



Recent Developments in Arthropod Ecology and Evolution

Fifth Symposium in Memory of Merav Ziv Mitrani Department of Desert Ecology, Blaustein Institute for Desert Research Ben Gurion University, Sede Boqer Campus & The Israel Society of Zoologists & The Israel Entomological Society

29 April, 2004

Seminar room, Blaustein Institute for Desert Research, Ben Gurion University, Sede Boqer Campus

09:45 Introduction and opening remarks

10:00 Ecology student award in memory of Merav Ziv

Scientific Program

- 10:15-10:45 **Dr. Sharoni Shafir** (Dept. of Entomology, Hebrew Univ.) – Caste-specific differences in risk-sensitivity.
- 10:45-11:15 **Dr. Nadav Shashar** (Inter-university Inst., Eilat) – Artificial coral reefs, what can they do and how to build them.
- 11:15-11:45 **Prof. Zvika Mendel** (Dept. of Entomology, Volcani Center) – Structure-activity relationships of natural and designed analogs of the sex pheromone of the Israeli pine bast scale: biological and sylvicultural significance.
- 11:45-12:00 **Refreshments**
- 12:00-12:20 **Michal Segoli** (Mitrani of Desert Ecology, BGU) – What a male has to suffer: costs of mating in a widow spider.
- 12:20-12:40 **Dr. Tamar Keasar** (Achva College) – Reproductive conflicts in a polyembryonic parasitoid wasp.
- 12:40-13:00 **Einat Ben-Binyamin** – (Dept. of Entomology, Hebrew Univ.) – Intraguild predation between a predator and a parasitoid: Should it be avoided?
- 13:00-14:10 **Lunch**
- 14:10-14:30 **Moran Segoli** (Mitrani Dept. of Desert Ecology, BGU) – Predation of the desert isopod *Hemilepistus reaumuri* as a control factor in the wadi.
- 14:30- 14:50 **Dr. Victoria Soroker** (Dept. of Entomology, Volcani Center) – Characterization of broad mite-plant interaction.
- 14:50-15:10 **Refreshments**
- 15:10-15:30 **Efrat Gavish** (Mitrani Dept. of Desert Ecology, BGU) – Assemblages of spiders in desert agroecosystems.
- 15:30-15:50 **Mor Salomon** (Mitrani Dept. of Desert Ecology, BGU) – Maternal investment in a spider with suicidal maternal care.
- 15:50-16:10 **Eran Gefen** (Dept of Zoology, Tel Aviv University) – Water relations of scorpions- are xeric species better osmoregulators?
- 16:10 **Closing remarks**

Caste-specific differences in risk-sensitivity

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Honey bee workers (foragers) are risk-averse to variability in volume of reward when measured by conditioning of the proboscis extension response (PER), and the level of risk aversion depends on the coefficient of variation of the variable distribution. Since drones do not forage on flowers, they may have not been under selection for risk-sensitive choice behavior. We compared risk-sensitivity of workers and drones and their ability to discriminate between the reward volumes used in the risk-sensitivity experiments. Both castes discriminated better between 0 μ l and 0.4 μ l than between 0.4 and 1.2 μ l, consistent with Weber's law of relative discrimination. Workers discriminated between both volume pairs better than drones, and workers showed greater risk aversion than drones. This is the first demonstration of caste-specific differences in risk-sensitivity. Levels of risk aversion were consistent with the coefficient of variation model. The energetic state of both castes during the experiments was such that they could survive for several hours without being fed. Thus, it does not appear that the differences in risk-sensitivity between the castes could be attributed to differences in energy budgets. We calculated the relative associative strengths of the subjects to the reward volumes from their choice proportions in the discrimination tests. The relative associative strengths of workers were greater than those of drones, and in both castes the relative associative strength of 0.4 μ l relative to 0 μ l was greater than that of 1.2 μ l relative to 0.4 μ l. Due to Jensen's inequality, the decreasing functions of differences in relative associative strengths could explain differences in degree of risk-aversion between the castes. Our findings are consistent with both mechanistic and functional explanations. We finally discuss possible connections between Zipf's law as an ecological regularity, Weber's law as a psychological regularity, and the coefficient of variation as a measure of relative risk.

