This project seeks to provide greater coherence for the biocontrol knowledge system for regulators and researchers; create an open access information source for biocontrol research of agricultural pests in California, which will stimulate greater international knowledge sharing about agricultural pests in Mediterranean climates; and facilitate the exchange of information through a cyberinfrastructure among government regulators, and biocontrol entomologists and practitioners. It seeks broader impacts through: the uploading of previously unavailable data being made openly accessible; the stimulation of greater interaction between the biological control regulation, research, and practitioner community in selected Mediterranean regions; the provision of more coherent and useful information to enhance regulatory decisions by public agency scientists; a partnership with the IOBC to facilitate international data sharing; and progress toward the ultimate goal of increasing the viability of biocontrol as a reduced risk pest control strategy.

No Designated Session Theme

BIOLOGY OF *CIRROSPILUS INGENUUS* GAHAN (HYMENOPTERA: EULOPHIDAE), AN ECTOPARASITOID OF THE CITRUS LEAFMINER, *PHYLLOCNISTIS CITRELLA* STAINTON (LEPIDOPTERA: GRACILLARIIDAE) ON LEMON

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The citrus leafminer (CLM), *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) invaded the Jordan Valley in 1994 and was able to spread throughout Jordan within a few months of its arrival. It was the most common parasitoid from 1997 to 1999 in the Jordan Valley. An increase in the activity of *C. ingenuus* was observed in autumn and the highest number of emerged *C. ingenuus* adults was in November 1999. The reproductive capacity of *C. ingenuus* at three constant temperatures showed that this agent could be considered as a promising candidate for successful biological control of CLM.

Parasitoid biology. *C. ingenuus* is an ectoparasitoid that prefers the fourth instar larvae of CLM as revealed by the preliminary studies. Adults have uniform orange yellow color. Both males and females are similar in size of about 1227 mm long and 470 mm wide. Females are easily distinguished by the presence of a black ovipositor.

Longevity and pre-oviposition periods. Male longevity was significantly higher at 20°C than at 25°C and at 30°C. No significant differences were obtained between female longevity at 20°C and at 25°C, but female longevity was significantly higher at those two temperatures than at 30°C. No significant differences were obtained in the pre-oviposition period at 20, 25 and 30°C.

Fecundity and sex ratio. A female *C. ingenuus* paralyzed the leafminer larva first and then laid eggs beside or on the host. It was rare to observe two eggs per host and if this happened, only one of them completed its development. Significantly higher numbers of eggs were laid by female *C. ingenuus* at 25°C than that at 20°C and at 30°C. Percentage of emerged females was higher at 20 and 25°C than at 30°C.

Male longevity, female longevity, and pre-oviposition period (± SE) of *C. ingenuus* on CLM at three different temperatures

Temperature	Male longevity (days)	Female longevity (days)	Pre-oviposition period (days)	Female fecundity (eggs/ female)	Sex ratio Female: Male
20°C	7.56a ± 0.32	17.20a ± 0.52	2.95a ± 0.12	35.00(10)#b ± 1.15	1.38: 1 (19)
25°C	6.50b ± 0.24	16.11a ± 0.32	2.72a ± 0.09	43.11(9)a ± 0.99	1.36: 1 (26)
30°C	4.58c ± 0.20	9.75b ± 0.23	2.71a ± 0.07	29.75(12)c ± 0.89	1: 1.2 (22)

Means within columns with the same letter are not significantly different using LSD test at 5 % level.
(Number tested in sample.)

Development periods._ Eggs of *C. ingenuus* had protracted shape and transparent colour. The incubation period was significantly longer at 20°C than at 25°C and at 30°C. Larvae with white colour were seen beside or on the paralyzed host larvae. The development period of larva was significantly longer at 20°C than at 25 °C and at 30°C. Pupae were at first colourless, then light brown and finally black. The development period of pupa was significantly longer at 20°C than at 25°C and at 30°C.

Development periods of egg, larva, and pupa (± SE) of *C. ingenuus* at three different temperatures

	Development period (days)		
Stage	**20°C**	**25°C**	**30°C**
Egg	4.20(30)*a ± 0.20	3.08(30)b ± 0.07	2.32(30)c ± 0.06
Larva	7.14(22)a ± 0.11	6.41(270b ± 0.06	5.20(25)c ± 0.10
Pupa	8.29(19)a ± 0.10	7.33(26)b ± 0.10	4.91(22)c ± 0.08

* Values in parenthesis represents the number of the tested sample.
Means within rows with the same letter are not significantly different using LSD test at 5 % level.

No Designated Session Theme

INTERACTIONS AMONG BIOCONTROL AGENTS OF THE BALSAM GALL MIDGE, *PARADIPLOSIS TUMIFEX*, ON CHRISTMAS TREES

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With a production cycle of approximately 10 years, balsam firs planted as Christmas trees constitute a semi-natural, dynamic agroecosystem that is highly suitable for biological control. The balsam gall midge *Paradiplosis tumifex* Gagné (Diptera: Cecidomyiidae) is a major pest of balsam fir foliage, causing aesthetic damages. The pest exhibits cyclic outbreaks lasting 3-5 years, which are likely driven by foliage suitability to insect infestation interacting with pest mortality inflicted by natural enemies. We documented the impact of natural biological control of the gall midge during its recent outbreak in southwestern Québec, Canada. Field data collected on half grown to mature Christmas trees in three different localities in 2002 revealed 20-60% incidence of usurpation of *P. tumifex* galls by the inquiline midge *Dasineura balsamicola* Lintner (Diptera: Cecidomyiidae). This species cannot induce its own gall on fir needles, but invades and takes control of *P. tumifex* galls once developed and nutritionally functional, thus eliminating the initial gall resident. We also documented the incidence and phenology of a complex guild of endo- and ecto-parasitoids of the balsam fir midge, which in combination with *D. balsamicola* likely caused gall midge populations to crash to near zero levels in 2003. We clarified the taxomomic identity of the predominant parasitoids of the balsam gall midge system, and their host relationships in the gall.

No Designated Session Theme

STUDIES OF THE RED IMPORTED FIRE ANT, *SOLENOPSIS INVICTA*, INFECTED WITH THE MICROSPORIDIA *VAIRIMORPHA INVICTAE* AND *THELOHANIA SOLENOPSAE* IN ARGENTINA

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After their accidental introduction into the United States more than 80 years ago, the red and black imported fire ants, *Solenopsis invicta* Buren and *Solenopsis richteri* Forel (Hymenoptera: Formicidae) became aggressive pests for people, domestic animals, agriculture, and wildlife. A classical biological control approach has been considered since the 1970´s and emphasized since 1988 with an intensive search of biological control agents in South America. The pathogens *Vairimorpha invictae* Jouvenaz and Ellis (Microsporidia: Burenellidae) and *Thelohania solenopsae* Knell, Allen and Hazard (Microsporidia: Thelohaniidae) are obligate intracellular microorganisms specific to fire ants. They were originally discovered in *S. invicta* in Mato Grosso, Brazil, and later found in other species of South American fire ants such as *S. richteri*, *S. quinquecuspis* Forel and *S. macdonaghi* Santschi. They are important components of the complex of natural enemies that attack fire ants in South America; however, their effect on red imported fire ant populations in their native land was never reported. Thus, the objective of this study was to document the long-term effects of both pathogens on field populations of the red imported fire ant. Fire ant populations and microsporidia prevalence were monitored 3-5 times per year for 4 years in eight field plots in northern Argentina. The mean population index per plot showed an overall reduction of 69%. The percentage of infection with *V. invictae* and *T. solenopsae* showed fluctuations that ranged from 29.2 to 1.4% and 13.6 to 2.6% respectively. The highest infection rates were observed at the beginning of the study. A total of 394 colonies were sampled during the study, 325 (82.5%) were healthy and 69 (17.5%) were infected with microsporidia. The proportion of infected colonies with brood was 81% (56/69), similar to the proportion of healthy colonies with brood, 78% (255/325). The proportion of infected and healthy colonies in the population index categories was significantly different. Of the infected colonies with brood, 49.3% was medium and 1.4% was large in size. In contrast, healthy colonies were larger, with 29.7 and 10.4% being medium and large, respectively. The general environmental conditions in the area of the plots were appropriate for fire ant population growth; consequently, they do not explain the overall reduction in the populations. These results, combined with additional evidence reported previously, suggest that the infection with *V. invictae* and *T. solenopsae* has deleterious effect on native populations of *S. invicta*.

No Designated Session Theme

PARASITISM OF THE SILVERLEAF WHITEFLY FEEDING ON TEN SOYBEAN GENOTYPES IN SINALOA, MEXICO

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The silverleaf whitefly SLWF *Bemisia argentifolii* Berrows & Perring (Hemiptera: Aleyrodidae) is a key pest of several crops in northwestern Mexico. Plant resistance and Natural Biological Control are one of the tactics that may be used to reduce populations of this pest. However, genotypes and natural enemies must be identified and evaluated before they are effectively used to suppress SLWF populations. Soybean is a preferred SLWF crop host.

Parasitoids identified. *Eretmocerus californicus* Howard (Hymenoptera: Aphelinidae), is the only parasitoid that has been obtained, attacking last instar nymphs, after two soybean crop seasons. Higher number of parasitism has been observed on July reaching near of 50% (Fig. 1 and 2).

