P-1 Influence of Constant Temperatures on The Development, and Reproductive potential of The Ladybird Beetle, *Coccinella undecimpunctata* L (Coleoptera : Coccinellidae)

M. A. A. ABDEL-RAHMAN
Plant Protection Research Institute, Agricultural Research center, Egypt

Development and reproductive potential of the ladybird beetle, *Coccinella undecimpunctata* L. feed on cereal aphids as preys were studied at constant temperatures of 20º, 25º and 30ºC. Temperatures ranged from 25º to 30ºC were found to be the most favorable temperatures for the development and multiplication of this predator. Threshold temperatures (t_0) of 10.62º, 12.25º, and 8.61 ºC were calculated for the egg, larval and pupal stages, respectively. Based on these thresholds the stages respectively needed about 40.69, 114.09 and 107.21 day-degrees to complete their development. Thermal units required to develop one generation of this predator was about 256.58 day-degrees using 11.02 ºC as a base temperature. Net reproductive rate (R_0), mean generation time (GT), population doubling time (DT), intrinsic (r_m) and finite (λ) rate of increase of the predator were also calculated and discussed.

P-2 Parasitism of two parasitoids, *Anagyrus subalbipes* Ishii (Hymenoptera: Encyrtidae) and *Allotropa citri* Muesebeck (Hymenoptera: Platygastridae) on three mealybug species

T. ARAI
Department of Citrus Research, Kuchinotsu, National Institute of Fruit Tree Science; Kuchinotsu, Nagasaki 859-2501, Japan
Present address: Department of Apple Research, NIFTS; 92-24 Nabeyashiki, Shimokuriyagawa, Morioka, Iwate 020-0123, Japan

The parasitism of *Anagyrus subalbipes* and *Allotropa citri*, which were important natural enemies of *Pseudococcus cryptus*, on three mealybug species, *P. cryptus*, *Planococcus kraunhiae* and *Planococcus citri*, were investigated. *A. subalbipes* could parasitize all the developmental stages of *P. cryptus*. It was considered that the third instar nymphs and adult females of *P. cryptus* were suitable host stages for *A. subalbipes*. This parasitoid could parasitize the first and second instar nymphs of *P. kraunhiae* and *P. citri*, although few *A. subalbipes* could parasitize the third instar nymphs and adult females of *P. kraunhiae*, and this parasitoid could not parasitize the third instar nymphs and adult females of *P. citri*. *A. citri* could parasitize all the stages of three mealybug species. The percentage parasitism of this parasitoid on the first and second instar nymphs of three mealybug species was higher than those on the third instar nymphs and adult females. The percentage parasitism of *A. citri* on *P. citri* was lower than that of *P. cryptus*, and the survival rate of this parasitoid mummies on *P. kraunhiae* nymphs were lower than that on *P. cryptus*. It was considered that *A. subalbipes* and *A. citri* could parasitize *P. kraunhiae* and *P. citri*, although these mealybugs were not as suitable host as *P. cryptus* for these parasitoids.

P-3 Potential of *Cybocephalus binotatus* Grouvelle for Biological Control of Cycad Scale *Aulacaspis yasumatsui* Takagi, in Taiwan

R. BAILEY

Department of Tropical Agriculture and International Cooperation,National Pingtung University of Science and Technology,1Hseuh-Fu Road, Neipu Hsiang,Pingtung, Taiwan, Taiwan ROC. 91201

The armored scale, *Aulacaspis yasumatsui* Takagi was described from specimens collected on a *Cycas* species by Dr. Keizo Yasumatsui in 1972 in Bangkok, Thailand (Takagi, 1977). These specimens were collected as part of a field survey funded by the Ministry of Education and Japanese Government on the biological control of rice stem-borers, aphids, diaspine scales and phytophagous mites in South East Asia. In 1996, severe infestations of *A.yasumatsu*i were discovered on *Cycas* species at Montgomery Foundation in Southern Florida, which contains one of the largest and finest collections of palms and cycads in the world. Since then this pest has spread to most of Florida. It has also been found in other countries such as Cayman Islands, St.John, Hawaii and Hong Kong. The cycad scale, *Aulacaspis yasumatsui* is now a pest in Taiwan, affecting mainly an indigenous species of cycad, *Cycas taitungensis* and causing a major threat to a cycad protected area. Two natural enemies, namely, a predatory beetle, *Cybocephalus binotatus* Grouvelle and a parasitoid, *Coccobius fulvus* have been identified in Thailand and have been used successfully in Florida for biological control of the cycad scale. This research includes a field survey to determine the extent of infestation in the field and to identify natural enemies of this scale in Taiwan. The predator *Cybocehalus binotatus* Grouvelle is the main focus for biological control of the scale. The *C.binotatus* has been imported from its native Thailand to the "National Pingtung University of Science and Technology" quarantine laboratory where it is screened. The investigation is being carried out to determine important biological parameters such as Life Table and Life History, Fecundity, Sex ratio and Longevity as well as ecological factors such as predation differences between male and female beetles, functional responses, interference and selective efficiency, which will contribute to a better understanding of the beetles' dispersion in different geographical and climatic regions of Taiwan as well as their value as biological agents against the cycad scale, *Aulacaspis yasumatsui.*

P-4 Biology and Functional response of aphid parasitoid, *Aphelinus asychis* Walker (Chalcidoidea: Aphelinidae) in the Laboratory

Y. W. BYEON, J. H. KIM and Y. H. KIM

Applied Entomology Division, National Institute of Agricultural Science & Technology, Suwon 441-707, Republic of Korea

Experiments were conducted to investigate biology including type of reproduction, oviposition, host feeding , age-specific survival rate and effect of temperature on development and functional response of indigenous aphid parasitoid, *Aphelinus asychis* Walker in Korea. Reproduction of *A. asychis* was haploid-diploid deuterotokous parthenogenesis. Male and mated female survived 8.2±1.7 (n=12) and 21.3±3.2 (n=12), respectively. *A. asychis* initiated oviposition and host feeding after emergence and laid 373.0±22.0 eggs and fed on 83.0±10.0 aphids in her life span. Peak age-specific fecundity (24.8 eggs per day) and host feeding (5.2 aphids per day) was observed on fifth day and declined gradually thereafter. No significant correlation was found between pupal mortality and temperature for *A. asychis*. Mean development time of *A. asychis* from oviposition to adult emergence when reared on *A. gossypii* under constant 25℃ was 13.2 and 13.9 days for male and female, respectively and significantly different at eight constant temperature. The functional response of *A. asychis* in relation to *Myzus persicae* Sulzer and *Macrosiphum euphorbiae* (Thomas) was examined in a simplified eggplant leaf arena under laboratory condition. 2nd or 3rd-instar aphids were isolated individually and maintained to emit chemical cue for parasitoid ovipositon for 24h with different host densities (5, 10, 20, 30, 50, 80 aphids) at 25℃, a photoperiod of 16:8 (L:D). The number of host parasitized by the parasitoid for 24h was checked at mummification. *A. asychis* showed a Type II functional response. Based on the random equation (Royama (1971) and Rogers (1972)), estimated attack rate of *A. asychis* to *M. persicae* and *M euphorbiae* were 0.1714 and 0.1189h, estimated handling times were 0.8467 and 0.8019h, respectively.