Artificial coral reefs, capacities and limitations

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Coral reefs in shallow waters are decaying worldwide. In specific locations, where a high demands for the use of coral reefs exists, artificial reefs are proposed as a means of diverting human pressure away from the natural environment, as tourist attractions, and for cultivation of specific reef animals. Artificial reefs are deployed world wide by governmental, commercial, NGOs, and privet-volunteering entities. Fishes colonization of artificial reefs occurs within 6-12 months. However, approximately 20 years are required to obtain coral species composition similar to a natural reef and approximately 80 years are needed for obtaining coverage and diversity similar to the natural environment. Hence construction of artificial reefs requires long term planning. A range of materials were found suitable, in terms of durability and being non toxics, for use in artificial reefs. Similarly a wealth of information exists regarding the spatial and structural requirements of artificial reefs and the impact of these structures on the inhabiting species composition. Nevertheless artificial reefs change their surrounding natural environment. This change can be by concentrating herbivores or predators, which in turn forge on the natural surroundings, by changing species composition in the neighboring area, or by concentrating potentially damaging human activities to a single location. Accordingly, in Israel a policy was established prohibiting the construction of artificial reefs within nature reserves or in the vicinity of natural coral reefs. Artificial coral reefs are likely to be of high economical value and serve as an important tool in coral reefs conservation; a tool whose effectiveness depends on parallel conservation actions on the natural reefs.

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**Structure-activity relationships of natural and designed analogs of
the sex pheromone of the Israeli pine bast scale: biological and
silvicultural significance.**

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The sexual and kairomonal attractiveness of three female sex pheromones of pine bast scales, *Matsucoccus* spp. (Insecta; Hemiptera; Matsucoccidae) were studied using sticky traps and stem tree arenas baited with the pheromones and their modified analogs. The major objectives were (1) to explore the structure-activity relationship of the studied semiochemicals and conspecific males of the *Matsucoccus* as well as known and potential predators of *Matsucoccus* spp. and (2) to discover new predators which can be used as biological control agents of the noxious *Matsucoccus* spp. with special emphasis on the Israeli pine bast scale.

The traps and the tree arenas were set up in pine forests in several countries of the Northern Hemisphere. In addition to the attraction of conspecific males and a weak cross-attraction of congener ones, three taxa of predators were lured by the pheromones: flower bugs of the genus *Elatophilus* Reuter (Heteroptera: Anthocoridae), two brown lacewings (Neuroptera; Hemerobiidae) genera *Hemerobius* L. and *Sympherobius* Banks; and lady beetle (Coleoptera: Coccinellidae) near *Rhyzobius*. The attracted predators responded to one or two or all three tested pheromones depending on the guild. The larvae of the studied predators were not captured in the suspended sticky traps. However they were attracted to arenas baited with the pheromones by walking, displaying a similar attractiveness pattern as their conspecific adults.

Analogues and parapheromones displaying subtle designed changes in the structure of the pheromones, lost to some extent or a great deal of their pheromonal and/or kairomonal activity.

The function of the *Matsucoccus josephi* sex pheromone in the sexual and breeding of the predatory bug *Elatophilus hebraicus*

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We examined the role the sex pheromone of the pine bast scale *Matsucoccus josephi* (Hemiptera: Matsucoccidae) in the intraspecific communication of its predator, *Elatophilus hebraicus* (Heteroptera: Anthocoridae). The sexual attraction and courtship behavior of the predator was studied in arenas with and without the sex pheromone of its prey. Observations were carried out in Aleppo pine forest. The arenas were 20x20 cm bark area at 150 cm above ground, after the removal of the scales and the attachment of dispenser impregnated with 50µg *M. josephi* sex pheromone at the arena center. Observations in laboratory were conducted in petri dishes. Food searching activity and courting or mating attempts could hardly be detected in the absence of the pheromone. In arenas, baited with the pheromone dispensers, an intensive sexual activity was noticed, which displayed by the high numbers of mating couples, mating attempts between males as well as frequent attacks on mating couples. The ovaries of females attracted to the pheromone were undeveloped bearing an average of 0.3 mature eggs. The ovaries of such females, collected from the arena before mating, and fed in the laboratory, after 4 days and 7 days, contained an average of 16.3 eggs and 26.3 eggs, respectively. Similar results were obtained with laboratory-reared females. Ovaries of virgin females reared in laboratory remained undeveloped for at least 9 days. Females did not respond to courtship attempts if their ovaries consisted of more than 3.5 visible eggs. It seems that the sex pheromone of its prey has the role in *E. hebraicus* of congregation kairomone and sexual stimulant. In the forest, while mating the females tend to leave the pheromone arena with their mates.

Reproductive conflicts in a polyembryonic parasitoid wasp

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Polyembryonic wasps provide dramatic examples for intraspecific developmental conflicts. In these parasitoids, each egg proliferates into a brood of genetically identical larvae that consume their host's tissues. If more than one egg is oviposited into a host, broods may compete for the limited host resources. In several species of *Copidosoma*, larvae differentiate into a reproductive caste and a sterile soldier caste. Female soldiers attack intra- and interspecific competitors. We hypothesized that increasing intraspecific competition would induce larval mortality in multiply parasitized hosts that contain females. We tested the hypothesis by comparing primary and secondary sex ratios in parasitoids under varying levels of intraspecific competition.