Parasitism on soybean genotypes. Percent parasitism was variable depending of the soybean genotype, but it was not consistent in the two crop seasons evaluated.

Soybean yield. Yield was significantly different among soybean genotypes (P= 0.01) in both 2003 and 2004 seasons. Suaqui D-1-2-M showed the highest yield and Hutcheson the lowest.

Figure 1. Season 2003.

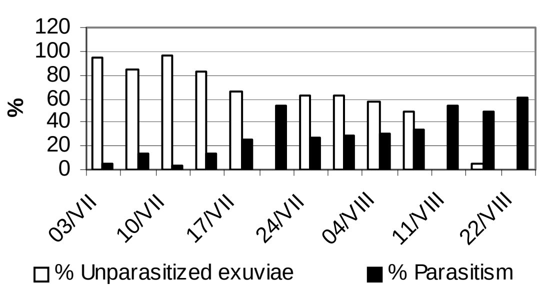
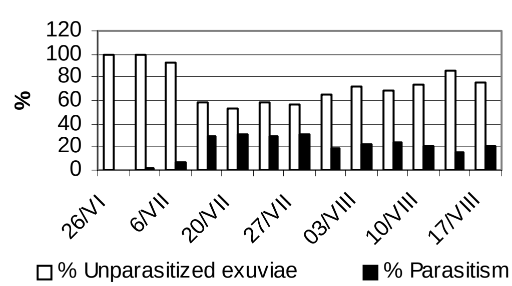


Figure 2. Season 2004.



Figures 1 and 2. Percent of parasitized and unparasitized exuviae of SLWF on soybeans.

No Designated Session Theme

NATURAL PARASITOID COMMUNITY OF THE GREEN BUD MOTH *HEDYA NUBIFERANA* (HAWORTH) (LEPIDOPTERA: TORTRICIDAE) IN ROMANIA

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Certain secondary pests, including the green bud moth, can be found in most commercial orchards, but rarely cause economic damage. However, they can act as alternative hosts for parasitoids of primary pests, such as *Cydia* spp (Lepidoptera: Tortricidae). Presence of secondary pests and their suite of parasitoids can therefore contribute to the natural regulation of primary pests. Between 1992 and 2004, we collected immature stages (eggs, larvae and pupae) of the green bud moth, *Hedya nubiferana*, attacking different fruit trees (apple, pear, plum, cherry) in mostly organic orchards in eastern Romania. Parasitoids were reared to adult under laboratory conditions and identified to species level.

We obtained 47 parasitic species from the following orders and families with the number of species in brackets: a) Hymenoptera - *Ichneumonidae* (22), *Braconidae* (9), *Chalcididae* (2), *Eulophidae* (6), *Encyrtidae* (1), *Torymidae* (1), *Pteromalidae* (1), *Eupelmidae* (2), *Trichogrammatidae* (1); b) Diptera - *Tachinidae* (1); and c) Nematoda - *Mermithidae* (1). Most of the species (32) behave as primary parasitoids, 12 are secondary parasitoids and three act as both. Most of the primary parasitoids (24) attack the larval stage of *H. nubiferana*, three attack larvae and pupae, three only pupae and one species was reared from eggs.

From 1992 to 1995, parasitism rates of both larval and pupal parasitoids reached 30.4% in pear orchards, 21.4% in apple, and 9.6% in plum orchards. The most important agents were parasitoids from the family Braconidae, contributing to 28.6% of parasitism in pear orchards, 16.6 % in apple, and 7.8% in plum orchards. The braconid wasps *Macrocentrus pallipes* (Nees), *Apantheles xanthostigma* (Hal.) and *Apanteles longicauda* (Wesm.) were the most efficient species in limiting the number of the green bud moths. Our survey revealed more than 50 trophic relationships, most of them new for Romania and almost 30 of them new to science.

No Designated Session Theme

EFFECTS OF REGULAR INTRODUCTIONS OF *DINARMUS BASALIS* RONDANI (HYMENOPTERA: PTEROMALIDAE) ON THE EVOLUTION OF BRUCHIDS POPULATIONS WITHIN TRADITIONAL STORAGE SYSTEM IN SAHELIAN AREA

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Bruchidius atrolineatus Pic. (Coleoptera: Bruchidae) and *Callosobruchus maculatus* Fab. (Coleoptera: Bruchidae) are, in Sahelian area, Nigeria, the most important pests of cowpea beans, *Vigna unguiculata* (L.) Walp (Fabales: Fabaceae). Cowpea infestation by these two species of bruchids starts in the field at the beginning of the plants fruit bearing and continues during storage when damage can be high if no control action is taken. *B. atrolineatus* adults emerging in the stores from December to January are in reproductive diapause and the *C. maculatus* population is small. Numbers of *C. maculatus* increase substantially from February onward when temperatures and humidity rise.

In field as well as in stores, bruchids are associated with two larval parasitoïds: *Eupelmus vuilleti* CRW (Hymenoptera : Eupelmidae) and *Dinarmus basalis* Rondani (Hymenoptera: Pteromalidae) which is the most efficient natural enemy of the bruchids. The number of *D. basalis* is low at the beginning of cowpea storage in December and because of the insterspecific competition between the two parasitoid species, it cannot control the *C. maculatus* population, which therefore causes important seed weight losses.

In this study we investigated the effect of regular introductions of *D. basalis* on the evolution of bruchid populations within traditianal storage systems. The experiment consists of a comparison between the evolution of a bruchids population in a standard jar and in one which received 200 couples of *D. basalis* adults every two weeks. Releases of *D. basalis* adults were made in stores containing varieties of cowpea which had been infested naturally in the fields before harvest. The results obtained from this study point out that the number of bruchids eggs deposited on cowpea pods and bruchid adults which emerged from seeds are much higher in the standard jars than in the ones which have received regular imputs of the parasitoïd. A rate of reduction of 75 % is observed in the treated jar compared to the standard one.

These results clearly demonstrated that biological control of bruchids using the ectoparasitoïd *D. basalis* adults in cowpea stores throughout the storage period is possible and limits the evolution of bruchid populations.

No Designated Session Theme

EVALUATION OF THE EFFECT OF PREDATOR EXCLUSION ON CASSAVA INFESTED WITH THE CASSAVA GREEN MITE (*MONONYCHELLUS TANAJOA* BONDAR) IN THE MIDDLE BELT REGION OF NIGERIA

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A chemical exclusion method using Permethrin to assess the effectiveness of a predator *Thyphlodromalus aripo* (De Leon) utilized in the Biological control of the cassava green mite (CGM) *Mononychellus tanajoa* (Acari; Tetranychidae) was investigated. The results obtained in trials showed significant differences in green mite population and cassava root yields between fields where the predators were present and the fields where they were excluded by chemical spray. There were also differences in both shoot and stem weight however these were not significant.

No Designated Session Theme

BIODIVERSITY OF TRICHOGRAMMATIDAE (HYMENOPTERA) EGG PARASITOIDS AS BENEFICIAL BIOCONTROL AGENTS

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The biodiversity of parasitic wasps (Hymenoptera: Trichogrammatidae), being parasitoids of eggs of 12 orders of insects and other arthropods (Arachnida), are discussed on the basis of original and literature data.

Trophic relations of parasitic Hymenoptera are recorded for 14 orders of insects: Coleoptera, Lepidoptera, Diptera, Heteroptera, Psocoptera, Odonata, Isoptera, Orthoptera, Neuroptera, Thysanoptera, Blattoptera, Hymenoptera, Megaloptera, Embioptera, and also with spiders (Arachnida), mites (Acari) and nematodes.

The 5 types of parasitism (in relation to development stage of host) recorded for parasitic Hymenoptera are egg-parasitism, larval, pupal, egg-pupal, and imaginal parasitism. The egg-parasitism is represented in several groups of Hymenoptera Parasitica: in superfamily Chalcidoidea - 7 families Trichogrammatidae, Mymaridae, Aphelinidae, Encyrtidae, Pteromalidae, Tetracampidae, Eulophidae; in superfamily Platygastroidea – families Scelionidae, Platygastridae.

Features of egg-parasitism in Hymenoptera are: 1) polyembryony (development of many parasitoid larvae from one laid egg); 2) thelythoky (only females progeny from laid eggs); 3) arrenothoky (only males from laid eggs); 4) deiterothoky (males and females from laid eggs); 5) symbiosis with microorganisms (Wolbachia) (only females develop in the offspring).

The family Trichogrammatidae and Mymaridae are exclusively egg-parasitoids of other insects. The egg-parasitoids of family Trichogrammatidae have trophic relations with 12 orders of insects and egg-parasitoids of the family Mymaridae with 8 insect orders.

Importance of worldwide use of Trichogramma in biocontrol is recorded. Trichogramma is used on 22 agricultural and forestry crops including maize, wheat, cabbage, soya bean, cotton, rice, tomatos, sugar beat, sugar cane, apples, plums, citrus, grape, pine-tree forests and others. Only 6 species are used in biocontrol as most important – *T. evanescens* Westw., *T. pintoi* Voegele, *T. brassicae* Voeg., *T. nubilale* Ertle & Davis, *T. dendrolimi* Mats., *T. pretiosum* Riley.

