

longevity, which appeared to be due to feeding repellency rather than toxicity. No effects were apparent when the predator larvae were fed with aphids kept on artificial diet containing ASAL.

**Implications.** The fact that ASAL shows a high activity towards the target pest, but has little effect on the non-target predator species makes it an interesting compound to deploy in transgenic chickpeas. To fully assess the potential of this transgenic approach it has to be verified whether ASAL expressing chickpeas would eventually protect the crop from virus infection.

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Session 8: The Role of Food Supplements in Biological Control

## THE EFFECT OF FOOD SUPPLEMENT ON LIFESPAN AND NUTRIENT METABOLISM IN A PARASITIC PHORID FLY

**Henry Y. FADAMIRO and Li CHEN**

Department of Entomology & Plant Pathology  
Auburn University  
Auburn, AL 36849, U.S.A.

fadamhy@acesag.auburn.edu

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The phorid fly, *Pseudacteon tricuspis* Borgmeier (Diptera: Phoridae) has been released in many parts of southern United States for biological control of red imported fire ant, *Solenopsis invicta* Buren (Hymenoptera: Formicidae). However, little is known about the nutritional ecology and foraging behavior and of phorid flies and the impact of sugar feeding on their lifespan. We investigated the effect of sugar feeding on the longevity of female and male *P. tricuspis* along with temporal patterns of nutrient accumulation and mobilization in flies provided different diet regimes.

**Parasitoid longevity.** Flies fed 25% sucrose continuously throughout their lifespan have greater longevity than completely starved (provided no water and no sugar solution) flies, sugar starved (provided water only) flies, or flies fed sugar solution only on their first day of adult life (see Table 1). Flies fed 50% sucrose have similar survivorship as those fed 25% sucrose. There was no significant effect of sex on longevity. Sex, however, had a significant effect on wing length with females being larger than males. *P. tricuspis* adults are also able to utilize floral nectar from buckwheat and honeydew produced by cotton aphids, suggesting that availability of supplemental sugar sources near its release sites may enhance the efficacy of *P. tricuspis* as a biological control agent of imported fire ant.

**Patterns of nutrient metabolism.** The temporal patterns of nutrient accumulation and utilization are also compared in *P. tricuspsis* fed different diets: sugar-starved, sucrose-fed on the first day of adult life only, and sucrose-fed continuously. Adult *P. tricuspsis* emerge with no gut sugars, and only minimal amounts of body sugars and glycogen. While the levels of body sugars and glycogen decline gradually in sugar-starved flies, a single day of sugar feeding resulted in the accumulation of maximum amounts of gut sugars, body sugars, and glycogen. High levels of these nutrients are maintained in female and male phorid flies feeding sucrose continuously over the observation period, whereas nutrient levels decline in flies fed only on the first day of life, beginning 1 day postfeeding. Honeydew-fed phorid flies also show a slight increase in the levels of body sugars. Female and male *P. tricuspsis* emerge with an estimated  $12.3 \pm 2.3 \mu\text{g}$  and  $7.2 \pm 1 \mu\text{g}$  lipid reserves per fly, respectively. These teneral amounts represent the highest lipid levels detected in adult flies, irrespective of their diet and are maintained over the life times of sucrose-fed female and male flies, but declined steadily in sugar -starved females. Wing length was positively correlated with the amounts of gut and body sugars in female and male flies, and also with glycogen levels in male flies. However, no significant relationship between wing length and lipid amounts was detected in female and male flies, suggesting that the amount of lipid reserves at emergence is not a function of size. These data suggest that adult *P. tricuspsis* are capable of converting dietary sucrose to body sugars and glycogen, but not lipids.

