whether a copulation will occur. This study set out to ascertain the effects of the females' nutritional state and prior sexual experience on the level of choosiness they display when given a chance to mate.

Females fed on dry fig were significantly choosier than those fed on a protein rich diet of yeast hydrolysate. This was evident in the latency to mate and in the rate of pair formation.

Exposure to male pheromone had a more complex effect on female choosiness. While there was no apparent effect on the average latency to mate or on average copula duration, prior exposure to pheromone changed female preferences to mate size. Additionally a correlation was found between female size and latency to mate. Exposure to pheromone also had an effect on the correlation between copula duration and female or male size. In naïve females a negative correlation was found between female and male size and copula duration, i.e. the bigger the male or female the shorter the copulation, while in females exposed to pheromone no such correlation was found. In addition, after exposure to pheromone, copula duration was prolonged when the females out weighed their mates.

These preliminary results open a window to continued research on mate choice in general and specifically female choice in the Mediterranean fruit fly. A better understanding of this mating system will improve our ability to control this important agricultural pest.

Whitefly (Aleyrodidae) in Israel: Pest Species

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The Whitefly (Hemiptera: Aleyrodidae) family comprises circa 1500 species around the world. Some are severe pests whose damage is expressed directly by reducing plant resources through sucking plant fluids, and indirectly by secreting honey-dew that causes stickiness and encourages the growth of sooty mold reducing photosynthesis, and by acting as vectors of plant viruses.

Information is provided on 12 of the 24 known species of the Aleyrodidae in Israel. Eight of them, namely *Aleurothrixus floccosus, Aleurolobus marlatti*, *Bemisia tabaci*, *Dialeurodes citri, Parabemisia myricae, Trialeurodes lauri* and *Trialeurodes vaporariorum*, are known as pests in Israel whereas the remaining five, *Acaudaleyrodes rachipora, Bemisia afer, Paraleyrodes minei, Trialeurodes ricini* and *Tetraleurodes perseae*, are pests in different places in the world, but so far their damage potential has not been noticeable locally or is still being assessed.

The presented data includes the names of the pest species, the morphological aspects of the 4th instar that are used for differentiation, pictures of the lifecycle stages and plant damage.

The knowledge that is provided here in a visual and concise way is important for the recognition of the different species, enabling the plant and nature protection in Israel.

Whiteflies (Aleyrodidae) in Israel: Insect – Plant Interactions

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An updated list of the whitefly (Hemiptera: Aleyrodidae) fauna in Israel is presented. It consists of 24 known species belonging to 15 genera. The list includes the species *Aleurothrixus floccosus, Paraleyrodes minei, Tetraleurodes aff. mori, Tetraleurodes persea* and *Trialeurodes ricini.* These five species, all of which have not appeared in previous monographs of the Israeli fauna, represent together an addition of approximately 25% to the 19 species reported in 1990. The species *P. minei* and *T. persea* are the most recent introductions having arrived with plant material or through migration from neighboring countries. Acclimatization of the new species is indicative of the suitable climatic and ecological conditions for the invasion of the generally thermophilic aleurodids into Israel.

The presented data includes ecological information such as seasons of activity, number of generations/year, developmental duration, the size of different instars and adults, host ranges and taxonomic distinguishing traits of the 4th nymphal instars. The latter which are used for whitefly classification enable the taxonomic identification of the species. Special attention is given to the species *Aleurolobus marlatti* since this species, which is a new name for *A. niloticus*, is now

infesting hosts previously unknown from Israel, especially citrus trees. Ongoing studies are conducted to ascertain that these are truly one species.

We trust that the taxonomic and biological characteristics presented herewith in a concise and informative manner, constitute an important and helpful tool to all, from scientists to pest control operators.

