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PARASITOIDS OF *CHROMATOMYIA HORTICOLA* (GOUREAU) (DIPTERA: AGROMYZIDAE) ON GARDEN PEA IN JAPAN

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The leafminer, *Chromatomyia horticola*, which infests garden pea, is exposed to various parasitoids. We studied the biological control of *Liriomyza* leafminer species, especially *L. sativae* Blanchard and *L. trifolii* (Burgess) (Diptera: Agromyzidae), on glasshouse tomatoes using parasitoid complexes from *C. horticola*. Garden pea and tomato plants were collected in Shizuoka Prefecture, Japan, between April and May 2004. The numbers and species of leafminers and the parasitoids emerging from them were determined.

Species of leafminers and parasitoids. *Liriomyza sativae*, *L. trifolii*, and *L. bryoniae* (Kaltenbach) were collected from tomato plants, whereas *C. horticola* was mainly collected from the garden pea. *Liriomyza* leafminers were very rare on garden peas and their occurrence was limited to summer. The predominant parasitoids on the garden pea were *Diglyphus isaea* (50.5%), *Chrysocaris pentheus* (25.6%), *Neochrysocaris formosa* (10.8%), and *C. pubicornis* (7.5%) (Hymenoptera: Eulophidae). The former three parasitoid species were also frequently collected from tomato plants, suggesting that parasitoids of *C. horticola* also commonly parasitize *Liriomyza* leafminers.

Emergence of parasitoids. About 15 parasitoids emerged per 10 leaves. Ninety percent of parasitoids had emerged from garden peas on the 24th, 18th, and 15th day at 20°C, 25°C and 15°C, respectively (Table 1).

In conclusion, *Liriomyza* leafminers can be controlled by the parasitoids that emerge from *C. horticola* when garden pea plants are cut and introduced into tomato-growing glasshouses.

Table 1. Percentage of parasitoids emerging from leafminers on garden pea and tomato in Shizuoka Prefecture, Japan, between April and May 2004.

Species	Garden pea* n = 14,266 40 fields	Tomato* n = 148 7 fields
Diglyphus isaea	50.5%	6.4%
Chrysocaris pentheus	25.6%	19.1%
Neochrysocaris formosa	10.8%	32.0%
Chrysocaris pubicornis	7.5%	0.3%
Others (*Opius* sp., *Dacnusa sasakawai,* etc.)	5.6%	42.3%

*Average percentage of parasitoids per field.

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REPRODUCTIVE BEHAVIOR OF THE GENERALIST PREDATOR *MACROLOPHUS CALIGINOSUS*

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Macrolophus caliginosus Wagner (Heteroptera: Miridae) is a polyphagous predator native to the Mediterranean region where it spontaneously colonizes open field and protected vegetable crops. Several companies produce this natural enemy that it is widely used in vegetable crops in Europe. Nevertheless, its use in greenhouses is somehow unpredictable and a slow installation of the population is observed in some circumstances. Due to a lack of knowledge of its main biological traits it is difficult to overcome many of the difficulties that appear in the general practice of releasing this predator. Reproduction is one issue not well known and that affect the performance of the predator both in the greenhouse and in commercial mass rearing. In this work we have studied the copulatory behavior and the ovary maturation of this predator with the aim of implementing its use in augmentative releases in greenhouses.

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INTRAGUILD PREDATION AND FEEDING PREFERENCES IN THREE SPECIES OF PHYTOSEIID MITES USED FOR BIOLOGICAL CONTROL

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There has been much recent debate about the ecological impact on native insect and mite species by introduced arthropod biological control agents. This study investigated the ability of the non-native predatory mite *Neoseiulus californicus* (McGregor) (Acari: Phytoseiidae) to feed on the native *Typhlodromus pyri* (Scheuten) (Acari: Phytoseiidae) and *vice versa*, as both species now co-occur in UK orchards. *Typhlodromips montdorensis* (Schicha) (Acari: Phytoseiidae) is a candidate for introduction into the UK as a glasshouse biological control agent. The ability of *T. montdorensis* to feed on the widely used *N. californicus* was investigated to identify possible intraguild predation, which may impact positively or negatively on the effectiveness of either or both species as predators of *Tetranychus urticae* in the glasshouse. Both *N. californicus* and *T. pyri* consumed larval stages of each other, but in choice experiments both showed a preference for *T. urticae*. Both *N. californicus* and *T. montdorensis* also fed on each other, but whereas *N. californicus* again showed a preference for *T. urticae*, *T. montdorensis* fed equally on *T. urticae* and *N. californicus*. Interactions between *N. californicus* and *T. pyri* and *N. californicus* and *T. montdorensis* are discussed in relation to their effectiveness as biological control agents in the glasshouse and the natural control of spider mite in the field.