**Table 1.** Mean longevity (days  $\pm$  SE) of female and male *P. tricuspsis* subjected to different feeding regimes.

Diet	Females	Males
Completely starved <sup>1</sup>	1.2 $\pm$ 0.1 c	1.3 $\pm$ 0.1 d
Sugar starved	3.0 $\pm$ 0.2 b	3.3 $\pm$ 0.2 c
Sugar fed day 1 only	4.2 $\pm$ 0.3 b	5.0 $\pm$ 0.3 b
Sugar fed throughout lifespan	7.9 $\pm$ 0.8 a	8.9 $\pm$ 0.9 a

<sup>1</sup>Completely starved = flies provided with no water and no sugar solution. Means within the same column having different letters are significant ( $P < 0.05$ ).

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## POTENTIAL EFFECT OF FLOWERING PLANTS ON THE ACTIVITY OF THE EGG PARASITOID *TRICHOGRAMMA BOURARACHAE* PINTUREAU AND BABAULT (HYMENOPTERA, TRICHOGRAMMATIDAE), A CANDIDATE FOR BIOLOGICAL CONTROL IN OLIVE CULTIVATION

Annette HERZ<sup>1</sup>, S.A. HASSAN<sup>1</sup>, F. NASR<sup>1</sup>, A. YOUSSEF<sup>2</sup>, and E. HEGAZI<sup>3</sup>

<sup>1</sup>Biolog. Bundesanstalt für Land- und Forstwirtschaft  
Heinrichstr. 243  
64287 Darmstadt, Germany  
A.Herz@bba.de

<sup>2</sup>Plant Protection Research Institute  
536 Horria St. Fleming  
21545 Alexandria, Egypt

<sup>3</sup>Faculty of Agriculture, University of Alexandria  
Aflaton Street  
21545 Alexandria, Egypt

The egg parasitoid *Trichogramma bourarachae*, isolated from sentinel eggs in an olive grove near Alexandria, Egypt, and experimentally released in an olive grove near Cairo for control of Lepidopterous olive pests, was significantly attracted by flowering vegetable islands. These islands were introduced in the olive grove to enhance the productivity of the beneficial fauna. They were distributed in 2 x 2 m plots alternating between olive trees in four rows and included six different treatments: 1- Uncovered soil as control, 2- Summer squash, *Cucurbita pepo* L. (Magnoliopsida: Cucurbitaceae), 3- Radish, *Raphanus sativus* L. (Capparales: Brassicaceae), 4- Roquette, *Eruca sativa* Miller (Capparales: Brassicaceae), 5- Turnip, *Brassica rapa* L. (Capparales: Brassicaceae), and 6- Wild Groundsel, *Senecio vulgaris* L. (Asterales: Asteraceae). Each island was sown at two or three different dates to create continuous flowering of vegetables from April to July. *T. bourarachae* was mass-reared in the laboratory and released in several applications from March to August 2004 at a rate of 9.000 wasps/tree. *Trichogramma bourarachae* could be frequently collected from sentinel eggs, distributed on olive trees neighbouring vegetable islands. Captures occurred more than 60 m apart from the releasing area suggesting an attractiveness of flowering vegetation for this egg parasitoid, which was not autochthonous distributed in this olive grove before release. The potential use and effect of *Eruca sativa*-flowers as food source for *T. bourarachae* was studied in laboratory and greenhouse tests by evaluating fecundity, longevity as well as searching capacity of this species in the presence of flowers in comparison to wasps which were offered honey or water.

**THE EFFECT OF FOOD RESOURCES ON THE LONGEVITY OF  
*GONATOCERUS ASHMEADI*, *G. TRIGUTTATUS*, AND  
*G. FASCIATUS*, EGG PARASITOIDS OF THE GLASSY-WINGED  
SHARPSHOOTER (*HOMALODISCA COAGULATA*)**

**Nicola A. IRVIN<sup>1</sup>, Mark S. HODDLE<sup>1</sup>, and Steve CASTLE<sup>2</sup>**

<sup>1</sup>Department of Entomology, University of California  
Riverside, CA 92521, U.S.A.  
nic.irvin@ucr.edu

<sup>2</sup>USDA-ARS  
4135 E. Broadway Road  
Phoenix, AZ 85040, U.S.A.