The Ecology of the Plusiinae (Lepidoptera: Noctuidae) of Israel with Special Reference to Pest Species

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We present here original pictures of 16 Lepidopteran species, subfamily Plusiinae, collected in Israel. The distribution within Israel's main phytogeographic regions, and the known host-pest associations are discussed. Three quarters of the Israeli species are local, rare, or possibly extinct. *Euchalcia augusta*, *Euchalcia emichi* and *Abrostola clarissa* have not been observed during the last seven decades. The Afro-tropical species, *Trichoplusia vittata,* is restricted to wetlands and irrigated areas along the Coastal Plain. *Trichoplusia circumscripta*, *Agrapha accentifera* and *Abrostola clarissa* are sylvicolous. The genus *Euchalcia* with *Euchalcia emichi*, *Euchalcia augusta*, *Euchalcia maria* and *Euchalcia paulina* are restricted to open and forested grasslands and steppes of the Rift Valley north of the Dead Sea, while *Euchalcia olga* (Kravchenko, Müller, Fibiger & Ronkay, 2006), a species new to science, is so far known from only a single site in the Negev (Mamshit Nature Reserve).

Macdunnoughia confusa, *Thysanoplusia daubei* and *Thysanoplusia orichalcea* inhabit the Mediterranean Zone but cannot be associated with a particular type of habitat. Four species: *Autographa. gamma*, *Cornutiplusia circumflexa*, *Trichoplusia ni* and *Chrysodeixis chalcites* are serious pests in Israel and Europe. They are ubiquitous, very common, found almost all year round and are known migrants in Israel. In the Arid Zone, especially in the Arava Valley, they predominantly concentrate in oases. *Macdunnoughia confusa* and *Thysanoplusia orichalcea*, well known pests in Europe, are extremely rare in Israel.

Survey of Beetles (Coleoptera) in the Upper Galilee

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Black ladder traps were placed in the surroundings of Ne`ot Mordekhay in the northern part of Israel in 2005. The traps contained specific pheromones for family Scolytidae. Pheromones were replaced once a month. 49 species of beetles (belonging to 13 families) were recorded for the first time from the Upper Galilee.

Following is the list of families in which new species for the Upper Galilee have been recorded (the number in parentheses indicates the newly recorded species in each family):

Anthicidae (12), Bostrichidae (1), Carabidae (10), Coccinellidae (1), Dermestidae (3), Dryopidae (1), Helophoridae (1), Histeridae (9), Hydrophilidae (1), Scarabaeidae (4), Scolytidae (2), Staphylinidae (13), Throscidae (1)

It's not just a Duct – Wide Multi Level Characterization of *Drosophila melanogaster* Female Oviduct

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Internal fertilization, the union of male and female gametes in the female reproductive tract requires fine-tuned spatiotemporal coordination of all three players involved. While most work in fertilization research concentrates on the role of sperm and egg for successful fertilization, relatively little is known about the role of the female reproductive tract in facilitating successful fertilization. We hypothesized that in Drosophila, as in other organisms, the female reproductive tract is structurally complex and is composed of different functional units in a control system governing fertilization. As a first step towards characterization of female reproductive tract we followed changes in the female oviduct (upper part of the female reproductive tract) at 3 hours postmating by parallel DNA microarray and proteomic screens. We found that mating mostly induces up regulation of transcripts and proteins in the oviduct. Whereas antimicrobial peptides exhibit the highest increase in gene expression level in mated female, proteins that are associated with muscle activity showed the highest increase in protein expression level, suggesting that mating mediates muscle activity possibly to promote movement of oocytes outward. To further our characterization of the female reproductive tract, we are conducting a structural analysis using neural, muscle and epithelial markers. Preliminary results reveal that the oviduct and sperm storage organs are innervated by type I-like nerve terminals. While axons extend along the entire length of the oviduct, the lateral most part of the oviduct (nearest the ovaries) appears to be more

densely innervated. This suggests that differences in neural and/or muscle properties modulation may be exist along the length of the oviduct.

Seasonal and Spatial Distribution of Noctuidae Moths (Noctuidae: Lepidoptera) in Northern and Central Arava Valley, Israel

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During a three year survey 141 noctuid species were collected by light-traps at six sites which represent different habitats in the extreme Arava Valley desert. Highest species richness and turn over in species diversity was found between March to May and October to November. The desert species typically peaked once a year either in March (spring species), in November (autumn species), or in January (winter species). In May and October, multivoltine, polyphagous species, mostly of Palaearctic origin or even wider distribution, peak around the oases and settlements. Some multivoltine species, restricted to oases, are Afrotropical elements that have a few peaks during the summer.