P-5 Screening and selection of entomopathogenic fungi for management of cabbage aphid, *Brevicoryne brassicae* (Homoptera: Aphididae)

A. DERAKHSHAN[1], R.J. RABINDRA[2] and B. RAMANUJAM[2]

[1]Department of Entomology, University of Agricultural Sciences, Bangalore, India

2Project Directorate of Biological Control (PDBC),Bangalore, India

The virulence of 25 isolates of entomopathogenic hyphomycetes consisting of ten of Baeuveria bassiana, seven of Verticillium lecanii, five of Metarhizium anisopliae, two of Nomuraea rileyi and one Paecilomyces fumosoroseus originating from a wide range of insect species was investigated in laboratory bioassays on cabbage aphid, Brevicoryne brassicae, at different regimes of temperature (20,25,30^{o}C) and relative humidity (75,85,90, and 95 %).All the isolates of the fungi except N.rileyi isolates were pathogenic to the aphid, but in varying degrees. At 90% RH and 25^{0}C two isolates of V.lecanii (Vl-6 and Vl-7) and P.fomosoroseus caused 100% mortality followed by M.anisopliae (Ma-1) and B.bassianae (Bb-2) with 96.65 and 91.65 % mortality respectively .At 30^{o}C and 75 % RH (Closed to field condition)V.lecanii isolate Vl-7 caused the highest mortality (71.15%) followed by V.lecanii isolate Vl-6 and Vl-1, P.fomosoroseus and B.bassiana (Bb-2) with 55.76,51.91,46.14 and 40.37 % mortality respectively. The virulence of V.lecanii isolate Vl-7 was significantly higher than the other species of fungi. Based on these results, V.lecanii isolate Vl-7 has been selected for further investigation on mass production, formulation, shelf life and safety tests.

P-6 Temporal variation in the complex of pupal parasitoids of *Coccinella septempunctata*

A. HONEK and Z. MARTINKOVA

Research Institute of Crop Production, Drnovska 507, CZ 16106 Praha 6 - Ruzyne, Czech Republic

In the Czech Republic abundance of *C. septempunctata* dramatically decreased since the mid 1990s. An increased parasitation was hypothesized among causes of this change. Pupa, the stage particularly vulnerable to parasitism, is attacked by several Hymenoptera and Diptera species. The occurrence of these parasitoids was recorded at Prague, in maize stands grown for three years at the same site. The abundance of parasitoids varied between years. It was high in 2002 when dominant parasitoid was *Phalacrotophora fasciata* (Fallén) (Diptera, Phoridae), and in 2004 when dominant species was *Tetrastichus coccinellae* Kurdjumov (Hymenoptera, Eulophidae). Other species, *Homalotylus* spp. (Hymenoptera, Encyrtidae) and *Dinocampus coccinellae* (Schrank) (Hymenoptera, Braconidae) were rare. In 2003 the abundance of parasitoids was low. Proportions of parasitised pupae in samples collected from other crops (sugar beet, cereals) were similar to samples collected from maize. Since parasitoid development was longer than that of coccinellid pupae, proportion od parasitised pupae at the end of the period of *C. septempunctata* pupation was apparently greater than at its beginning. In all years, the total proportion of parasitised pupae was low and could hardly affect *C. septempunctata* abundance. Supported by grants 0002700603 of MZe and 522/05/0765 of GACR.

P-7 A simple mass-rearing method for predaceous *Orius* bugs (Heteroptera: Anthocoridae) in the laboratory

K. ITO

National Agricultural Research Center for Hokkaido Region, 1 Hitsujigaoka, Sapporo, Hokkaido 062-8555, Japan

Orius species are known as valuable predaceous natural enemies of agricultural arthropod pests including aphids. Several species of *Orius* bugs have come onto the market as biocontrol agents. It is important now to study the judicious use of these biocontrol agents in the greenhouse, as well as the efficacy of indigenous populations of *Orius* bugs as native predators against pests in the field. To elucidate such subjects, simple mass-rearing in the laboratory should be the first consideration. Though *Orius* bugs are successfully bred on eggs of the Mediterranean flower moth, *Ephestia kuehniella,* as an alternative food, cannibalism in rearing cages under crowded conditions is a problem.

Orius strigicollis and *O. laevigatus* were reared successfully using a common plastic Petri dish (90mm in diameter, 20mm in depth) as a rearing cage with wheat grains to avoid cannibalism and excessive moisture. Frozen eggs of *E. kuehniella* were supplied as food and a soybean seedling with a piece of water-soaked cotton was provided as an oviposition substrate. The adult emergence rate was 74 -87% on average when the initial nymphal density was 100 – 400. A maximum of 521 adults emerged in *O. strigicollis* and 735 adults in *O. laevigatus* using this cage. In addition to the high breeding capacity, these insects were able to be separated without difficulty from wheat grains by using a suitable sieve, and wheat grains were reusable after sterilization in an oven. These mass-reared *Orius* bugs could be used for biological and physiological studies in the laboratory, such as investigating their susceptibility to insecticides.

P-8 Development of artificial diets for two aphidophagous syrphids, *Episyrphus balteatus and Eupeodes frequens* (Diptera: Syrphidae)

H. IWAI and K. NIIJIMA

Division of Applied Entomology & Zoology, Faculty of Agriculture, Tamagawa University, Machida City, Tokyo 194-8610, Japan

The larvae of hoverflies are important biological control agents for various aphid species. Mass production of them is indispensable for the practical use. Many commercial production systems use natural or substitute living prey, such as aphids or lepidopteran eggs, but they are very expensive. This study examined artificial diets and feeding methods for rearing the two common Japanese syrphids, *Episyrphus balteatus* and *Eupeodes frequens,* which are promising biological control agents.

Lyophilized and pulverized drone honeybee brood (drone powder: DP) is a well-known and excellent substitute diet for rearing some aphidophagous insects, such as coccinellids and chrysopids. We found that DP was useful as a substitute diet for *E. balteatus.* However, although the pupation rate reached about 70%, the emergence rate was only about 20%, and there was some deterioration in larval period and body size. On the other hand, all *E. frequens* larvae died when fed on this diet alone. Feeding on aphid powder yielded the same result, so the diet physical properties were improved by gelatinization. An agar-gel diet composed of DP (20%−50%) successfully sustained all larval stages and the pupation rate was about 50%. Addition of sucrose and autolyzed yeast to the gelatinized diet improved the pupation rate to 70%, although the emergence ratio was 23.5%. However, the larval period and adult body size were inferior to the period and size of individuals fed on aphids.

These results suggest that DP provides the minimum nutrients necessary for larval development of these two syrphids and that addition of some low-cost ingredients would improve the emergence ratio while reducing the diet cost.

P-9 Does nitrogen limitation promote intraguild predation in an aphidophagous ladybird ?