The effect of water only, 3:1 honey-water solution, floral and extra-floral nectars from five different plants [buckwheat (*Fagopyrum esculentum* Moench (Polyganles: Polygonaceae)), alyssum (*Lobularia maritima* L. (Capparales: Brassicaceae), *Phacelia tanacetifolia* Benth (Solanales: Hydrophyllaceae)), dill (*Anethum graveolens* L. (Araliales: Umbelliferae)) and broad bean (*Vicia faba* L.), honeydew from *Coccus hesperidum* L. (Homoptera: Coccidae) and *Homalodisca coagulata* (Say) (Hemiptera: Cicadellidae), a commercially available food supplement (Eliminade) and citrus foliage on the longevity of male and female *Gonatocerus ashmeadi* Girault, *G. triguttatus* Girault and *G. fasciatus* Girault (Hymenoptera: Mymaridae), was determined in the laboratory. Additionally, the sugar composition of each food resource was determined using high performance liquid chromatography (HPLC) analysis. Honey-water and *F. esculentum* significantly increased longevity of male and female *G. ashmeadi*, *G. triguttatus*, and *G. fasciatus* up to 1760%, 1223% and 1359%, respectively, compared with water.

These results indicate that resource procurement maybe extremely important for enhancing the survival of these parasitoid species in agroecosystems for *H. coagulata* biological control. For both sexes and all three parasitoid species, survival on citrus foliage and *P. tanacetifolia* flowers was equivalent to that on water only. *Vicia faba* extrafloral nectaries increased survival of both male and female *G. fasciatus* by 263% and 376%, respectively but did not significantly increase the survival of *G. ashmeadi* and *G. triguttatus* compared with water only. *Lobularia maritima* and *A. graveolens* significantly enhanced survival of female *G. ashmeadi* and *G. triguttatus* by up to 670%, but not *G. fasciatus*. The longevity of both sexes of *G. ashmeadi* and *G. triguttatus* was up to 439% higher on Eliminade compared with water only, however there was no significant effect of Eliminade on survival of *G. fasciatus*. *Coccus hesperidum* honeydew increased survival times up to 565% for all mymarid species compared with citrus foliage alone, whereas, parasitoid survival on *H. coagulata* excrement was equivalent to that on citrus foliage which was comparable to longevity estimates when parasitoids had access to water only.

These results suggest that in citrus orchards, *H. coagulata* excrement is not an adequate food supply for *Gonatocerus* parasitoids, and that low non-damaging *C. hesperidum* populations may be beneficial for enhancing parasitoid survival and could augment biological control of *H. coagulata*. HPLC analysis showed that food resources that were most beneficial to *Gonatocerus* parasitoids (honey-water, *F. esculentum* and *C. hesperidum*) possessed a high proportion of glucose (up to 44.3%) and fructose (up to 52.5%), and results suggested that sucrose may not be important for parasitoid survival since honey-water resulted in maximum parasitoid longevity, yet did not contain sucrose. Honey-water and *C. hesperidum* were very beneficial for parasitoid survival and were the only food resources that contained maltose (3-9%), thereby indicating maltose may be beneficial for parasitoid survival. Citrus and *P. tanacetifolia* contained favorable proportions of glucose and fructose, and possessed a significantly higher (up to 255.2%) total sugar concentration compared with *C. hesperidum* excreta and *F. esculentum*, which both promoted greater longevity of these parasitoids. Therefore, the inability of *Gonatocerus* spp. to benefit from nectar produced by citrus and *P. tanacetifolia* may be related to flower morphology.