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DETERMINING THE EFFICIENCY OF TWO METHODS OF RELEASING LACEWING EGGS IN GREENHOUSES

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Lacewings are predatory insects that are widely used in biological control programs. Among them, *Chrysoperla carnea* (Stephens) (Neuroptera: Chrysopidae) is a promising biological control agent for use against pests in greenhouses and fields. In this study, two lacewing egg release methods were compared: 1- Distribution of eggs mixed with sawdust as an egg carrier and 2- dispersal of eggs using a Chrysobag (special net bags). Experiments using randomized block design were conducted using the cotton aphid, *Aphis gossypii* Glover (Homoptera: Aphididae), on 4 cucumber plants, *Cucumis sativum* L, in each net cage. A first egg release showed no significant difference between the two methods. An approximately 80-84% reduction in population density of aphids was observed compared with a control treatment. However, a second egg release, 7 days after the first release, caused a 94-95% reduction in aphid populations. Better control of aphids was observed with repeated egg release. The two methods had the same effect in controlling aphids in experiments conducted in cages without generalist egg predators (such as ants). Although the two methods had the same efficacy in the absence of ants, if eggs are released in greenhouses and fields, the Chrysobag would protect eggs from ants and other predators. Therefore, the Chrysobag is a more effective method, with a high efficiency and without the negative effect that sawdust has on host plants. We suggest that the Chrysobag method should be used in commercial greenhouses and in the field.

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INFLUENCE OF LIGHT ON THE EFFICACY OF BIOCONTROL AGENTS IN GREENHOUSE ENVIRONMENTS

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A key issue affecting adoption of biological control in protected culture is the variability in effectiveness of natural enemies. Growers need natural enemies to provide predictable and reliable control of a pest. Predictable biological control requires that we have an understanding of how environmental conditions affect both the pest and biocontrol agent. Greenhouses are unique in that environmental conditions can be manipulated. The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (Homoptera: Aleyrodidae) and western flower thrips, *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) are important pests of greenhouse vegetable crops worldwide. It has long been recognized that the effectiveness of biological agents in the winter in northern temperature regions is reduced. Short day length, low light intensity and low temperatures have been suggested as possible explanations for this reduced efficacy. Little information is known about the influence of light on the behaviour of natural enemies. We present results from studies investigating the influence of light quality (intensity) and light quantity (day length) on the feeding and oviposition activity of: 1) two aphelinid parasitoids, *Encarsia formosa* Gahan and *Eretmocerus eremicus* Rose and Zolnerowich (Hymenoptera: Aphelinidae) on greenhouse whitefly and, 2) a predacious mite, *Neoseiulus cucumeris* (Oudemans) (Acarina: Phytoseiidae) on western flower thrips. Results are put in context of greenhouse management in Canada.

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THE INFLUENCE OF FORMULATION AND PACKAGING ON PERFORMANCE OF BENEFICIAL ARTHROPODS

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Research into biological control agents often focuses on the characteristics of the species being researched, such as intrinsic rates of increase, predation rates and host range. One to one comparisons in laboratory or semi-field situations will show that a novel species may be superior to one already in use. This approach fails to account for various factors which will influence the commercial production and use of an agent. Excellent predators may be impossible or expensive to produce in sufficient quantities, and so fail to displace weaker predators which can be economically mass produced. The formulation of products and the way they are presented in crops can turn a relatively weak predator into a viable means of control. Changes in formulation and product design can further improve performance and extend the range of crop situations in which a given product can be used. Whilst the species used is a key component of a product, and can be regarded as the active ingredient, it is by no means the only element which defines performance.