The situation for application of *Trichogramma* in Ukraine is reviewed. Eleven (11) species of *Trichogramma* were recorded from Ukraine: *T. evanescens* Westw., *T. pintoi* Voegele, *T. dendrolimi* Mats., *T. telengai* Sorok., *T. embryophagum* Hart., *T. elegantum* Sorok., *T. principium* Sug. et Sorok., *T. semblidis* Auriv., *T. piceum* Djurich, *T. bistrae* Kostad., *T. aurosum* Sug. et Sorok.. Only 3 species *Trichogramma* are used in Ukraine for mass rearing and application in plant protection: *T. pintoi*, *T. dendrolimi*, *T. embryophagum.*

In the European part of Russia 19 species of *Trichogramma* are recorded, in the Palaearctic region 52 species of *Trichogramma* were recorded. In Japan 7 species of *Trichogramma* are recorded at the present time: *T. papilionis, T. ostriniae,T. japonicum, T. chilonis, T. dendrolimi, T. pintoi, T. yawarae.* In Japan 24 genera and nearly 70 species of the family *Trichogrammatidae* are recorded at the present time. It is highly desirable to discover and describe new species of the genus *Trichogramma* and other genera of Trichogrammatidae in the nearest future.

No Designated Session Theme

PARASITOIDS (HYMENOPTERA: EULOPHIDAE, APHELINIDAE) OF THE CABBAGE WHITEFLY, *ALEYRODES PROLETELLA* (HEMIPTERA: ALEYRODIDAE), ASSOCIATED WITH THE GREATER CELANDINE (*CHELIDONIUM MAJUS*)

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The whiteflies (Hemiptera: Aleyrodidae) are an economically important group of insects damaging wide variety of plants. They are more pesticide-resistant compared to other sucking pests because the nymphs are well-protected by the external cases of their puparia. The most perspective area of their control is therefore the use of natural enemies, in particular parasitoids that attack the immature stages. The cabbage whitefly, *Aleyrodes proletella* (Linné, 1758) has a comparatively wide spectrum of host plants, being, in particular, serious pest of *Brassica oleracea* in Europe (Ramsey, Ellis, 1996) and North Africa (Nebreda, 2005). We have studied the parasitoids of this whitefly on the host populations inhabiting the greater celandine, *Chelidonium majus*, in Ukraine. Three species of parasitoids were reared from puparia of *A. proletella* collected in nature. These are: one eulophid, *Euderomphale chelidonii* Erdös 1966, and two aphelinids, *Encarsia tricolor* Forster, 1878 and *Encarsia inaron* (Walker, 1839). No-choice tests were conducted for the parasitoids with the greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood, 1856). Both *Encarsia* species were found to attack the greenhouse whitefly, whereas *E. chelidonii* avoided the puparia of this species. The behavior and preimaginal stages of *E. chelidonii* were studied in details. It is found that only some penetrations of the whitefly puparia by the parasitoid ovipositor result in egg laying, but oviposition punctures often are used for host haemolymph extraction; both sexes of the parasitoid feed on host fluids. The courtship repertoire of *E. chelidonii* is complex and differs from most other chalcidoids. The larvae of *E. chelidonii* differ significantly from the larvae of *Encarsia tricolor* and *E. inaron* in habitual appearance (swollen in *E. chelidonii* and slender in *Encarsia*-species) and tiny details of morphology (e.g. shape of mandibles).

No Designated Session Theme

SMALL TUMBLEWEED MUSTARD, *SISYMBRIUM LOESELII*, AS A TRI-TROPHIC MODEL SYSTEM: INTERACTIONS BETWEEN SEED-EATING WEEVILS (COLEOPTERA: CURCULIONIDAE) AND THEIR PARASITOIDS (HYMENOPTERA: EULOPHIDAE)

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The small tumbleweed mustard, *Sisymbrium loeselii* L. (Capparales: Brassicaceae), is a plant of European origin that was accidentally introduced to the New World, and is now recorded in 31 states of the USA, and regarded as an invasive weed (Stubbendieck *et al*., 1994). The weevil *Ceutorhynchus sisymbrii* (Dieckmann) (Coleoptera: Curculionidae) was described nearly fifty years ago and it was proposed that this species is monophagous on *Sisymbrium loeselii*. However, the biology of this weevil remained unknown. No host records were available also for the parasitic wasp *Entedon sylvestris* Szelényi (Hymenoptera: Eulophidae), a representative of the genus *Entedon*, which comprises many parasitoids of Curculionidae. The original studies conducted by the author demonstrated that adults of *C. sisymbrii* feed on shoots, flowers and fresh seeds of *S. loeselii*. Females lay eggs in May-July, when the seeds are fully-grown, but still soft. The female makes an opening in the pod with her rostrum, eats the seed below the opening and then turns back and begins oviposition. The hatched larvae feed on the seeds and remain in pods until they are fully-grown. In late May - beginning of July, the females of the parasitoid *Entedon sylvestris* search along the pods of *S. loeselii* for weevil larvae. Once the parasitoid female has located a host, she walks back and forth several times and starts ovipositing. Females of *E. sylvestris* parasitized weevil larvae of various instars and the parasitoid larva remains within the body of the host weevil larva until the emergence of the latter from the dried host-plant pods. In the end of June – beginning of July the pods of *S. loeselii* split and the mature larvae of the host weevil (parasitized and non-parasitized) leave the host plant's pods, fall to the ground and quickly bury themselves. Soon thereafter they prepare an earthen cell, in which pupate. The larvae of the parasitoid, *E. sylvestris*, are in their second instar stage when the host larvae leave the pods of *S. loeselii*. The moult of the parasitoid larva into the last (third) instar, as well as pupation takes place within the host's body, underground. Adults of *E. sylvestris* as well as their hosts, *C. sisymbrii*, must therefore overcome a soil layer to emerge the following spring. These data may be used in the development of the biocontrol programs against the small tumbleweed mustard and other invasive weeds of Brassicaceae.

No Designated Session Theme

DIVERSITY AND ECOLOGY OF NATURAL ENEMIES OF OLIVE FRUIT FLY, *BACTROCERA OLEAE,* IN SOUTH AFRICA

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The recent establishment in North America of olive fruit fly, *Bactrocera oleae* (Gmelin) (Diptera: Tephritidae), has renewed interest in classical biological control of this pest. Previous surveys conducted in Africa and Asia during the 20th century demonstrated a greater natural enemy diversity in southern and eastern Africa than in the Mediterranean region, but comprehensive evaluations were not conducted, and all attempted introductions were unsuccessful. To identify new natural enemies of olive fly for efficacy and specificity evaluation and possible importation into California, a new exploration program was planned by ARS EBCL. Surveys have been conducted in wild olives, *Olea europaea* subsp. *cuspidata* (Wall.ex G. Don), in both East and West Cape Provinces (Rep. South Africa) during the southern hemisphere fall seasons of 2001-2004, in the NE provinces (vicinity of Pretoria) in 2003, and also in Namibia in 2004. Through co-operators, surveys have also been conducted in Kenya and Pakistan.

Olive fly populations were consistently higher in West Cape than in East Cape Province, as were populations of their natural enemies. Several braconids (*Bracon*, *Psyttalia* and *Utetes* spp.) were the most abundant parasitoids of the fly recovered in these surveys in southern Africa. The parasitoid fauna of southern Africa was similar to that found in Kenya (Copeland et al., 2004, Bishop Museum Bull. Entomol. v.12), but much richer than the diversity known from North Africa. Only one species of braconid, *Psyttalia c.f. ponerophaga* (Sylvestri), has thus far been reared from olives in Pakistan. Numerous chalcidoids were also reared from wild olive in Africa, but they do not appear to be as abundant or widespread as the braconid species, and many are associated with seed chalcids attacking olives.

Although wild olive is widely distributed across southern and eastern Africa, rainfall patterns strongly influence the occurrence and abundance of fruit, and consequently the abundance of flies and their parasitoids. The dominant parasitoid species varied from region to region, and also varied from one year to the next. Braconid parasitoids were often present even at low densities of olive fly.

No Designated Session Theme

TOWARDS CLASSICAL BIOLOGICAL CONTROL OF LEEK MOTH

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The leek moth, *Acrolepiopsis assectella* (Zeller) (Lepidoptera: Acrolepiidae), is an invasive alien species of European origin that has become established in eastern Ontario and southwestern Quebec in Canada. The larvae of this pest mine the leaves of *Allium* plants, with the potential to reduce the marketability of the plants if not destroy them outright. Laboratory- and field-based research is currently being carried out to evaluate European leek moth parasitoids as potential agents for classical biological control in Canada. While records of parasitism on leek moth can be found in the literature, there has been little recent research activity covering the ecological relationships between this pest and its natural enemies. Moreover, very few of the earlier relevant papers provide a close look at the dynamics of leek moth parasitoid communities.

In 2004 and 2005, field surveys were carried out in commercial organic *Allium* crops to assess the severity of leek moth infestations and the occurrence of parasitism on leek moth in west-central Europe. Since biological control programmes against highly concealed pests tend to have reduced success compared to similar initiatives targeting species with more exposed developmental stages, the relative vulnerability of the leek moth's developmental phases was examined. To accomplish this, a complete life table study was executed whereby the mortality associated with each leek moth life stage was evaluated. Preliminary results show that leek moth populations in general are effectively regulated on leek and onion crops in west-central Europe. Leek moth mortality was higher in the egg and pupal stages than in each of the five larval instars. Another interesting observation was that leek moths suffer high mortality during the brief period between egg hatch and first penetration into the leaf tissue of the host plant. Parasitism was consistently low at the life table study sites. However, pupal mortality was significantly higher on exposed plants than on control (mesh-covered) plants, suggesting that this stage of leek moth development is most susceptible to natural enemy attack. Collectively, these results suggest that unless a highly specialised and efficient larval parasitoid is identified, the eggs or pupae of the leek moth might be the most effective life stages to target for classical biological control.