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## CONSERVATION BIOLOGICAL CONTROL TO ENHANCE THE EFFICACY OF A PARASITOID OF THE ARGENTINE STEM WEEVIL

**H. Don VATTALA<sup>1</sup>, Steve D. WRATTEN<sup>1</sup>, Craig B. PHILLIPS<sup>2</sup>,  
and Felix L. WÄCKERS<sup>3</sup>**

<sup>1</sup>National Centre for Advanced Bio-Protection Technologies  
PO Box 84, Lincoln University  
Canterbury, New Zealand  
vattalad@lincoln.ac.nz, wrattens@lincoln.ac.nz

<sup>2</sup>AgResearch  
PO Box 60,  
Lincoln, New Zealand  
craig.phillips@agresearch.co.nz

<sup>3</sup>Netherlands Institute of Ecology (NIOO-KNAW), Centre for Terrestrial Ecology  
Boterhoeksestraat 48  
6666 GA Heteren, The Netherlands  
f.waeckers@nioo.knaw.nl

Conservation biological control aims to enhance the efficacy of biological control agents, partly by providing them with 'resource subsidies'. *Microctonus hyperodae* Loan (Hymenoptera: Braconidae) is a parasitoid of *Listronotus bonariensis* (Kuschel) (Coleoptera:

Curculionidae), a major pasture pest in New Zealand. To understand the delivery of benefits to *M. hyperodae* in the field, carbohydrate metabolism in the parasitoid was investigated using high performance liquid chromatography (HPLC). Lifetime patterns of carbohydrate metabolism were compared in the laboratory between unfed and honey-fed *M. hyperodae*. These patterns were compared with field-collected parasitoids.

**Laboratory-reared parasitoids.** The honey-fed individuals lived twice as long as did parasitoids given water only. Fed and unfed parasitoids could be distinguished by measuring total sugar levels. Furthermore, the glucose/(glucose+fructose) ratio [g/(g+f)] of honey-fed *M. hyperodae* was always lower than that of the unfed and newly-emerged individuals.

**Field-collected parasitoids.** The HPLC analysis of field-collected parasitoids from near buckwheat (*Fagopyrum esculentum* Moench cv. Katowase) plots showed that a high proportion of parasitoids near flowering plants had fed from buckwheat. Those which fed had a low [g/(g+f)] ratio and varying levels of total sugar in their body. Recently-fed individuals had high levels of total sugars whereas previously-fed had low total sugars. The field-collected and laboratory-reared unfed parasitoids showed similar total sugars and [g/(g+f)] ratios.

These results can be very useful for determining the nutritional state and feeding history of field-collected *M. hyperodae* and the analytical procedure tested here can be used to help evaluate the benefits to parasitoids through the provision of plant 'resource subsidies' in the field.

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## **EFFECT OF FLOWER PRESENTATION METHOD ON PARASITOID WASP SURVIVAL**

**Mark R. WADE, Steve D. WRATTEN, and Ashley A. K. SHADBOLT**

Bio-Protection and Ecology Division, Lincoln University  
Canterbury, New Zealand

wadem@lincoln.ac.nz  
wrattens@lincoln.ac.nz  
shadboa2@lincoln.ac.nz

The first stage in developing a conservation biological control strategy typically involves ranking the suitability of various plant species as food resources for the target natural enemy species in the laboratory. It is unclear whether excised flower shoots in water will generate similar effects on the life history traits of a natural enemy compared with those using flowers remaining attached to a rooted plant. Both methods have been used in previous studies, yet none has quantified this effect. It is possible that plant nectar quality and quantity is altered as a result of changes in the physiological condition of the excised flowers. Laboratory tests are being conducted to assess the influence of flower presentation method for 10 plant species on the lifespan of *Aphidius ervi* Haliday (Hymenoptera: Braconidae), a potentially important parasitoid wasp of lucerne aphids, *Acyrtosiphon kondoi* Shinji and *Acyrtosiphon pisum* (Harris) (Homoptera: Aphididae). It is predicted that parasitoid wasp survival will be lower on excised compared with intact flowers for each plant species, but that the overall ranking of the plant species tested will remain unchanged. Results and recommendations for the design and interpretation of future laboratory studies are provided.