H. KAGATA and N. KATAYAMA
Center for Ecological Research, Kyoto University, Hirano 2-chome, Otsu, Shiga 520-2113, Japan

Intraguild predation occurs between the two aphidophagous ladybirds *Coccinella septempunctata* L. and *Harmonia axyridis* (Pallas). However, its direction is asymmetrical; *H. axyridis* generally acts as an intraguild predator, and *C. septempunctata* as intraguild prey. According to Denno and Fagan (2003), who predicted that nitrogen shortages in predators may promote intraguild predation, it was hypothesized that growth of intraguild predator *H. axyridis* is more limited by nitrogen than that of intraguild prey *C. septempunctata*, and that *H. axyridis* growth is enhanced by feeding on *C. septempunctata*, comparing to feeding on aphids. First, it was predicted that the nitrogen content of *H. axyridis* is higher than that of *C. septempunctata*, when both feed on aphids. However, nitrogen content did not differ between the two ladybirds. Second, it was predicted that nitrogen use efficiency of *H. axyridis* is lower than that of *C. septempunctata*. However, it was rather high in *H. axyridis* for third instar larvae, and there was no significant difference between species for fourth instar larvae. In addition, the present study found that growth of *H. axyridis* was not enhanced, but rather decreased, by eating high-nitrogen *C. septempunctata*, compared to eating low-nitrogen aphids. Thus, the present study showed that strong intraguild predation in *H. axyridis* cannot be explained by nitrogen limitation.

P-10 How do bodyguard effects on aphids differ among ant species?: the mechanisms that determine the mutualistic effects

N. KATAYAMA[1] and N. SUZUKI[2]
[1]*Center for Ecological Research, Kyoto University, Hirano-cyo 2-509-3, Otsu 520-2113, JAPAN*
[2]*Department of Applied Biological Sciences, Faculty of Agriculture, Saga University; Honjo 1, Saga 840-8502, JAPAN*

Aphids provide ants their honeydew, and the ants protect them from natural enemies. However, behavioral patterns differ among ant species, so it is necessary to analyze ant behavior on a plant parasitizing aphids to understand the mechanisms that determine this mutualistic effect. We carried out laboratory experiments to clarify the bodyguard effects on the aphid, *Aphis craccivora*, against a predatory larva of the ladybeetle, *Coccinella septempunctata*, by two ant species, *Tetramorium tsushimae* and *Lasius japonicus*. *L. japonicus* was a superior mutualistic partner of *A. craccivora* to *T. tsushimae*. Therefore, in particular, we compared foraging and aggressive behaviors of the two ant species in relation to the number of ants on the plant, and discussed how these ant behaviors contribute to the difference in bodyguard effects on aphids.

One hundred individuals of aphids were placed on a seedling of broad bean. Each of ant species was colonized in test tubes, and the entrance of the nest was set near the base of the seedling. About 90 min after the setting of the ant nest, a fourth instar larva of *C. septempunctata* was released on the top of the plant. Until the ladybeetle larva was dropped from the plant, the number of attacks on it by ants did not differ between ant species. Therefore, the two ant species could exclude a predator with similar probabilities when they attack it (i.e. similar success rates of predator exclusion per attack). However, the number of attacks per min by *L. japonicus* was five times greater than that by *T. tsushimae*. Thus, the encounter rate between ants and predators is one of the most important factors for bodyguard effect on aphids, resulting from the markedly different foraging behaviors of the two ant species. Furthermore, we found that there was not only a positive correlation between the number of ants on a plant and the encounter rate of ants with a predator per min, but also a positive correlation between the number of ants and the ant attack rate on the predator. *L. japonicus* became to more frequently encounter a predator and to be more aggressive against it by increasing the number of ants than *T. tsushimae*. Based on these data, we show that an ant-bodyguard effect on aphids can increase rapidly when the number of ants on a plant attains a certain level. We also argue that this level, however, should vary among ant species that show different foraging styles.

P-11 Comparative biology of *Anagyrus fujikona* and *Allotropa subclavata*, parasitoids of the Japanese mealybug, *Planococcus kraunhiae*

K. KAWANO[1], R. INOUE[1], T. TSUTSUMI[2], M. TESHIBA[2] and M. TAKAGI[3]
[1]*Institute of Biological control, Kyushu University, Fukuoka, Fukuoka 812-8581, Japan*
[2]*Fukuoka Agricultural Research Center, Chikushino, Fukuoka 818-8549, Japan*
[3]*Faculty of Agriculture, Kyushu University, Fukuoka, Fukuoka 812-8581, Japan*

Two species of parasitoids, *Anagyrus fujikona* and *Allotropa subclavata* attack effectively the Japanese mealybug, *Planococcus kraunhiae* which is a key persimmon pest in Japan. We studied biology of these parasitoids to assess their potentials as natural enemies of the mealybug. *Anagyrus fujikona* produced mature eggs gradually after emergence and oviposited for a long time (synovigenic species), wherea *A. subclavata* had many mature eggs when emergence and oviposited intensively for a short time (proovigenic species). The mean longevity of adult females of *A. fujikona* is longer than that of *A. subclavata* and the mean number of eggs deposited of *A. fujikona female* is smaller than that of *A. subclavata* . In addition, *A. fujikona* attacked first instar larvae, second instar lavae, third instar larvae and adults of the mealybug. This parasitoid oviposited preferentially first and second instar larvae, and host-fed third instar larvae and adults. On the other hand, *A. subclavata* oviposited preferentially first instar larvae and second instar larvae. The net reproductive rate of *A. fujikona* was lower than that of *A. subclavata* and the intrinsic rate of natural increase of *A. fujikona* was higher than that of *A. subclavata*. These results suggested that this Japanase mealybugs could be controled effectively by the combination of conservation *A. fujikona* and inoculative release of *A. subclavata*.

P-12 Life table parameters of the pseudococcids' predators *Nephus includens* (Kirsch) and *Nephus bisignatus* (Boheman) (Coleoptera: Coccinellidae)

D. C. KONTODIMAS[1], P. G. MILONAS[1], G. J. STATHAS[1], L. P. ECONOMOU[2] and N. G. KAVALLIERATOS[1]
1. Benaki Phytopathological Institute, St. Delta 8, 145 65, Kifissia, Greece,
2. Technological Educational Institute of Kalamata, 24 100, Antikalamos, Greece
3. Agricultural University of Athens, 75 Iera Odos str., 118 55, Votanikos, Athens, Greece

The fecundity of the pseudococcids' predators *Nephus includens* and *N. bisignatus* was studied under several constant temperatures: 15, 20, 25, 30, 32.5 and 35°C (relative humidity: 65%, photoperiod: 16h light / 8h dark, on *Planococcus citri* Risso, Hemiptera: Pseudococcidae). With additional data from the development of the immature stages, the life-fecundity tables and the development matrices (Leslie matrices) were constructed and some population parameters were calculated. The average total fecundities of *N. includens* in the above temperatures were 49.2, 97.8, 162.8, 108.5, 87.4 and 31.1 eggs / female respectively and the average longevities were 99.5, 84.7, 69.5, 61.1, 49.6 and 30.1 days respectively. The net reproductive rates (R_o) were evaluated 8.0, 32.2, 60.7, 32.6, 20.7 and 2.6 females/female respectively and the intrinsic rates of increase (r_m) were 0.014, 0.041, 0.083, 0.086, 0.077 and 0.024 females/female/day respectively. The average total fecundities of *N. bisignatus* at 15, 20, 25, 30 and 32.5 °C were 54.7, 72.1, 96.9, 56.0 and 22.8 eggs / female respectively and the average longevities were116.1, 108.7, 71.8, 68.8 and 43.7 days respectively. The net reproductive rates (R_o) were evaluated 13.9, 26.4, 31.3, 15.2 and 3.6 females/female respectively and the intrinsic rates of increase (r_m) were 0.017, 0.035, 0.060, 0.051 and 0.024 females/female/day respectively. The survival of the females at each temperature was fitted with Weibull distribution [$S_{(t)} = e^{-\left(\frac{t}{b}\right)^c}$]. Furthermore, four mathematical models [Enkegaard equation: $F = (a + b \cdot x) \cdot e^{-(c+d \cdot x)}$, Analytis equation: $F = a \cdot (x - x_{min})^n \cdot (x_{max} - x)^m$, Bieri-1 equation: $F = a \cdot (x - x_{max}) - b^{(x - x_{min})}$ and Bieri-2 equation: $x = \frac{a \cdot (x - x_{min})}{b^{(x - x_{min})}}$] were fitted with the fecundity data.