No Designated Session Theme

ABIOTIC AND BIOTIC FACTORS AFFECTING THE BIOLOGICAL CONTROL OF CEREAL STEMBORERS IN EAST AFRICA

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The exotic braconid larval parasitoid, *Cotesia flavipes* Cameron (Hymenoptera: Braconidae), is used as a biological control agent against the invasive crambid *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae), a serious pest of cereal crops in East and Southern Africa. It was hypothesized that the success of the parasitoid was determined by the composition of stemborer species, which might be acceptable but suitable or unsuitable, climate (temperature mainly), the availability and suitability of host larval stages at the time of release, quality of the host plant (nutritional status and age of the plant, and host plant species), which affects both the insect host and parasitoid, as well as the accessibility of the host inside the stem.

To predict the effect of different borer species compositions, found in the different agroecological zones in Kenya, on the performance of *C. flavipes* a two-host-two-parasitoid model was used. The model assumed both intra-specific competition of *C. partellus* and included the major indigenous parasitoid species, *Cotesia sesamiae* Cameron, the invasive and the primary indigenous pest species in a given agroecological zone. The model predicted that in areas where both host species were suitable to either parasitoid species, stemborer densities would be reduced to and controlled at low densities and *C. flavipes* would become the dominant parasitoid species. This, however, would increase the risk of extirpation of *C. sesamiae*. If the indigenous host species was unsuitable to *C. flavipes*, both parasitoid species could coexist but the indigenous host would not be reduced to low densities. Intra-specific competition of host species was vital for the coexistence of the four species; high competition coefficients of indigenous stemborer hosts enhanced the stability of the system if the host was unsuitable to *C. flavipes*, but it increased the risk of extirpation of *C. sesamiae* if the host was suitable. The model output was validated with real-field situations.

Temperature effect studies showed that development time of *C. flavipes* immatures significantly decreased with temperature and with host instar, while sex ratio changed from male to female-biased. Fourth larval instars were considerably more suitable than third instars. Parasitized larvae kept feeding at the same rate as unparsititized. Thus, *C. flavipes* had no direct effect on yield formation of the plant but rather through a long-term reduction of the pest over several generations.

Nitrogen fertilization applied to sorghum and maize significantly increased survivorship of *C. partellus*. Parasitism tended to decrease with age of the maize plant and it tended to be lower on sorghum than maize. Nitrogen had no effect on number of progeny and sex ratio of the parasitoid while egg load increased significantly with nitrogen level applied to maize. On sorghum, the effects were mostly not significant.

Host species – cultivated or wild – had a significant effect on the performance of both *C. partellus* and *C. flavipes*. The percentage of *C. partellus* larvae producing cocoons and egg load of *C. flavipes* progeny tended to be lower on wild than cultivated host plants.

No Designated Session Theme

CONTROL OF CHESTNUT WEEVILS WITH ENTOMOPATHOGENIC NEMATODES: FIRST EXPERIENCES

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Entomopathogenic nematodes were used to control the chestnut weevil, *Curculio elephas* Gyll. (Coleoptera: Curculionidae), under semi-field conditions in 2003 and 2004. PVC tubes (diameter 10cm; length 40cm) filled with sandy soil were buried in a chestnut orchard and artificially infected with pest larvae by applying nematodes at a rate of 2 Mio infective juveniles (IJ)/m^2. Mortality was 43, 56, 56, and 52% respectively, after applying *Steinernema carpocapsae* (Weiser), *S. feltiae* (Filipjev), *S. kraussei* (Steiner) and *Heterorhabditis megidis* Poinar, Jackson and Kleine, all (Nematoda: Rhabditidae). However, mortality was not significantly increased in nematode treatments compared to the untreated control. Most of the surviving pest larvae were found at a depth of 31-40cm in the soil columns, whereas increased numbers of dead weevils were in the upper soil layers. It is concluded that nematodes failed to follow and attack chestnut weevils at increased soil depths and that application timing and technique needs improvement for sufficient control of this pest with nematodes.

No Designated Session Theme

APPLICATION OF RESPONSE SURFACE METHODOLOGY FOR DEVELOPMENT AND OPTIMIZATION OF INSECT DIETS FOR MASS PRODUCTION OF PARASITOIDS

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Insect diet development can be difficult and time-consuming because of the large number of component permutations to test. One-factor at a time (OFAT) approaches are time, labor and cost prohibitive and inherently confounded. However, factorial mixture designs provide a powerful and relatively simple approach to de-convoluting effects and interactions of multiple diet components. Screening designs facilitate analysis of up to 24 components in a single experiment, while crossed, full D-Optimal mixture designs are capable of quantifying interactions/effects of 6 or more components across a temperature range. The response surfaces generated by this approach can be used to define numerous diet "optima" as functions of multiple responses, such as development time, male to female ratios, and/or days to adult emergence. Mixture response surface methodology, as it relates to insect diet formulations and component screening, will be discussed along with results and implications of a newly developed rearing medium for the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) (Hemiptera: Pseudococcidae).

M. hirsutus was unknown in the Western Hemisphere (with the exception of Hawaii) prior to its discovery in the Caribbean in 1994. It has now spread to the Americas including California, Mexico, Central America, and Guyana, Venezuela, and Colombia in South America. *M. hirsutus* is a global pest of ornamentals, vegetables, grapes and various tree crops. It was discovered in Florida (USA) in 2002 and has been inadvertently distributed through ornamental commerce to several US states. The economic risk to U. S. agriculture has been estimated at $750 million per year due mainly to its wide host range that includes over 125 plant species. The largest risk is to ornamental crops, followed by vegetables, citrus, grapes, and avocados. The U.S.D.A. has provided two encyrtid parasitoids, *Anagyrus kamali* Moursi and *Gyranusoidea indica* Schaffe, Alam & Agarwal (Hymenoptera: Encyrtidae) throughout the Western hemisphere and is currently conducting international surveys for additional parasitoids. For mass-producing parasitoids, *M. hirsutus* must be reared on fruits of various species of cucurbits, sprouted potatoes, or hibiscus plants. Of these, the preferred host has been Japanese pumpkin (*Cucurbita moschata* Duchesne (Curbitales: Cucurbitaceae) due to its ribbed rinds and characteristic warted surface, which provide large settling areas for mealybugs. However, seasonal shortages of produce, and difficulties in maintaining a continuous supply of etiolated sprouts of potato, threaten production and increase costs. Work in our laboratory compared plant hosts and showed the potential of a pumpkin-based meridic diet for rearing *M. hirsutus*. Complete mealybug development was obtained on meridic diet as well as five plant substrates. There was a positive linear relationship between developmental rates of female *M. hirsutus* obtained on plant hosts and diet, and those of *A. kamali* females and males. Adult parasitoid emergence was approximately 20% on meridic diet compared with 60% on the best plant substrate. These results with a simple diet encouraged us to pursue a semi-defined artificial diet based on readily available materials. To simplify diet optimization, we applied response surface methods. Our results and the broader application of this approach will be discussed.

No Designated Session Theme

EGG PARASITOIDS FROM ARGENTINA, POTENTIAL CANDIDATES FOR THE BIOLOGICAL CONTROL OF GLASSY-WINGED SHARPSHOOTER IN THE UNITED STATES

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The glassy winged sharpshooter (GWSS), *Homalodisca coagulata* (Say) (Hemiptera: Cicadellidae), vector of the Pierce's disease, is a very serious pest problem in several crops, especially grapes in southern California. Because GWSS does not occur in South America, its biological control using South American natural enemies relies on the 'new-association' approach. Field surveys for eggs parasitoids were conducted in Argentina on *Tapajosa rubromarginata* (Signoret), a common and native sharpshooter. Eggs of *T. rubromarginata* were obtained in the laboratory and later exposed to parasitization in 92 selected sites in nine ecological regions of Argentina.

Additionally, laboratory studies on bionomics (development time, progeny sex ratio, adult longevity) and host range were conducted with the most promising candidates, *G. tuberculifemur* (Ogloblin), *G. annulicornis* (Ogloblin) and *Gonatocerus* sp. (Hymenoptera: Mymaridae). For the specificity experiments, eggs of 18 potential hosts were tested for each parasitoid: Delphacidae (3 spp.), Cicadellidae (12 spp. in 3 subfamilies and 5 tribes), Lepidoptera (1 sp.), Coleoptera (2 spp.).

From the 14,922 eggs exposed, 1,730 (11.6%) were parasitized at 53 sites (57.6%) and wasps of 14 different species in 5 genera were obtained: eight species of *Gonatocerus* and one of *Polynema* (Mymaridae), one species of *Paracentrobia*, 2 species of *Oligosita* and 2 of *Zagella* (Trichogrammatidae). Parasitoids emerged from all eco-regions (from rain forest to desert) except from Temperate Patagonian Forest. A richness latitudinal gradient was observed (Fig. 1).

