

A NOVEL METHOD TO REAR *DIADEGMA INSULARE*  
(HYMENOPTERA: ICHNEUMONIDAE), A PARASITOID OF THE  
DIAMONDBACK MOTH (LEPIDOPTERA: PLUTELLIDAE)

DENISE L. JOHANOWICZ<sup>1</sup> AND EVERETT R. MITCHELL<sup>2</sup>

<sup>1</sup>Department of Entomology and Nematology, University of Florida  
P.O. Box 110620, Gainesville, FL 32611

<sup>2</sup>Center for Medical, Agricultural and Veterinary Entomology  
U.S. Department of Agriculture, Agricultural Research Service  
P.O. Box 14565, Gainesville, FL 32604

*Diadegma insulare* (Cresson) (Hymenoptera: Ichneumonidae) is a solitary, host-specific endoparasitoid of diamondback moth (*Plutella xylostella*) (L.) (Lepidoptera: Plutellidae) larvae, and is considered one of its most important natural enemies (Idris & Grafius 1993). *Diadegma insulare* and related species occur naturally throughout much of the United States and in other cabbage-growing regions of the world (Lasota & Kok 1986, Idris & Grafius 1993, Muckenfuss et al. 1992, Fitton & Walker 1992). Additionally, they are augmentatively released for biological control programs.

Our laboratory is involved in developing methods to further suppress diamondback moths in Florida cabbage, including augmenting natural populations of *D. insulare* early in the season before they normally appear (Mitchell et al. 1997). To this end, we conduct research on more efficient methods of rearing *D. insulare*. An ideal rearing method would be easy, inexpensive, and produce large enough quantities of wasps. In addition, the sex ratio should be as female biased as possible, since the females are the individuals actively controlling larval populations.

We currently rear *D. insulare* on diamondback moth larvae feeding on cruciferous plants. In order to have enough plant material for our rearing operation, we grow or purchase pesticide residue-free crucifers. The material must be of the right stage, since daughter-production by *D. insulare* is sensitive to the chemistry and age of crucifers, even with other host quality parameters held constant (Fox et al. 1990). We have had little success rearing *D. insulare* on larvae feeding on artificial diet. A recent study demonstrated that the addition of collard extract to an artificial diet or to the sides of the rearing container containing the diet increased oviposition rates and the production of daughters (Sieglaff et al. 1998), but the level of parasitism was not high enough to switch to this rearing method. In addition, the age of the collard extract and the plant quality of which it was extracted from appear to have been factors in low production of *D. insulare* females (unpublished information).

We recently expanded upon the work of Sieglaff et al. (1998) with the goal of increasing the percentage of larvae parasitized (parasitism in the previous study ranged between 28-46% in the amended diets), while maintaining an adequate female sex ratio to maintain the colony and allow for experimental releases in the field. This study consisted of two treatments replicated five times, each on five different dates. Treatments were plain artificial diet (Wheat germ-based artificial diet, Shelton et al. 1991; 8 cm diameter, approx. 1.5 cm thick) versus artificial diet coated with approximately 6 g of cabbage flour (BIO-SERV, Frenchtown, NJ) immediately prior to the exposure. Cabbage flour is made from washed, blanched, dehydrated, and powdered fresh cabbage (Y. Bai, Director of Nutrition, Bio-Serv). Artificial diet cakes were infested with diamondback moth eggs approximately 5 days prior to the experiments, and maintained at 25°C under constant light. Larvae ranged between late second and early third instar, with 250-350 larvae per diet cake. Diet cakes with similar numbers of larvae were used per each

paired replicate. Treated and untreated diet cakes were placed on steel mesh (5 mm) platforms (1 cm high) in separate 5 L cylindrical plexiglass containers with an organdy cloth top for ventilation. Cages were placed near a window in the laboratory with an oscillating fan blowing at low speed over the tops of the cages. Four, four-day-old pairs of *D. insulare* were placed in each cage immediately after the addition of the cabbage flour. Wasps were provided by the rearing unit at the USDA-ARS laboratory in Gainesville, FL. Wasps were provided fresh honey and water daily for the duration of the study. After four days, wasps were removed and larvae were allowed to continue feeding on the same diet cake until pupation. The resulting parasitism data were compared using the sign test (a nonparametric test used to test the hypothesis that the median of the differences in the pairs is zero), where a positive sign was given to the treatment with the higher value for each given replicate ( $n = 5$ ) (Snedecor 1956).

The percent of larvae parasitized on the amended diet cakes ( $93.4\% \pm 0.9$ ) was significantly greater than the percentage on the plain diet ( $61.8\% \pm 15.5$ ) ( $p = 0.03125$ ); each replicate yielded a higher percentage in the treated vs. the untreated diet. The percent of daughters produced was not significantly different between the plain diet ( $49.5\% \pm 4.2$ ) and the cabbage flour-amended diet ( $49.9\% \pm 1.9$ ). The absolute numbers of daughters produced per female was significantly greater in the amended diet treatment ( $34.7 \pm 3.0$ ) than in the plain diet treatment ( $21.6 \pm 6.1$ ) ( $p = 0.03125$ ); each replicate yielded a higher number in the treated vs. the untreated diet. In each replicate, *D. insulare* females were observed to land on and parasitize hosts on the amended diet within 45 minutes. No landings were observed on the plain diet; all observed attacks were on larvae crawling on the bottom or sides of the cage.

It is likely that the cabbage flour has a volatile chemistry similar to larval-damaged or otherwise disrupted plant material, shown to provide host location cues to *D. insulare* (Hu et al., unpublished data). Whether the cabbage flour acts a searching stimulant or if it actually aids in the location of the larvae after they ingest the material along with the artificial diet is unknown.

The results obtained suggest that cabbage flour as an artificial diet amendment may improve a *D. insulare* rearing program. It is relatively easy (larvae do not need to be transferred to plant material, plant material does not need to be grown or purchased, extracts do not need to be made and incorporated into the diet), inexpensive (the same diet cake is used for all stages of the rearing, the cabbage flour is inexpensive), and produces large numbers of female offspring while minimizing numbers of non-parasitized larvae. Also, it can be incorporated into the diet-larvae complex immediately prior to parasitism so there is less chance of the important chemical constituents breaking down, which possibly may happen with liquid extracts mixed into the diet. Studies are planned which address the long-term consequences of incorporating this method into our rearing program. We also will study the importance of natural light and airflow on the oviposition behavior of *D. insulare*, since these were not controlled for in the previous studies with collard extract, and the present results in both the amended and plain treatments were better than in the previous studies with collard extract.

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#### SUMMARY

The addition of cabbage flour to the surface of diamondback moth - infested artificial diet cakes was shown to increase the percent of parasitism and the numbers of daughters produced by the host-specific, larval-endoparasitoid *Diadegma insulare*. This may be a useful method to integrate into a *D. insulare* rearing program.

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