P-13 The effects of a predatory ladybird, *Harmonia axyridis* Pallas, on abundance of five species of hoverfly larvae on hibiscus trees

K. KUSHIBUCHI and H. YASUDA
Faculty of Agriculture, Yamagata University, Yamagata 997-8555, Japan

In Yamagata, Japan, a predatory ladybird species, *Harmonia axyridis* Pallas, other species of ladybirds, hoverfly and spiders, exploit colonies of cotton aphid, *Aphis gossypii*, and form an aphid predator guild during from middle of May to early July. To determine the effect of *H. axyridis* on abundances of aphids and five species of hoverfly larvae in particular on hibiscus trees field experiments were conducted. Our experimental treatments were (1) all aphid predators were present (control treatment), (2) no *H. axyridis* was present due to removing the eggs of this species. In addition, (3) third treatment, 90 individuals of second instars of *H. axyridis* were released on each tree after aphids increased, while the eggs of this species were removed through the experiments, was also conducted to reveal the effect of *H. axyridis* on the abundance of the hoverfly species. In general, *A. gossypii* significantly decreased in its abundance when third and fourth instars of *H. axyridis* were present. In addition, the effects of *H. axyridis* on abundance of hoverfly larvae tended to differ among hoverfly species and its mechanism showing different pattern in terms of the abundance is discussed.

P-14 Assessment of patch quality in ladybirds' guild : role of larval tracks

A. MAGRO[1], A.F.G DIXON[2], N. BASTIN[1]and J-L. HEMPTINNE[1]
[1] *Laboratoire d'Agroécologie, Ecole Nationale de Formation Agronomique, 2 route de Narbonne, BP 22687 Auzeville Tolosane, 31326 Castanet cedex, France*
[2] *School of Biological Sciences, University of East Anglia, Norwich NR4 7TJ, United Kingdom*

Aphid colonies last for relatively short periods of time and rapidly change in abundance. Larvae of aphidophagous ladybirds that have been oviposited in a patch are therefore exposed to starvation (when aphids are sparse at the first and late stages of a colony or due to competition), cannibalism and eventually intraguild predation.
In order to maximise their fitness, a female should be able to assess the quality of patches in terms of their potential to sustain the development of their larvae, and lay eggs or refrain from ovipositing accordingly.
After Dixon (1959), females first lay eggs in a colony when first instar aphids are abundant enough for the vulnerable fist-instar larvae to catch sufficient prey to sustain their development. In what concerns the "closing of the oviposition window", it occurs when females detect tracks deposited by conspecific larvae. This is the case with females of *Adalia bipunctata* and *Coccinella septempunctata* (Hemptinne *et al,* 1992; Doumbia *et al.,* 1998).
Honek (1985) shows that there are some overlap in the habitat preference of ladybird. Therefore, in order to maximise their fitness females of one species should refrain from laying eggs in the presence of tracks deposited by heterospecific larvae. However, the first data available (Hemptinne *et al,* 1992; Doumbia *et al.,* 1998) do not support this prediction.
In the present work we analyse the oviposition reaction of females of 3 species - *A. bipunctata, Adalia decempunctata* and *C. septempunctata* - in the presence of each others larval tracks. These species have different percentage of niches overlap; our hypothesis is that females should react more strongly to larval tracks of individuals from the species they are more likely to meet. From this study, it appears that females from the 3 species are reluctant to oviposit in the presence of heterospecific larval tracks.

P-15 Nutrition, body size and egg load in *Coccinella septempunctata*

Z. MARTINKOVA and A. HONEK
Research Institute of Crop Production, Drnovska 507, CZ 16106 Praha 6 - Ruzyne, Czech Republic

Egg load measured as instantaneous potential fecundity (number of eggs available for oviposition within the next 24 h) is determined by several factors. The effects of female age, body size and nutrition were studied in *C. septempunctata*. Females collected in different crop or wild plant stands on several dates were allowed to lay eggs for 24 h, under conditions that forced them to deposit all available eggs. The number and mass of eggs and the residual mass of the females were determined. The number of deposited eggs was significantly positively correlated with the female mass. In cereal stands the slope of fecundity vs. female body mass regression was not affected by female age (within 15 days of oviposition period) or prey availability (abundance of aphids). However, the slope of fecundity vs. mass regression was significantly lower in a sample of females collected on host plant stands populated by a rejected prey (*Uroleucon* spp.). The body mass vs. fecundity relationship is thus significantly affected by food quality. The proportion of females not laying eggs increased after feeding the rejected prey and with female age. Supported by grants 0002700603 of MZe and 522/05/0765 of GACR.

P-16 Use of Game theory for the study of the oviposition deterring pheromone's evolution

X. MARTINI and J-L. HEMPTINNE
Laboratoire d'Agro-Ecologie. École nationale de formation agronomique BP 22687, F-31326 Castanet Tolosan Cedex France.

Use of chemical messengers is common in predator and parasitoïde insects. In *Adalia bipunctata* (L.) an oviposition deterring pheromone (ODP) is produced by larvae (Doumbia et al. 1998). Larvae have a small capacity of movement, so they must grow in the patch their mother chose. Consequently, chronology of lying in a patch should influence larvae's survival. Females must avoid laying in a patch, which contains older larvae.
However, for the first larvae, the presence of youngest larvae may be an advantage in case of aphids become scarce because they are another food resource.
When two females convoy a laying site, fitness of their larvae, and by extension, their own fitness will depend of the comportment of each other's competitor. That's why, for studding evolution of oviposition deterring pheromone in aphidophagous ladybirds, we tried to use Maynard-Smith's game theory (1982).
A simple model is studied: supply is the egg-laying site. Two gravid females, who had two distinct strategies, convoy it: one uses oviposition deterring pheromone, the other not. We study the two scenarios that are likely to describe the majority of cases where marking pheromone systems have evolved (Roitberg and Mangel 1988). In the first, we consider that all larvae produced ODP, but only mutant females recognise it. In the second scenario, we consider "double mutants" who have the ability to both mark when they are at larval stage and recognize marks when they are adult.
Finally, the model has two predictions:

(i) Larvae do not have an advantage to be recognised by females, so ODP must have an indispensable role in the biology of larvae.

(ii) The system with ODP produced by larvae is advantageous if the benefits on larvae's survival outweigh the costs of food lost by the youngest larvae.