Bionomic results for the 3 spp. of *Gonatocerus* tested are shown in Table 1.

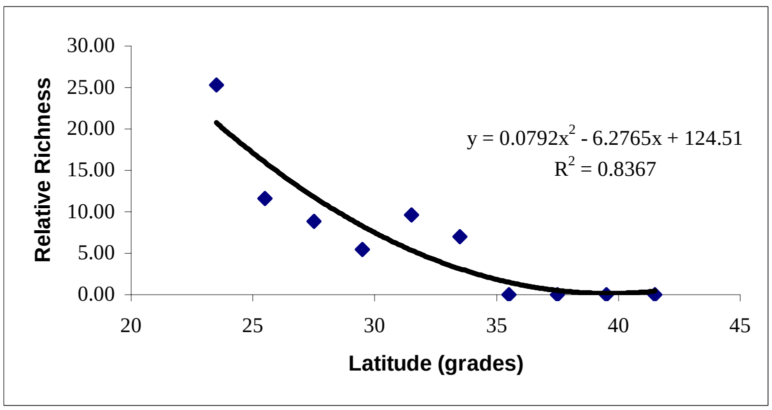

Figure 1. Relationship between species richness and latitude.

Table 1. Laboratory results on *T. rubromarginata* eggs exposure to 3 spp. of *Gonatocerus*. n.s. Not significant (*t* test), * significant (*t* test P<0.05)

Species	Generations	Eggs		Sex ratio F/M	Development time (days)	Longevity (days)	
		Exposed	Parasitized (%)			Female	Male
G. tuberculifemur	7	2095	1500 (71.6)	2.1	12.6 ± 1.8	6.7 ± 3.9	n.s.
G. annulicornis	6	1277	969 (75.8)	1.2	10.9 ± 1.5	7.1 ± 4.0	4.7 ± 2.9*
Gonatocerus sp.	4	1503	907 (60.5)	1.4	11.0 ± 1.5	6.6 ± 4.3	4.3 ± 2.6*

Preliminary results of the host range studies indicated that the genus *Gonatocerus* is restricted to the tribe Proconiini, where GWSS belongs. The females of *G. tuberculifemur*, *G. annulicornis* and *Gonatocerus* sp. oviposited and the larvae developed to adults only in sharpshooters of that tribe. None of the other 14 species tested were attacked during the study. Since March 2001, these parasitoids have been successfully cultured using eggs of the factitious host, *H. coagulata,* at the quarantine facilities in USDA-APHIS Mission, TX, and Riverside, CA. Complementary studies on the biology and host range are being carried out.

No Designated Session Theme

ARTIFICIAL SELECTION ON FECUNDITY IN WINGLESS TWO-SPOT LADYBIRD BEETLES (*ADALIA BIPUNCTATA*)

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Wingless ladybirds in biocontrol. Predatory ladybird beetles are being used as control agents in augmentative biological control against aphids. Because adult ladybirds disperse by flight at low host density, larvae are commonly released. However, repeated releases are usually required making their use in biocontrol costly.

A ladybird stock that is not able to fly away would be likely to increase the efficiency of biocontrol and to decrease the costs. Wingless ladybirds might have additional benefits such as increased fecundity because energy is not invested in developing and maintaining the structures needed for flight. Such a trade-off has been found in other insects, e.g. crickets.

Fecundity of wingless *A. bipunctata*. A wingless individual of the two-spot ladybird beetle, *Adalia bipunctata* (L.) (Coleoptera: Coccinellidae), was collected in the wild and used to establish a pure-breeding laboratory stock. Pilot experiments showed that in segregating families, wingless *A. bipunctata* were larger and heavier than their winged siblings, indicating a trade-off. Although insect size is often positively correlated with fecundity, in contrast to this, the wingless individuals in our stock show reduced fecundity. However, if there is potential for evolution of a trade-off between fecundity and the ability to fly, artificial selection on the wingless stock might be able to increase fecundity, perhaps eventually to the extent of exceeding that of wildtypes.

Artificial selection on high early fecundity. We have, therefore, selected for high early fecundity in wingless *A. bipunctata*. Two lines were set up simultaneously, consisting of 120 single wingless pairs in each line in each generation. Pairs were kept together for 12 days and eggs collected several times. The number of larvae that hatched from these eggs was recorded, and the top 30 families then selected as parents for the next generation.

Here we present the results over the first seven generations of selection.

No Designated Session Theme

SEASONAL OCCURRENCE OF THE *APHIDIUS ROSAE* HALIDAY (HYMENOPTERA: BRACONIDAE) PARASITOID OF *MACROSIPHUM ROSAE* L. (HOMOPTERA: APHIDIDAE) IN ISFAHAN, IRAN

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Aphidius rosae is the most important parasitoid of rose aphid, *Macrosiphum rosae*, in many parts of the world. This parasitoid is specialized on *M. rosae.* The seasonal occurrence of *A. rosae* in rose gardens in Isfahan, Iran, was studied from September 2003 to October 2004. Weekly sampling included 10-15 cm of terminal portion of 10 shoots. This parasitoid has two activity periods in a year. Initially spring activity started at the end of March and continued to early June, when the temperature increased and density of the *M. rosae* on rose decreased. The other activity period in autumn started from the end of October to early December. Thereafter, the cold weather did not allow the parasitoid to be active. The number of parasitized aphids gradually increased during spring and peaked in early May. In autumn, parasitoid peaked on 10 November. Range of percentage parasitism in the field in spring and autumn was from 2.75% to 11.69% and from 0.84% to 2.72%, respectively.

Percentage parasitism in spring when the number of parasitoids was high, was estimated for apterous adults and late nymphal stages (3 and 4) of aphids under laboratory conditions. The maximum parasitism was 27% and 29% for apterous adults and late instars, respectively. This information, together with seasonal changes of the aphid, can be used for determining the best date for applying classical biological control techniques on *M. rosae*.

No Designated Session Theme

INFLUENCE OF TWO ENDOPARASITIC WASPS, *HYPOSOTER DIDYMATOR* (HYMENOPTERA: ICHNEUMONIDAE) AND *CHELONUS INANITUS* (HYMENOPTERA: BRACONIDAE), ON THE GROWTH AND FOOD CONSUMPTION OF THE HOST LARVA *SPODOPTERA LITTORALIS* (LEPIDOPTERA: NOCTUIDAE)

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The most obvious effect of parasitization is a reduction on numbers of the next host generation, but there can be also a direct effect on the population of the host, because parasitized pest larvae by different biological agents, usually modify their feeding behaviour reducing food consumption, giving as result, lesser damage on host plants before finally dying. *Hyposoter didymator* (Thunberg) and *Chelonus inanitus* (Linnaeus) are frequently found in Spain parasitizing larvae and eggs, respectively, of the important noctuid pest *Spodoptera littoralis* (Boisduval). In this study, we have compared effects of parasitism by these species, on development, growth and food consumption of the host larvae. Parasitized larvae always consumed significantly less artificial diet than non parasitized ones, and they were unable to finish the development, dying on the fifth larval instar. When *C. inanitus* parasitized *S. littoralis* eggs, host larval consumption was reduced very soon, since emerged larvae moulted into the second instar two days after eclosion. In contrast, *H. didymator*, which parasitized third instar *S. littoralis* larvae, only reduced their food consumption four days after parasitization. However, overall feeding reduction on host larvae achieved by the latter was higher than that caused by the former species *C. inanitus*. Final body weight of host larvae parasitized by *H. didymator* and *C. inanitus* was 6.7 and 13.0%, respectively, of the maximum weight of a healthy 6th instar host larvae. Based on these results, both parasitoids had a direct effect on *S. littoralis* populations, reducing enormously larval food consumption, but lesser damage on host plants can be expected from *H. didymator* parasitized larvae because this species seems to be more effective.

No Designated Session Theme

BIOLOGICAL CONTROL OF THE GLASSY-WINGED SHARPSHOOTER IN CALIFORNIA - ANATOMY OF A STATE RUN PROGRAM

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The glassy-winged sharpshooter, *Homalodisca coagulata* (Say) (Homoptera: Cicadellidae) became established in California in the late 1980s and has now become naturalized throughout most of southern California. The insect's size, polyphagy, and longevity all contribute to its ability to vector a complex of plant diseases caused by the of xylem-limited bacteria *Xylella fastidiosa*. The threat to grape production due to an increase in the spread of Pierce's disease has lead to the initiation of a State-run program to suppress populations of the glassy-winged sharpshooter in California

Initial evaluation of important mortality factors for the glassy-winged sharpshooter in California and in its native range identified the importance of a complex of mymarid egg parasitoids. Over one dozen agents were recovered from their native range and screened for target and non-target effects under quarantine conditions. Three species of mymarid, *Gonatocerus ashmeadi* Girault, *G. morrilli* Howard and *G. triguttatus* Girault, were selected for release as biological control agents against the glassy-winged sharpshooter in California in late 2000. One further species, *G. fasciatus*, was added in 2002.

On release from quarantine, the agents were moved to two biological control agent production facilities in California for production, release, and evaluation. Production research included the selection of plants and rearing conditions to optimize glassy-winged sharpshooter growth and egg production for parasitoid colonies. Release work included appraisal of release sites in urban, riparian, and agricultural settings. Evaluation of all release sites was carried out prior, during, and after releases to assess efficacy of both native species of egg parasitoids and introduced biological control agents.