We manipulated the potential intensity of competition in *Copidosoma koehleri* by varying parasitoid-host ratios and exposure durations. When parasitoid densities and exposure durations increased, fewer hosts developed, and the mean number of offspring per parasitoid decreased, suggesting increased competition for host resources.

As competition increased, primary sex ratios (proportion of male broods) decreased, but secondary sex ratios (proportion of adult males among offspring) depended on brood composition: Male-female broods contained excess females in all experimental treatments, suggesting selective killing of male competitors by female soldiers. All-female broods were significantly smaller than all-male broods at high parasitoid densities, possibly reflecting aggression of soldiers in competing broods.

The results support the hypothesis that female larvae modify secondary sex ratios in response to increasing competition. Our hypothesis did not predict the effect of competition on primary sex ratios. In our presentation, we will discuss possible fitness consequences of this effect.

Intraguild Predation between a predator and a parasitoid: Should it be avoided?

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Predators may feed on both herbivores and their endoparasitoids. Such intraguild predation (IGP) is often asymmetrical, imposing strong selection pressure on the parasitoid, the IG prey in the system. If so, we hypothesize that the IG prey should evolve strategies to minimize IGP. Female parasitoids may change foraging site, behavior or both in the presence of their IG predators, thus reducing their risk of predation.

The study system consisted of an IG predator, *Coccinella undecimpunctata*, a parasitoid IG prey, *Aphidius colemani*, and their aphid prey/host. The parasitoid preferentially parasitized hosts on which it was reared, regardless of the presence of the predator. Confronting a predator, *A. colemani* did not leave the host plant, even when predator-free plants were available nearby. Yet lower parasitism rates occurred in the presence of predators.

C. undecimpunctata larvae fed on parasitized aphids showed decreased prey consumption and increased handling time with increasing parasitoid age. Larvae reared on mummies rather than aphids developed more slowly and had lower pupal and adult weights. Contrary to expectations, results show that (I) the IG prey in the system does not avoid predation although it experiences significant reduction in reproductive output; and (II) the IG predator is adversely affected by feeding on IG prey.

Predation of the desert isopod *Hemilepistus reaumuri* as a control factor in the wadi

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It is widely accepted that the low productivity of deserts limits the length of food chains in them. Therefore, predation is expected to have a limited role in the determination of animal distribution and abundance in deserts. Previous studies of desert isopods suggested that the densities of isopods in the plains and rocky slopes of the Negev Desert were positively affected by soil humidity. However, no convincing argument has been offered to explain why the isopod is rarely found in wadis. In the present study I tested the hypothesis that predation plays a major factor in eliminating the desert isopods from the wadi. The main predators of the desert isopod are various arachnids and skinks. Plant cover provides a refuge for these predators, which are found in the wadi in high densities. We tested our hypothesis by planting isopods in predator-exclusion and predator-open plots in the wadi and monitoring them during the summer.

Survivorship of both isopod burrows and isopods per burrow were significantly higher in predator-exclusion plots than in predator-open plots or natural burrows in the same wadi. The survivorship of isopods in predator-open plots was similar to that of the naturally settled burrows. The number of isopods in the predator-exclusion plots was two times higher at the end of the season than the number planted in them initially, whereas in the unfenced plots their number was only half of those planted in them initially. We concluded that predation can explain the absence of the desert isopod in the wadis.

Assemblages of spiders in patchy desert agroecosystems

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Agroecosystems are a mosaic of patches in time and space. The agroecosystem landscape is composed of arable and natural habitat patches. Annual crop agroecosystems are also characterized by patches in time, caused by tilling processes, that create a mosaic of arable fields with and without crops throughout the year. Desert agroecosystems are characterized by extreme differences between the managed fields and surrounding natural habitats in productivity, microclimate and habitat structure. Yet, the effect of these differences on the structure of spider assemblage in agricultural fields is poorly understood. We collected spiders from winter wheat fields and the surrounding natural habitats in the Negev desert in southern Israel. We used pitfall traps, emergence traps and visual searching to determine the effects of the patchiness on the species composition and relative abundance of spiders in the arable fields. Data show that Linyphiidae (residents), Gnaphosidae and Theridiidae (migrants) are the dominant spider families in the fields throughout the growing season. Furthermore, we were able to determine which taxa colonize fields each growing season, and which ones remain in the fallow fields between successive crops. Implications for the role of spiders as natural enemies in desert agroecosystems are discussed.