P-17 Rapid change in settling behavior of the scale stabilized host-parasitoids interaction

T. MATSUMOTO[1], T ITIOKA[1]and T NISHIDA[2]
[1]*Grad. School of Human and Environmental Studies, Kyoto Univ. 606-8501, Japan*, [2] *Grad. School of Agriculture, Kyoto Univ. 606-8502, Japan*

Fitness of sessile herbivore greatly depends on where they settle. We examined whether selection pressure by parasitoids affect the settling behavior of the arrowhead scale *Unaspis yanonensis* Kuwana in the field. We used the following four methods: a comparison of parasitism risk in different settling behaviors; a comparison of the settling behavior between before and after parasitoid introduction; a comparison of the settling behavior between parasitoid-present and parasitoid-free populations; and a laboratory observation of the settling behavior of the first instars derived from the two population categories. In parasitoid-introduced population, some proportion of individuals concealed themselves and settled under another individual. These individuals (defined as crawler) increased in number following to the parasitoid introduction and more successfully escaped the parasitism. While in the parasioids-free populations, few settled in such a place. First instars from parasitoid-present population settled under conspecific more frequently than those from parasitoid-absent population under parasitoid-free condition. Mortality and developmental rate of the crawler were higher and slower under parasitoid-free condition. These results strongly suggest that the arrowhead scale has rapidly changed their settling site in order to avoid the parasitoids attack. Further, we will discuss the possibility that the rapid change of the settling behavior affect host-parasitoid interaction.

P-18 Biological of Red Coconut Scale, *Furcaspis oceanica* Lindinger (Hemiptera: Diaspididae) in Micronesia

R. MUNIAPPAN and G.V.P. REDDY
Agricultural Experiment Station, University of Guam, Mangilao, Guam 96923, U.S.A.

The red coconut scale (RCS), *Furcaspis oceanica* Lindinger (Hemiptera: Diaspididae) is an endemic species in the Caroline Islands of Micronesia, where its population is kept at a low level by the parasitoid, *Adelencyrtus oceanicus* Doutt (Hymenoptera: Encyrtidae). During the World War II, this scale insect got introduced to Saipan in the Marianas Islands. The parasitoid, *A. oceanicus* was collected from Yap and Palau islands in the West Carolines and released in Saipan in September and November 1948. No follow up work was carried out after the introduction of the parasitoid, however, a survey carried out in 1954 reported that the parasitoid was not established. In 1987 one of the authors (RM) conducted a survey in Saipan and found that the parasitoid has well established and it has suppressed the population of RCS very effectively. In the early 1970s RCS got introduced to Guam. The parasitoid, *A. oceanicus* was collected from Yap and Palau and 623 individuals were released in the central part of Guam in 1988-89. The parasitoid has established and it has brought down the population of RCS in Guam in 15 years after the introduction. The spread of RCS and the parasitoid on Guam has been monitored and recorded. The maximum parasitism recorded was 39 % in 1996 and 57 % in 2002. The percent parasitization remained constant at lower and higher densities of the scale population indicating that this parasitoid is density independent. Since RCS population has been effectively suppressed by the parasitoid on Guam and Saipan without the need for additional agents or other control methods.

P-19 How male-killer is maintaining at low infection frequency in the ladybird beetle *Harmonia axyridis*

K. NAKAMURA[1], H. UENO[2] and K. MIURA[1,3]
[1] *Graduate School of Biosphere Sciences, Hiroshima University*
[2] *Faculty of Education and Human Sciences, Niigata University*
[3] *Laboratory of Insect Pest Control, WeNARC*

In two populations in Japan, Fukuyama, Hiroshima, and Muikamachi, Niigata, *Harmonia axyridis* were infected with male-killing bacteria. According to the sequence analysis of the gene fragment for 16S rDNA, these bacteria belong to the genus *Spiroplasma*. Tetracycline treated infected females produced female and male progeny, although untreated females produced only female progeny, demonstrating that *H. axyridis* is male-killed by the *Spiroplasma*. The proportion of females infected in Muikamachi and Fukuyama was 0.039 and 0.135, respectively, indicating that infection frequency of male-killer in *H. axyridis* is low in Japan. Also, vertical transmission efficiencies have been observed to be close to perfect.

The killing of male hosts by the bacteria is thought to be an adaptive bacterial trait because infected female hosts gain in fitness by the death of their brothers due to inbreeding avoidance, reduction of antagonistic sibling interactions, and/or the availability of additional resources. Mathematical models were showed that invasion of a male killer is only possible when both the vertical transmission is imperfect. A perfectly transmitted male killer reaches a frequency in the population of 1, and therefore the population becomes extinct because *H. axyridis* female has to mate with male to breed her offsprings. None of the previous studies can explain the observations of the existence of perfectly transmitted male killer and the maintaining of low frequency of male killer. We have attempted making a lattice model to explain them. We will show that a perfectly transmitted male killer in a spatial setting can invade and maintain at low density without driving the population to extinction.

P-20 Effectiveness of an indigenous aphid parasitoid, *Aphidius gifuensis* as a biological control agent against *Myzus persicae* and *Aulacorthum solani*

I. OHTA and K. HONDA
Laboratory of Entomology, Department of Fruit Vegetables, National Institute of Vegetable and Tea Science, Ano, Mie 514-2392, Japan

Aphidius gifuensis is a primary aphid parasitoid distributed in the East Asia including Japan, China, Korea and Taiwan. *A. gifuensis* is observed frequently as a natural enemy predominantly attacking the green peach aphid, *Myzus persicae* and the foxglobe aphid, *Aulacorthum solani* infesting eggplants, green peppers, and soybeans in domestic fields. In order to show the effectiveness of *A. gifuensis* as a biological control agent for the pest aphids, first of all, we compared the parasitism of *A. gifuensis* for some vegetable aphids in a laboratory. *M. persicae* was most highly parasitized and the next was *A. solani*. Parasitization was observed for the pea aphid, *Acyrthosiphon pisum,* but not for the cotton aphid, *Aphis gossypii* and the potato aphid, *Macrosiphum euphorbiae*. Secondly, life history parameters of *A.gifuensis* were measured at constant temperatures. Developmental periods from egg to adult emergence of the female parasitoids on *M. persicae* were 19.9 days at 15℃, 13.0 days at 20℃, 9.7 days at 25℃ and 10.7 days at 30℃ in average. The males required slight less times to complete their development than the females. The lower developmental threshold and total effective temperature were computed to be 5.5℃ and 188.6 degree-days for the females, 5.7 days and 181.0 degree-days for the males. Total mortalities through the immature stage were less than 20% at the all temperatures tested from 15 to 30℃. A single female adult parasitoid produced 529.0 progenies at 20℃ and 536.7 at 25℃ in average during their life spans. Their longevities were 12.8 and 12.3 days at 20 and 25℃, respectively. Intrinsic rates of natural increase for *A. gifuensis* were calculated as 0.350 at 20℃ and 0.462 at 25℃. These values are higher those for the host aphids, *M. persicae* and *A. solani*, suggesting a significant character of *A. gifuensis* that indicates its great potential for use as a biological control agent for *M. persicae* and *A. solani*.