Over one million agents have now been released in an area that covers over 50,000 square miles. Releases of single or combinations of agents have been made into multiple sites and have led to over 140 recoveries. molecular approaches are being developed to assist us in the rapid identification of parasitized eggs and in discriminating between native and exotic individuals of the same species.

The glassy-winged biological control program is one of the largest biological control efforts in existence and is the product of much theoretical research invested in biological control. A large part of the responsibility of the biological control facilities is the support of research into to new control strategies and agents. The collaboration between all levels of government (county, state and federal), university, farmers, and industry is remarkable and is being seen as a model on which to base future biological control strategies in California. One facility is currently being purchased and will be dedicated to the development of biological control strategies of current and future pests in California. It is anticipated that the state-operated facilities will provide a bridge between researchers into biological control and the nation's biological control industry, 50% of which is based in California.

No Designated Session Theme

BIOLOGICAL CONTROL IN THE WALNUT-FRUIT FORESTS OF KYRGYZSTAN

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In Kyrgyzstan, the forest covers an area of about 864,900 ha, which represents only 4,32% of the territory. All forests are very valuable and highly protected. Management is focused mainly on protection and includes primarily sanitary activities, whereas industrial sylviculture is prohibited. Despite the small areas involved, forests play an important role in the development of rural economies and in the improvement of environmental conditions. For example, forests provide important fruit crops such as walnut and pistachio.

However the sanitary condition of the forests causes concern. Among the main factors affecting resources in walnut forests are pest insects and diseases. Consequently, forest protection against pest insects is an essential part of the activity in the State Forest Service of Kyrgyzstan.

Walnut forests constantly suffer from pest insects and diseases, among which the main ones are: *Lymantria dispar* L. (Lepidoptera: Lymantriidae), *Erannis defoliaria* Clerck (Lepidoptera: Geometridae), *Malacosoma parallela* Staudinger (Lepidoptera: Lasiocampidae), *Sphaerocanium prunastri* Fonsc. (Homoptera: Coccidae), *Caliroa cerasi* (*limancina*) L. One of the most serious forest protection problems in Kyrgyzstan has been the outbreak of gypsy moth (*Lymantria dispar*) in walnut forests that started in 1970. Defoliation by the gypsy moth has strongly affected pistachio, walnut and apple harvests. The gypsy moth is one of the most important forest insect pest species in Central Asia. Larvae of this moth defoliate large areas of the walnut-fruit forest stands annually, not only in Kyrgyzstan (Romanenko, 1984; Ashimov, 1989; Orozumbekov et al., 2003).

The wide use of chemical insecticides against forest pests during the past 30-35 years has had a detrimental effect on the forest biocenose. Chemical insecticides are cheap, highly efficient but not environmentally friendly and non-selective. NPV (Nuclear Polyhedrosis Virus) has been used against gypsy moth since 1984 in Kyrgyzstan. Bt preparations are effective against gypsy moth but have not been evaluated yet in the mountain conditions of Kyrgyzstan. Investigating natural enemies in these populations should help to detect species that might play an important role in the natural control of the pest. Modern biological control methods in mountain forests would be practically harmless for the environment and could be applied not only in Kyrgyzstan but also in all Central Asian Republics where the use of chemical insecticides has been limited.

No Designated Session Theme

TWO NEW LARVAL ECTOPARASITIC MITES (ACARI: ERYTHRAEIDAE) ON SUNN PEST FROM IRAN

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Sunn pest *Eurygaster integriceps* Puton (Hemiptera: Scutelleridae) is the most important pest of cereals in Iran especially in the Fars Province. During 2000-2002 studies were carried out to identify mites associated with sunn pest from Iran in the Fars region. A total of five species were recorded and identified. Of these two species of genera *Charletonia* Oudemans and *Leptus* Latreille are new species and ectoparasites of *E. integriceps.* Our literature survey suggests that this might be the first *Charletonia* described in the world. Some of the key taxonomic characteristics distinguishing these red mites are noted. Sites of attachment on the sunn pest are the dorsal of the abdomen and legs. The idiosoma are oval in outline. The dorsal scutum is longer than wide and oblong with rounded angles. The anterior border is smoothly rounded, while lateral borders are less convex. The posterior border is almost straight, with sensilla bases protruding through the margin. Sensillary setae have small setules in distal halves. In the gnathosoma: chelicerae-bases are rounded; the squatpyriform is without special markings. The palpal tibial claw is small and terminally split, and the tines subequal. Field results showed that the adult of sunn pest was a suitable host for *Charletonia* and *Leptus*. These mites are suitable candidates for the biological control of agricultural pests, whereas the classification of these mites is still problematic.

No Designated Session Theme

REPRODUCTIVE AND DEVELOPMENTAL BIOLOGY OF *GONATOCERUS ASHMEADI* (HYMENOPTERA: MYMARIDAE), AN EGG PARASITOID OF *HOMALODISCA COAGULATA* (HEMIPTERA: CICADELLIDAE)

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Gonatocerus ashmeadi Girault (Hymenoptera: Mymaridae) is a common natural enemy associated with the insect pest *Homalodisca coagulata* (Say) (Hemiptera: Cicadellidae) in its home range of southeastern USA and northeastern Mexico. It is a self-introduced resident of southwestern USA and most likely came into the area in parasitized eggs and has since established a local association with *H. coagulata* and the native congeneric *H. liturata*.

Investigating a biological control agent's environmental requirements for reproductive and developmental biology with that of the host can allow for an enhanced understanding of the potential impact the natural enemy will have on its target.

The developmental and reproductive biology of *G. ashmeadi* was studied in the laboratory at five different temperatures (15, 20, 25, 30, and 33°C) and collected data were used to create life tables for this parasitoid. Mean adult longevity was significantly different between temperatures ($P<0.001$) and was greatest at 15°C and declined as the temperature increased. The rates for oviposition that led to successful reproduction of offspring were highest at 30°C and were significantly different between temperatures ($P<0.001$). At 30°C approximately 46% of host eggs presented to parasitoids produced viable offspring. This rate decreased with temperature to approximately 3% at 15°C. Higher temperatures similarly lowered the production of viable offspring with 10% of GWSS eggs producing viable offspring at 33°C.

The number of offspring produced by individual parasitoids over their lifetime was greatest at 25°C and fell as temperature either increased of decreased ($P<0.001$). There were no statistically significant differences in offspring sex ratios between the temperatures. Survivorship of *G. ashmeadi* decreased as temperature increased and declined at a similar rate to female offspring production.

The lower threshold temperature for egg to adult development was determined by linear regression and was calculated as approximately 8°C. The Modified Logan Model indicated that the upper developmental threshold was approximately 36°C and the fastest rate of development was at 30°C. A total of 137 degree days above the minimum temperature threshold were required for successful development of *G. ashmeadi* from egg to adult.

Statistically significant differences were calculated across the five temperatures among five demographic growth parameters that were analyzed using the jackknifed values generated from the $l_x m_x$ life tables. Mean net reproductive rate ($P<0.001$), intrinsic rate of increase ($P<0.001$) and finite rate of increase ($P<0.001$) were significantly higher for *G. ashmeadi* reared at a constant 25°C, 30°C and 33°C respectively. Population doubling times were significantly ($P<0.001$) fastest when parasitoids were reared at 30°C. Mean generation time was significantly lower at 33°C ($P<0.001$).

No Designated Session Theme

CAN MUSTARD SEED MEAL INCREASE THE ABUNDANCE OF *ALEOCHARA* SPECIES IN CANOLA?

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Delia radicum L. (Diptera: Anthomyiidae), the cabbage root maggot, is a species of European origin, and is a pest of vegetable brassicas and of canola in Canada. Three species of *Aleochara* (*A. bilineata* (Gyllenhal).), *A. bipustulata* (L.) and *A. verna* (Say) (Coleoptera: Staphylinidae)) have been identified as playing important roles in reducing the populations of *Delia radicum* (L.) in many brassica crops. *Aleochara bilineata* and *A. verna* are present in both North America and Europe. However, *A. bipustulata* is not present in North America and so may be a potential candidate for use as a biological control agent against *D. radicum* in Canadian canola. If risk assessment tests reveal *A. bipustulata* is safe to release in the Canadian prairies then a method of manipulating and maintaining the populations of *A. bipustulata* would be beneficial. In southern Sweden the addition of white mustard seed meal as a mulch was shown to attract and maintain *Aleochara* spp. to suppress *D. radicum* populations in vegetable brassicas (1992; IOBC/WPRS Bulletin XV (4): 171-175).

Our study examined whether attraction of *Aleochara* species to mustard seed meal would occur in canola, what species of *Aleochara* are attracted, and investigated the nature of the attraction mechanism. In field plots of summer canola in Switzerland, *Delia radicum* and *Aleochara* populations were compared between plots with and without mustard seed meal mulch. Parasitism levels and adult activity of *A. bipustulata* were consistently higher in plots treated with mustard seed than in untreated plots. However, levels of parasitism and adult activity of *Aleochara bilineata* were not influenced by the mustard seed meal treatment. Analysis of volatiles emitted by mustard seed meal, using GCMS, revealed seven major peaks, of which the highest was for limonene. Experiments in a Y-tube olfactometer were conducted to examine the attractiveness of mustard meal and associated volatiles to *A. bipustulata* and *A.*

bilineata. *Aleochara bipustulata* exhibited preference for volatiles from mustard seed meal when compared to clean air and to air passed over soil; whether the meal was wet or dry did not influence these responses. *Aleochara bipustulata* showed a tendency to choose the olfactometer arm with limonene over that with clean air, but in initial experiments this was not significant. *Aleochara bilineata* showed no attraction to mustard meal or associated volatiles in the olfactometer.