The effect of colony size on reproductive success in *Stegodyphus*

***dumicola* (Eresidae)**

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A common feature of group foraging models is that fitness is described by a peaked function of group size. Above a certain group size the benefits of cooperation per individual decrease because increased competition more than offsets the advantages associated with cooperation. Previous studies on the social spider *S. dumicola*, showed a variation in individuals size within a colony, probably relating to competition over prey. Dividing the prey unequally between females in the colony ensures that only the fittest females will accumulate enough resources to reproduce. Since this species is annual and cannot delay reproduction, and since colony members are highly inbred, females that do not have enough resources to produce a brood, can “donate” their resources to young of other females in the colony and thus increase their fitness indirectly. Thus, females in large colonies are expected to produce more egg sacs than females in small colonies because “more helping hands” are accessible in the colony. The spider *S. dumicola* exhibits extreme maternal care behaviors. Earlier studies suggest that females guard egg sacs, regurgitate pre-digested prey to the young and finally provide their bodies as food in matriphagy. Our observations show that allomaternal egg guarding occurs. The occurrence of helpers enables the reproducing females to lay more eggs and increases the helpers’ inclusive fitness. We show that the number of egg sacs in the colony increases both with the number of adult females in the colony, and also with increasing number of non-reproducing females. The results are consistent with the hypothesis that helpers increase individual reproductive success in colonies, in spite of the increasing negative effects of competition.

What a male has to suffer: costs of mating in a widow spider

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It is generally believed that a male's reproductive success is a function of the number of females he fertilizes. In some cases, however, the cost of mating for a male may be very high, preventing him from fertilizing many females and promoting strategies of high investment in each one. We investigated experimentally several possible constraints on the reproductive success of white widow males (*Latrodectus pallidus* (Theridiidae)). Courtship in this species is energetically demanding. During mating a male may leave one or both tips of his emboli (copulatory organs) inside the female's spermathecae (sperm storage organs). We placed each male in the center of a square arena containing four virgin females, one at each corner. We monitored male cohabitation with females and kept the females until egg laying to determine how many were mated. Females were examined post mortem for the presence of embolus tips inside their spermathecae. Only two males ($n = 19$) fertilized more than two females; these males were larger and in better condition than other males. The majority of males left both embolus tips inside the first female's spermathecae. Some of these males fertilized an additional female without embolus tips. We concluded that: 1) males fertilize fewer females than are available to them; 2) the size and condition of males influence their reproductive success and 3) the loss of the embolus tip is not an absolute constraint to further mating.

Water relations of scorpions- are xeric species better osmoregulators?

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Scorpions are generally considered as poor osmoregulators, tolerating increased haemolymph osmolarities when dehydrated. The xeric South-African buthid, *Parabuthus villosus* was reported as an exception to this trend, showing good osmoregulatory capacity in comparison with the mesic scorpionid *Opisthophthalmus capensis* and with various previously studied species. These capabilities, together with the scorpion's large body size, and low metabolic and water loss rates, were viewed as a "...very useful adaptation to a desert existence".

In order to determine the nature of possible interspecific differences in osmotic responses to dehydration, the following scorpion species were examined: *Scorpio maurus fuscus* (Scorpionidae) and *Buthotus judaicus* (Buthidae) from the mesic Lower Galilee; and *Scorpio maurus palmatus* (Scorpionidae) and *Leiurus quinquestriatus* (Buthidae) from the xeric Negev Desert. When sampled in the lab following their capture, *B. judaicus* ($548 \pm 4 \text{ mOsm/l}$; mean \pm S.E.) and *L. quinquestriatus* ($575 \pm 4 \text{ mOsm/l}$) had higher haemolymph osmotic concentrations than the scorpionids occupying the same habitats (511 ± 5 and $487 \pm 4 \text{ mOsm/l}$ for *S. m. fuscus* and *S. m. palmatus* respectively). After two weeks of *ad lib* feeding, the scorpions were desiccated at 30°C and 40-60% relative humidity. Following a 10% mass loss, the haemolymph osmotic concentration of *B. judaicus* increased by *ca.* 5% whereas that of *L. quinquestriatus* increased by 8%. In comparison, the two scorpionids showed a significantly higher ($p < 0.05$) increase of *ca.* 23% in haemolymph osmotic concentration following the same mass loss. Both xeric and mesic buthids showed higher and less variable haemolymph osmolarities than their sympatric scorpionids. In addition, the lower water loss rates of both buthids are reflected in their better osmoregulatory capabilities, largely as a result of the enhanced compensatory role of metabolic water production in species of this family. These characteristics may provide an adaptation to surface-dwelling existence, as unlike most other scorpion species buthids rarely burrow, and are thus more exposed to climatic extremes.