P-21 Functional and numerical responses of ladybirds in a two-predator system

OMKAR, A. PERVEZ* and A. K. GUPTA
Ladybird Research Laboratory, Department of Zoology, University of Lucknow, Lucknow - 226007 (INDIA)

The functional and numerical responses of two aphidophagous ladybirds, *Propylea dissecta* and *Coccinella transversalis* were studied in a two-predator system in laboratory on aphid, *Aphis gossypii* as prey. One adult ladybird female each species were kept together at various aphid densities (25, 50, 100, 200 and 400) for 24 hours and the above responses in terms of number of prey consumed and mean number of eggs laid were studied. The prey consumption increased curvilinearly from 25.00±0.00 to 263.00±10.24 with prey density from 25 to 400. Individual performances of *P. dissecta* (22.50±1.90 to 130.90±7.98) and *C. transversalis* (25.00±0.00 to 140.40±8.14) in terms of prey consumption were also curvilinear, which supports Holling's Type II model revealing negative density dependent prey consumption. Prey handling time decreased almost six times when both species were jointly employed (1.57 min) than their single performances (*P. dissecta* 9.31 min; *C. transversalis* 9.37 min). This revealed an additive effect of two predators on aphid mortality, which might be due to difference in spatio-temporal distribution of *P. dissecta* and *C. transversalis*, as former is negatively-, while latter is positively geotactic.

The ladybirds when employed together laid 0.00±0.00 to 29.24±0.67 eggs compared to individual performances of *P. dissecta* (16.66±2.29 to 66.16±14.19 eggs) and *C. transversalis* (21.66±2.08 to 81.03±15.20) with increase in aphid density from 25 to 400. The increase in egg production was curvilinear in all three cases supporting the Holling's Type II model. The numerical response in a two-predator system was significantly lower than individual performances, which might be attributed to the adult tracks containing oviposition-deterring pheromones that limit the oviposition. Efficiency of conversion of ingested food (E.C.I.) in *P. dissecta* (0.53±0.09 to 0.36±0.09) and *C. transversalis* (0.53±0.05 to 0.35±0.08) decreases with prey density, which indicates that female probably allocates most energy in egg production at low prey density and in process invests less in maintenance and metabolic activities. The E.C.I. was exceptionally low (0.00±0.000 to 0.07±0.01) in two-predator system than in a single predator system, largely attributed to relatively small experimental arena containing adult tracks as compared to plant structure in field conditions, where a decrease accumulation of adult tracks is expected because of larger exposed arena. The ladybirds understudy have additively brought the prey population down in the closed experimental arena. Thus, duo releases of *P. dissecta* and *C. transversalis* is recommended where there is an urgent need of biocontrol of *A. gossypii*.

P-22 Conservation of native natural enemies of foxglove aphid *Aulacorthum solani* in soybean

T. ONO, T. KIDOKORO and J. OYAMA
Miyagi Prefectural Furukawa Agricultural Experiment Station, Furukawa, Miyagi 989-6227, Japan

In recent years, the foxglove aphid *Aulacorthum solani* has become an important pest of soybean in Miyagi prefecture located in the northeastern part of Japan. In this region, the foxglove aphid has not transmitted a serious viral disease, such as soybean dwarf disease; however, outbreaks of this aphid have been occurring on a large scale in soybean fields from the end of August through the beginning of September. Consequently, the aphid has caused leaf fall in the early stage of soybean growth and resulted in a decrease in yield. Our aim in this study is to understand the mechanism behind the outbreaks and to maintain the foxglove aphid at a low density. First of all, we have investigated the seasonal prevalence of the foxglove aphid and the parasitoids of native natural enemies. The density of parasitoids significantly falls in August and thereafter the density of the foxglove aphid suddenly increases. Therefore, the lack of native natural enemies might be the cause of outbreaks of the aphid. Second, we have intended to conserve the native natural enemies of the foxglove aphid, such as parasitoids and predators. To increase the density of these native natural enemies, we have introduced wheat for the banker plant in the soybean field. Wheat has been introduced partly as a living mulch for weed suppression in soybean fields. In consequence, the native natural enemies of the aphid have immigrated to increase in densities on wheat from June to September and the foxglove aphid has been suppressed to low density as compared with those in the nonliving mulch plot. Our results suggest that the introduction of wheat as a banker plant is effective in the biological control of the foxglove aphid in soybean fields.

P-23 Seasonal prevalence of occurrence of natural enemies on the white peach scale, *Pseudaulacaspis pentagona* (Targioni), in tea fields

A. OZAWA

Shizuoka Tea Experiment Station, Kikugawa, Shizuoka 439-0002, Japan

Species composition and seasonal prevalence of occurrence of natural enemies on the white peach scale, *Pseudaulacaspis pentagona* (Targioni), in tea fields in Shizuoka prefecture of Japan were investigated by monitoring methods using yellow sticky traps hung on tea branches and sex pheromone traps of the scale. Four species of parasitic wasps, *Arrhenophagus chionaspidis*, *Pteroptrix orientalis*, *Thomsonisca typica* and *Anabrolepis lindingaspidis*, and some species of predacious insects, *Pseudoscymnus hareja*, *Chilocorus kuwanae*, *Cybocephalus gibbulus* and Cecidomyiidae (predacious gall midge) in which dominant species was *Dentifibula viburni*, were captured by yellow sticky traps. Primary dominant species of parasitoids was *A. chionaspidis* and secondary dominant parasitoid was *P. orientalis.* Dominant species of predacious beetles was *P. hareja*. Peaks of seasonal prevalence of *A. chionaspidis* adults agreed with the peaks that showed each occurrence of first instar larvae and adult male of *P. pentagona*, and *P. orientalis* occurred some days behind to capture peaks of the host larvae. Although peaks in seasonal prevalence of *P. hareja* adults were not clear, 3 or 4 peaks were observed in a year. Synthetic sex pheromone of *P. pentagona* strongly attracted *Thomsonisca typical* females, and 3 peaks in seasonal prevalence of the parasitoid catches were showed synchronizing with the occurrence of adult males of *P. pentagona* in a year. Number of *T. typical* catches by pheromone traps of *P. pentagona* were from 67.3 to 638.3 times as many as them by blank traps. However number of *P. pentagona* male catches by the pheromone traps were from 1.2 to 10.5 times as many as blank traps, effectiveness of attraction against the scale male was not so high.

P-24 Effects of three species of predatory ladybirds on oviposition preference and larval performance of two species of hoverflies

N. S. PUTRA and H. YASUDA

Faculty of Agriculture, Yamagata University, Tsuruoka, Japan

A couple of laboratory experiments were conducted to determine the impacts of three species of ladybirds, *Harmonia axyridis*, *Propylea japonica*, and *Scymnus posticalis*, on oviposition preference and larval performance of two species of hoverflies, *Episyrphus balteatus* and *Metasyrphus corollae*. In general, egg production of hoverflies were affected adversely when ladybirds were present; e.g. egg production of *E. balteatus* and *M. corollae*, respectively, minimized when *H. axyridis* and *S. posticalis* were present. In addition, larvae of *H. axyridis* were more likely to affect adversely performance of the hoverflies larvae compared with those of the other two ladybird species. Larvae of all species were more likely to affect adversely the two hoverflies species when they were fourth instars. Interaction between two groups of aphidophagous insects, ladybirds and hoverflies, and its mechanism differently affecting the egg production of the two hoverfly species were discussed.