No Designated Session Theme

BIOLOGICAL CONTROL OF THE PINK HIBISCUS MEALYBUG, *MACONELLICOCCUS HIRSUTUS* (GREEN), IN IMPERIAL VALLEY, CALIFORNIA, U.S.A.

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A cooperative biological control project against the pink hibiscus mealybug, *Maconellicoccus hirsutus* (Green) (Homoptera: Pseudococcidae), infestation in the low-desert region of California, USA was initiated in the fall of 1999. At that time, the average mealybug density on mulberry trees was 256 second instar nymphs to adult mealybugs per branch terminal. Subsequently, several strains of two encyrtid parasitoid species (*Anagyrus kamali* Moursi and *Gyranusoidea indica* Shafee, Alam & Agarwal) (Hymenoptera: Encyrtidae)) were mass reared and released. In 2000, over 400,000 parasitoids of the two species were released at 400 locations. Population densities of mealybug and percent parasitism were monitored at a number of mulberry tree and carob tree urban home sites for four consecutive years. The primary sample method consisted of sampling branch terminals and counting the number of second instar nymphs to adult mealybug life stages. The population density of *M. hirsutus* within the first year was reduced by approximately 95%. Over the entire four-year period of the project, the average regional population density of the mealybug exhibited a continued decline. *Anagyrus kamali* was the predominant parasitoid, often parasitizing in excess of 50% of the mid to late stage *M. hirsutus* in the first two years following the parasitoid's release. Although

Gyranusoidea indica was rarely found from spring through early fall, it did represent 40% of the parasitoid species composition during winter, based on data collected from corrugated cardboard bands wrapped around limbs near the trunk of each tree sampled. Hyperparasitism of *Anagyrus kamali* by resident species (*Marietta* sp. & *Chartocerus* sp.) was frequently over 35% during 2000. However, hyperparasitism was considerably lower during each successive year, coincident with declining densities of both mealybug and the primary parasitoid host. Field collections of two non-target species of mealybugs common in Imperial Valley demonstrated that they are not being utilized as alternate non-target hosts by the newly introduced parasitoids.

No Designated Session Theme

STUDY OF POPULATION PARAMETERS OF SUNN PEST, *EURYGASTER INTEGRICEPS*, EGG PARASITOIDS *TRISSOLCUS GRANDIS* AND *T. SEMISTRIATUS* (HYMENOPTERA: SCELIONIDAE)

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Sunn pest, *Eurygaster integriceps* Put. (Heteroptera: Scutelleridae), is the most important insect pest of wheat and barley in Iran. Yield losses from damage are estimated at 20-30% in barley and 50-90% in wheat if this pest is not controlled chemically. This pest is attacked by a number of generalist predators as well as more specialized parasites, the most important of which are hymenopteran egg parasitoids belonging to the genus *Trissolcus*. It is estimated that egg parasitoids reduce *E. integriceps* populations by ~23% each year in Iran. Life table parameters of *Trissolcus grandis* Thomp. and *T. semistriatus* Nees were determined under laboratory conditions. The second-generation (F_2) of parasitoids was used in all experiments. Twenty-five randomly chosen young female adults (<24 hr old) were used for life table studies of the parasitoids. Daily Schedules of mortality and fecundity were integrated into a life table format (Carey 1993) and used to calculate net reproductive rate (R_0), mean generation time (T), and intrinsic rate of increase (r_m).

Life table parameters of sunn pest *Eurygaster integriceps* egg parasitoids *Trissolcus grandis* and *T. semistriatus*

Parasitoid species	Longevity (day)	Proportion of males: m/(f+m)	Net reproductiv-e rate (R0)	Intrinsic rate of increase (rm)	Generation Time (T)	Doubling Time (DT)
T. grandis	38.6±5.4	0.37±0.08	118.37	0.298	15.81	2.32
T.semistriatus	36.3±2.8	0.33±0.06	104.99	0.297	15.67	2.33

No Designated Session Theme

STRAWBERRY ROOT BEETLE BIOLOGY AND CONTROL MEASURES USING ENTOMOPATHOGENIC NEMATODES

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Strawberry root beetle, *Mimela schneideri* Ohaus (Coleoptera: Scarabaeidae) has been a invasive white grub extensively destroying roots of strawberry growing the northern region of Thailand. The 2.5 mm long, oval creamy white eggs were laid in soil during April-May, hatching within 10-24 days. The first, second larval instars obviously having creamy white body and brown head capsule, the third showing yellow skin were found about 5-20 cm under soil surface. Late third instar moved furthers to the depth of 30 cm or more to pupate in the formed earthen cells. Root damage to Strawberry caused mostly by the 2nd and 3rd instars occurred from May to October. The pupal period was between November and April. Adult emergence began in the last week of April and followed by the mating activities which happened 1-2 hours after sunset. The elongate and oval body of adults showed pale pea green with a very faint golden luster.

The efficacy of three species of entomopathogenic nematodes *Steinernema carpocapsae* (Weiser), *S. glaseri* (Steiner) and *S. riobrave* (Cabanillas, Poinar & Raulston) (Rhabditida: Steinernematidae) for controlling the strawberry white grubs was evaluated in the field at Doi Angkang, Research Station of Royal Project Foundation, Chiangmai province. The experimental design was RCB with 4 treatments and 4 replications. The concentrations of the three species of nematodes were applied at the rate of 1 x 10^6 IJs/m^2, in comparison with chlorpyrifos

(Lorsban 40% EC). The result showed that *S. glaseri* was significantly more efficient than *S. carpocapsae* and *S. riobrave*. The percent of dead strawberry plants occurred by the white grub - damaged roots in the treatment of spraying *S. glaseri* was 3.8% as low as in the chlorpyrifos treatment whereas the treatment of spraying *S. carpocapsae* and *S. riobrave* were 6.3% and 6.5% respectively (Table 1).

Table 1. Percent of strawberry plants having the white grubs - damaged root after spraying three species of nematodes and chemical.

Treatments	Percent damage of strawberry plants with their roots attacked by white grubs
S. carpocapsae	6.3 b*
S. glaseri	3.8 a
S. riobrave	6.5 b
chlorpyrifos	3.7 a
CV. (%) = 70	

* In a column, means followed by a common letter are not significantly different at 5% level by DMRT.

No Designated Session Theme

REARING OF *TRIALEURODES VAPORARIORUM* AND *ENCARSIA FORMOSA* ON TISSUE OF SQUASH FRUIT

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The use of artificial diets for rearing insect is a phenomenon that has been developed in order to aid the fields of physiology, ecology, genetics and insect control techniques. The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Hemiptera: Aleyrodidae), is one of the well-known pests affecting several greenhouse-grown crops in Iran. The diversity of natural foods of these whiteflies is very large and larval instars, as well as adults, feed on the phloem sap of hundreds of species of plants. Three principle requirements in the formulation of a diet are: that it stimulates the insect to feed on an unfamiliar food; it must possess all the essential nutrients in balanced preparations needed of normal growth, development and reproduction; it must be free from microbial contamination.

Surfaces of tissue layers of squash fruit were disinfected and then females of *T. vaporariorum* released to oviposit on these layers for four hours and then removed. The layers were then kept in 21 C° to complete immature stages. After 20 days that host population is suitable for parasitism. *Encarsia formosa* Gahan (Hymenoptera: Aphelinidae) was then released for 24 hours and removed. Parasitized pupas were kept in 21 C° to complete all immature stages. All eggs completed immature stages successfully and adults emerged.

No Designated Session Theme

A ROLE OF *PEDIOBIUS SAULIUS* (WLK.) (HYMENOPTERA: EULOPHIDAE) IN THE PARASITOID COMPLEX OF THE HORSE CHESTNUT LEAFMINER, *CAMERARIA OHRIDELLA* DESCHKA & DIMIC (LEPIDOPTERA: GRACILLARIIDAE)

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Pediobius saulius (Wlk.) (Hymenoptera: Eulophidae) is a wide spread in Europe parasitoid on leafminers. Investigations on natural enemies of *Cameraria ohridella* Deschka & Dimic (Lepidoptera: Garcillariidae) conducted during last ten years showed that *P. saulius* was the dominant in the parasitoid complex of the moth mainly in Balkans. Study on biology and impact of *P. saulius* was conducted during the period 2001-2003.

Parasitoid biology. It was established that the parasitoid could be reared in laboratory conditions. The longevity of *P. saulius* depends on its diet. Females start their searching behavior 6-7 days after emergence. *P. saulius* has a synovigeny. Host feeding on prepupae and pupae was observed. *P. saulius* is a primary endoparasitoid on prepupae and pupae of the host. It is a koinobiont.