P-25 Classical biological control of the papaya mealybug (*Paracoccus mariginatus*) in Guam and Palau

G.V.P. REDDY and R. MUNIAPPAN
Agricultural Experiment Station, University of Guam, Mangilao, Guam 96923, USA

Guam and Palau are islands located in Micronesia in the North Western Pacific. The papaya mealybug, *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae), a pest in the Central America and the Caribbean was noted to have established on Guam in April 2002 and on Palau in March 2003 was causing serious damage to *Carica papaya*, *Plumeria* spp., *Hibiscus* spp. and other plants. The parasitoids *Anagyrus loecki* Noyes, *Pseudleptomastix mexicana* Noyes and Schauff and *Acerophagous papayae* Noyes and Schauff (Hymenoptera: Encyrtidae) totaling 46,200 individuals were introduced from Puerto Rico into Guam from June to October, 2002. The same parasitoids totaling 24,586 were released in Palau from August 2003 to June 2004. A reduction of below detection level of papaya mealybug was observed in six months after the introduction of these parasitoids both in Guam and Palau. High percentage of parasitism was observed in Guam and Palau. *Anagyrus loecki* and *A. papayae* were the promising biological control agents of papaya mealybug in Guam and Palau. No field recovery of *P. mexicana* was made in spite of the several field releases. In early 2002 and 2003, farmers on Guam and Palau, respectively gave up growing papaya as there were unable to control the papaya mealybug with conventional insecticides. A year after the introduction of the parasitoids, papaya cultivation has become common and homeowners were relieved of their worries over the deformation of the leaves and shoots of *Plumeria* spp. and *Hibiscus* spp. plants. These programs have reduced the risk of introduction of this mealybug to neighboring islands in Micronesia. These two are examples of a technology transfer of a successful biological control program developed in the Caribbean to the Pacific.

P-26 Life history of *Olla v-nigrum* (Coleoptera:Coccinellidae) in Japan

Y. SAKURATANI and Y.TODA
Laboratory of Environmental Ecology, Faculty of Agriculture, Kinki University, Nara 631-8505, Japan

In Japan, *Olla v-nigrum* was first recorded in 1987 in Okinawa Island. This ladybird beetle is an exotic species from North America and preys on psylla which infests an exotic tree, white lead-tree (*Leucaena leucocephala*). This food chain consists of all exotic species in Japan. We studied on the life history of this ladybird beetle on various plants in Okinawa Island and reared under constant temperature of 22.5 ℃ using various preys. The active stage was observed through the year in the field, especially *L. leucocephala* in Okinawa. However, most individuals aestivated in adult stage between overlapped leaves such as tropical almond (*Terminalia catappa*) with large and thick leaves. The ovaries of aestivating female adult did not developed. The microclimate between the leaves was kept to mild condition through the summer. The population density of *O.v-nigrum* was highest in winter and lowest in autumn. On *L. leucocephala* tree, some native ladybird beetle species such as *Menochilus sexmaculatus* were observed in active season and they competed with *O.v-nigrum* about the prey. Recently, some populations of *O. v-nigrum* preying on aphids and psylla were observed on pine tree and *Lagerstroemia indica*. In rearing experiment, *O.v-nigrum* preys on a species of psylla, *Accizia jamatonica*, distributed in most regions of Japan. *O. v-nigrum* may expand its distribution hereafter. and compete with the common native species of ladybird beetle such as *Harmonia axyridis* which appears on silk-tree (*Albizia Julibrissin)* in Japan.

P-27 A mechanism enables two species of aphidophagous ladybirds, *Harmonia axyridis* Pallas and *Coccinella septempunctata* brucki, to co-exist on the same habitat

S. SATO and H. YASUDA
Faculty of Agriculture, Yamagata University, Tsuruoka, Yamagata 997-8555, Japan

Harmonia axyridis Pallas, a recent invasive species of aphidophagous ladybird into USA and Europe, efficiently consume other species, and their negative impact on native species, such as decrease of native species in its abundance, has been suggested. However, in Yamagata, Japan, *H. axyridis* occurs on Hibiscus trees with other native species, such as *Coccinella septempunctata brucki* Mulsant, and form the same aphidophagous ladybird guild. In the present study, to assess the impact of *H. axyridis* on *C. s. brucki*, seasonal changes in the number of those two species in this habitat was determined during their development. As a result, the ratio of the two species were nearly 1:1, and this ratio was relatively constant throughout all developmental stages, suggesting that those two species co-existed on this habitat. A mechanism enables those two species to co-exist on the same habitat is discussed.

P-28 Genetic variation of flight ability in the ladybird beetle, *Harmonia axyridis* (Pallas) (Coleoptera, Coccinellidae) in Japan

T. SEKO[1], K. MIURA[1], M. OHTAISHI[2] and A. KIKUCHI[1]
[1]*National Agricultural Research Center for Western Region, Fukuyama, Hiroshima 721-8514, Japan*
[2]*National Institute of Vegetable and Tea Science, Kanaya, Shizuoka 428-0022, Japan*

Harmonia axyridis is an aphid predator in its native Asian range. This adult often leave outdoor and greenhouse crops when used in biological control program because they have high flight ability considerably. Tourniaire et al (2000) obtained a flightless strain by artificial selection from a laboratory population of *H. axyridis* which had been reared under controlled conditions for about 20 years after sampling in China. In their study, the frequency of flightless adults quickly increased in the second and third generations. However, it has been unknown either the origin of 'flightlessness' is present in wild population or it results from the continuous rearing of this ladybird for many years under laboratory conditions. Genetic variation of flight ability in wild population derived from area of origin should be checked to verify this assumption. In our study, 70 adults were collected from Fukuyama, Hiroshima in Japan and the flight ability of 100 adults per sex was measured by using flight mill in the first generation of the laboratory population. A large variation of flight ability among adults was found in both sexes, but few individuals indicated flightless character. We selected ones with lower flight ability and allowed them to mate. Two lines were established from these offsprings and selection was continued per line in several generations. Flight ability was tended to decrease with selection in both lines. These results suggest that genetic variation of flight ability in *H. axyridis* has been maintained in wild population considerably, so flightless individuals would be present potentially in wild population.

P-29 Species and population trends of aphidiid parasitoids on apple trees in relation to the occurrence of aphids on undergrowth

M. TAKANASHI

Department of Integrated research on Agriculture, National Agriculture Research Center for Tohoku Region, Morioka, Iwate, 020-0123 Japan

Recently, the outbreak of aphids has become prevalent under the insecticide-reduced control programs in apple orchards. It suggests that the selection of effective indigenous natural enemies and environmental augmentation preferable for them should be necessary for the sufficient control of aphids without using non-selective insecticides. For that purpose, the activities of aphidiid parasitoids, as the promising biological control agent of aphids, were surveyed in an apple orchard including natural vegetation under and around apple trees. As a result, total nine species of parasitoids including *Aphidius*, *Ephedrus*, *Lysiphlebus*, *Praon* and *Trioxys* were collected from six species of aphids. Four of nine species were collected from both apple and shrubs. On the contrary, only one species, *L. japonicus* was shared between apple trees and weeds. White clover was the most dominant undergrowth at the test plots, on which *Aphis craccivora* was observed consistently during the study. The dominant species of aphids was *A. spiraecola* on apple. The occurrence of aphids nearly synchronized between apple and undergrowth, however, densities of aphids on weeds were consistently low. The first observation of *L. japonicus* mummies was at the same date both on apple and white clover. The peak activity came one week earlier on clover than on apple. The parasitizing activity last longer on apple than on clover. From these results, it is not expected that population shift between the two host plants and host aphid alternation could contribute to the early establishment and stabilization of parasitoid population on apple trees. Two species of *Ephedrus* were entirely absent from the undergrowth in the field, although they can utilize both *A. spiraecola* and *A. craccivora* as suitable hosts in the laboratory. It is suggested that factors affecting the habitat preferences should be determined for the environmental manipulation which enhances the activities of aphidiid parasitoids in the apple orchards.

P-30 Host plant preference in a parasitoid wasp in relation to the presense of aphids and extrafloral nectary

T. UENO

Faculty of Agriculture, Kyushu University, Fukuoka, Japan

Host preference in terms of host species, stage and age, etc is well documented for many parasitoids. However, realized percentage of parasitism in the field is not determined solely by such host preference. Habitat selection by a certain species of parasitoids, for example, also affects the likelihood of a host being attacked by the parasitoid species. Host plant preference can be a form of habitat selection by parasitoids. Although there are a number of studies which suggest that parasitoids prefer to search on given plant species, few studies have examined the detail of host plant selection by parasaitoids. Here, I examine host plant preference in parasitoids and factors that can affect the preference. I show an example in which specialist parasitoids both in the field and laboratory prefer to search on certain plant species. There is no evidence that host plant preference by the parasitoids is associated with that by their host. Evidence is also given that host plant p!

Reference is intensified by the presence of extra floral nectary glands and honeydew produced by aphids. Thus, factors other than the plant characters may be involved in plant preference. Host plant preference by parasitoids is discussed in the context of its adaptiveness. The importance of food sources such as nectar and honeydew is also discussed as a factor influencing host plant preference.

P-31 Interaction between a predatory ladybird and two parasitoid species and its effect on abundance of two species of aphids

K. URAKAWA and H. YASUDA
Faculty of Agriculture, Yamagata University, Yamagata 997-8555, Japan

The effects of a ladybird, *Coccinella septempunctata brucki* Mulsant, and/or the parasitoids, *Aphidius colemani* or *Aphidius ervi*, on abundance of two species of aphids, *Aphis craccivore* Koch and *Acyrthosiphon pisum*, were studied in relation to the interaction between those natural enemies of aphids, and its effect on plant growth when one of two groups of these natural enemies or both groups were present. *C. septempunctata* decreased abundance of both species of aphids. The parasitoids, *A. colemani* and *A. ervi*, decreased abundance of *A. craccivore* and *A. pisum*, respectively, but not one another species of aphids. As interaction between natural enemies tended to intensify when they exploit the same aphid species, development and survival of natural enemies were likely to improve when other species was not present. In addition, plant growth was improved when *A. ervi* was present. Effective biological control attempts and the constitutions of the diverse arthropods communities are discussed.

P-32 Interspecific associations among aphid, ants and predators in a pomegranate ecosystem

A. VERGHESE[1], K. SREEDEVI[1], K. SUDHADEVI[1] and V. VASUDEV[2]
[1]Indian Institute of Horticultural Research, Hessaraghatta Lake – P.O., Bangalore – 560 089, India [2]Department of Applied Zoology, Kuvempu University, B. R. Project, Shimoga – 577 115, India

A perennial tree ecosystem like pomegranate (*Punica granatum*) offers niches for the coexistence of insects, predators and ants. Being an important component of the ecosystem, the foraging, migratory and other behavioural patterns of predators need to be monitored closely to evolve an effective biocontrol programme (Whitecomb, 1981). So, the interspecific associations among aphid (*Aphis punicae* Passerini) (Homoptera: Aphididae), ants (*Camponotus compressus* Fab., *C. sericeus* Fab. and *Tapinoma* sp.) (Hymenoptera: Formicidae) and predators (*Cheilomenes sexmaculata* (Fab.), *Scymnus* sp., *Pseudaspidemerus circumflexa* (Motsch.) (all Coleoptera : Coccinellidae); *Paragus serratus* (Fab.), *Ischiodon scutellaris* (Fab.) (both Diptera : Syrphidae) and *Chrysopa* sp. (Neuroptera : Chrysopidae) were studied in an unsprayed pomegranate ecosystem under natural conditions for two years (2000 – 2002). The study was carried out at the Indian Institute of Horticultural Research, Bangalore (12°58′N, 77°35′E), India.

The sampling was carried out each week on 1600 shoots (80 shoots/tree x 20 trees), which were selected randomly and counts of prey, predators and ants were documented. The data were subjected to suitable statistical analyses *viz.*, 2 x 2 contingency table with Chi-square test of significance, which expresses the strength and the type of association between the species (either positive or negative). Positive association implies overlap in the niche-range and negative association reflects exclusion (Southwood, 1978; Verghese and Tandon, 1987).

The results showed that the aphid and predator association (positive) was more evident during January - March, September – December, which coincided with aphid population peaks. Thus, there was an indication of significant association with numerical response, implying better overlap, as predator density increased with the prey's and perhaps improved searching ability, as coccinellids are known to acquire over time (Hagen *et al.*, 1976). Escape responses of the prey, and/or predator aggregation in response to prey densities can promote partial prey refuges, which in turn contribute to the stability of predator-prey interaction (Begon and Mortimer, 1981).

There was no association between aphids and ants at peak incidence of the former. However, a spatial positive association during later half of the year was observed, but ants never tended the aphids significantly, and were probably foraging on plant exudates or nectaries. *Aphis punicae* can be termed as facultative myrmecophiles as the relation between aphid and ants seemed to be casual or circumstantial.

Predators and ants showed positive association during June, July, September and November and no association during other months in all the three years. This indicates the co-existence of both without antagonism, which seem to get along with each other without any interference. It need not be compatibility between the two. This was a reflection of the trend in numbers and not indices of positive relationships.

From a biocontrol point of view, ants do not interfere with predators foraging on *A. punicae* in pomegranate ecosystem.

P-33 The effects of mutualistic ants on the structure of an arthropod community on mugworts

H. YASUDA and T. Fukuhara

Department of Agriculture, Yamagata University; Tsuruoka 997-8555, Japan

Mutualism between ants and aphids is well known as an interaction in arthropods. For instance, ants negatively affect the abundance of aphid predators and prey consumption of aphidophagous insects. Although the intensity and nature of these negative effects due to ants might differ among aphid predators, our understanding of these interactions remains incomplete. In addition, mutualistic ants might influence on abundance of arthropods except aphid predators on a plant with ant attendant aphids, however, there are few studies to understand these interactions. A complex arthropod community is constructed on mugworts in the campus at Yamagata University on which we can observe more than 8 species of aphids, 7 species of phytophagous insects, and 9 species of aphidophagous insects in addition to ants. In order to understand the effects of mutualistic ants on the structure of an arthropod community on mugworts, we have done a factorial experiment with and without ants in the field. Our studies revealed that ants tended to influence on the numbers of 1) ant non-attendant aphids, 2) aphidophagous insects except aphidophagous midges, 3) damages due to leaf chewing insects, and 4) plant growth through direct and indirect interactions, while the numbers of 1) ant attendant aphids, 2) aphidophagous midges, and 3) damages due to leaf mining insects were larger on the mugworts with ants than without ants. From these results, we discuss the direct and indirect interactions between mutualistic ants and arthropods on mugworts which in turn would influence on the structure of an arthropod community due to mutualistic ants.