Impact. The information is given on the relative abundance of *P. saulius* of each moth generation during three seasons with different infestation level. The phenology of *P. saulius* is compared with that of *C.ohridella.*The impact of *P saulius* on the population dynamics of *C. ohridella* in natural and urban stands of horse chestnut in Bulgaria is discussed.

No Designated Session Theme

TWO DIFFERENT SPECIES UNDER ONE NAME: MORPHOLOGICAL, BIOLOGICAL, AND MOLECULAR COMPARISON BETWEEN THE DIFFERENT GEOGRAPHICAL POPULATIONS OF *ANAGYRUS PSEUDOCOCCI*, A WELL-KNOWN AGENT USED IN BIOLOGICAL CONTROL OF CITRUS AND VINE MEALYBUGS

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Anagyrus pseudococci (Girault) (Hymenoptera: Encyrtidae) is a well-known primary parasitoid of *Planococcus* spp. (Hemiptera: Sternorrhyncha: Pseudococcidae) and has been used for biocontrol purposes in many countries. Over the course of a classical biocontrol project against the vine mealybug, *Planococcus ficus* (Signoret) (Hemiptera: Pseudococcidae), in California, USA, cultures of *A. pseudococci* of different origin were established at the University of California, Riverside quarantine laboratory, from the populations in Argentina, Israel, Italy (Sicily), Spain, Turkmenistan, and USA (Coachella Valley, California). Morphological and molecular studies as well as cross-breeding experiments revealed that the Argentine population (first funicle segment of the female antenna half black, half white) is also reproductively and genetically isolated from all other populations tested (first funicle segment of the female antenna entirely black), which cross-bred freely between each other and are genetically very similar. The type series of *A. pseudococci* (from Sicily) is morphologically identical to the population from Argentina; the latter apparently represents the real *A. pseudococci* and could have been unintentionally introduced there with the grape seedlings from Italy. The other, better known Mediterranean form (first funicle segment of the female antenna entirely black, previously introduced in California), thus belongs to a different, currently unnamed species which may coexist in Sicily with the real *A. pseudococci*.

No Designated Session Theme

FILM DOCUMENTATION OF THE BEHAVIOUR OF PREDATORS OF THE TWO-SPOTTED SPIDER MITE *TETRANYCHUS URTICAE*

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This video film (15 minutes duration) shows at first how *Tetranychus urticae* Koch (Acarina: Tetranychidae) females remove food from epidermal cells of bean plants. It then focuses on the precopulatory behaviour of males that wait on resting female deutonymphs and combat male competitors by means of their protruded chelicerae. Upon ecdysis, females are immediately inseminated. Details of egg deposition and egg hatching are shown accelerated. The life cycle from egg hatching to adults is briefly documented. The introduction closes with sequences of mite dispersal on firm webbing strands and the formation of massive aggregations when food sources are depleted.

Sequences of the foraging behaviour of *Phytoseiulus persimilis* Athias-Henriot (Acari: Phytoseiidae), the first predator presented, show how females locate prey and ingest food from eggs and captured mobile stages. A short sequence of the complex mating behaviour precedes a longer sequence, which demonstrates in detail how a female deposits its large egg. Further documentations of the life cycle include egg hatching, ecdysis processes and the predatory behaviour of proto- and deutonymphs. The foraging and feeding activities of another predatory mite, *Amblyseius californicus* McGregor (Acari: Phytoseiidae), are briefly demonstrated.

The tiny ladybird beetle *Stethorus punctillum* Weise (Coleoptera: Coccinellidae) has recently gained special attention as it also effectively controls the carmine spider mite *Tetranychus cinnabarinus* (Boisduval) (Acarina: Tetranycidae), against which *P. persimilis* is apparently not as effective as against *T. urticae*. Sequences of the predatory behaviour of *S. punctillum* show how adults and larvae feed upon eggs and mobile stages of both *Tetranychus* species. Adult beetles hunt for prey and then devour it completely, whereas repeated regurgitation is required for larvae to feed on captured mobile stages. *Tetranychus* eggs are sucked out within a few seconds by adult and older larval instars. Short sequences of the life cycle show the following features: mating behaviour, egg deposition, hatching from eggs, ecdysis, pupation and adult emergence from the pupa.

The larvae of the predatory gall midge *Feltiella acarisuga* (Vallot) (Diptera: Cecidomyiidae) usually stay immobile within dense *T. urticae* populations, where they wait for prey that is seized by sudden head movements. Sticky excretions glue the legs to the tiny mouthparts, by means of which paralysing substances are obviously injected before the contents of the prey are sucked out by a continuous and very rapid pharyngeal pumping action. Locomotion is required for predation upon eggs that are emptied within a short time by older larval instars. Newly hatched larvae require several hours to consume eggs completely. Older *F. acarisuga* larvae are well adapted to move on spider mite webs, where they show their typical ambush behaviour. Sequences of the life cycle document pupation and the emergence of a male midge from the pupa.

The film terminates with sequences of the predatory behaviour of the bug *Macrolophus caliginosus* (Wagner) (Heteroptera: Miridae), which is well adapted to forage in mite webbings, although frequent grooming is then necessary. Preferred food sources are eggs, which are located accidentally by random proboscis probings and are then emptied within a few seconds by adult bugs.

No Designated Session Theme

INDUCED PLANT RESISTANCE AND INSECT FEEDING BEHAVIOR: A COMPARISON BETWEEN A CHEWING AND A PIERCING-SUCKING INSECT

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Laboratory experiments were done to compare the effects of plant growth promoting rhizobacteria (PGPR), an elicitor of induced systemic resistance (ISR), and ActigardÔ, an elicitor of systemic acquired resistance (SAR), and combinations on feeding behavior of cucumber beetles (Coleoptera: Chrysomelidae) and aphids (Hemiptera). Results of cage experiments with cucumber indicated that cucumber beetle feeding was significantly greater on ActigardÔ-treated plants than on untreated control plants. However, the combination of PGPR plus ActigardÔ resulted in significantly lower feeding damage than occurred with ActigardÔ alone; suggesting that simultaneous induction of ISR by PGPR mitigated the stimulatory effect of ActigardÔ. Additional experiments to compare PGPR and ActigardÔ treatment effects on aphid feeding behavior were conducted using electronic monitoring of insect feeding (EMIF) techniques. Results of the EMIF experiments indicated that aphids feeding on cucumber plants where SAR was elicited by ActigardÔ exhibited an increased number of stylet probes and spent less time in phloem than aphids on untreated plants. As in the cucumber experiments, simultaneous induction of ISR by PGPR (in the combination treatments) mitigated this effect.

No Designated Session Theme

BIOLOGICAL CONTROL OF CASSAVA GREEN MITE IN THE HIGHLANDS OF CAMEROON - TESTING THE LIMITS OF A NEOTROPICAL PREDATOR

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Typhlodromalus aripo (DeLeon) (Acari: Phytoseiidae) is a neotropical predator which was first introduced into Africa in 1993 for the control of cassava green mite *Mononychellus tanajoa* (Bondar) (Acari: Tetranychidae). At present, *T. aripo* is established in 20 countries of sub-Saharan Africa. But the predator has been slow in colonizing and establishing in mid-altitude and highland regions (>1100 m asl) of the higher latitudes (> 4°N), which are climatically less favourable areas with cooler temperatures and more pronounced dry seasons. In our field release study, we tested a strain adapted to the mid-altitudes (Minas Gerais-Brazil) and compared it to the earlier released lowland strain (Piritiba-Brazil), in both the mid-altitude and the lowland ecology. Seeing that *T. aripo* prefers some cassava cultivars over others, we introduced two varieties which were new to the area, and compared their ability to host the predators to the local varieties. The predators were released in planted cassava fields in various habitats such as mid-altitude and low-altitude climates, savannah hill slopes, compound surroundings and riparian forests. The fields were monitored monthly, over two cassava cropping cycles (16 months per cycle).

We found that, unlike in other regions of sub-Saharan Africa, *M. tanajoa* populations peaked at the end of the dry season (or shortly after the beginning of the wet season) and not shortly after the onset of the dry season. At the same time, predator abundance dropped to very low levels in the dry season, and recovered only four to eight weeks after the beginning of the rainy season. Despite the asynchrony with its prey, *T. aripo* was able to persist in both lower and higher altitudes for more than one year, most probably because of its ability to develop on alternative food (e.g., grass pollens and extrafoliar exudates). The great challenge for the predator's long term persistence in the mid-altitudes, however, was crop harvest: T.aripo did not spread to neighbouring fields, and wasn't able to persist beyond one cropping cycle. This is different to the lower altitudes where *T. aripo* spread and persisted for more than one cropping cycle. No differences were found between the two strains, regardless of altitude. Humid and fertile habitats such as fields near compounds promote vigorous plant growth and higher plant turgidity which facilitate the persistence of *T. aripo* longer into the dry season. Further, the more extreme the climatic conditions (e.g. in savannah hills in the mid-altitudes), the more important were host plants preferred by T.aripo (featuring hairy apexes) for its survival. With the help of hairy varieties, and over-seasoning pools in fertile habitats nearby, it might be possible to establish *T. aripo* in these difficult environments, which are typical for cassava growing areas. But effectiveness of *T. aripo* to control cassava green mite in mid-altitude areas of higher latitudes is doubtful, because of its asynchronous cycle with the pest mite, and because of its low dispersal capacity in those environments.