J. Aust. ent. Soc., 1995, 34: 71-73



# Effect of Host Plant on Parasitism of *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) by *Hyposoter didymator* Thunberg (Hymenoptera: Ichneumonidae) and *Cotesia kazak* (Telenga) (Hymenoptera: Braconidae)

D. A. H. MURRAY, K. P. RYNNE, S. L. WINTERTON[1], J. A. BEAN and R. J. LLOYD

Department of Primary Industries, P.O. Box 102, Toowoomba, Qld 4350.
[1]Present address: Division of Entomology, CSIRO, Long Pocket Laboratories, Indooroopilly, Qld 4068.

**ABSTRACT** The effect of host plant on parasitism of second-instar *Helicoverpa armigera* by two introduced larval parasitoids, *Hyposoter didymator* and *Cotesia kazak*, was investigated in glasshouse experiments. Parasitism was lowest on chickpea (5.4% for *H. didymator* and 11.8% for *C. kazak*). Higher levels of parasitism (50.1-85.0% for *H. didymator* and 25.7-55.3% for *C. kazak*) were recorded on sorghum, sunflower, cotton, soybean and pigeonpea. This suggests that the parasitoids should be released against *Helicoverpa* spp. infestations on the major summer crops—sorghum, sunflower, cotton and soybean—rather than against the first spring generation infesting chickpea. Sorghum and sunflower are preferred release crops because parasitism levels are high and disruption by insecticide sprays is less likely.

## Introduction

*Helicoverpa armigera* (Hübner) and *H. punctigera* (Wallengren) are important pests of food, fibre, oilseed and fodder crops in Australia (Zalucki *et al.* 1986). Two exotic larval parasitoids of *Helicoverpa* spp., *Hyposoter didymator* Thunberg and *Cotesia kazak* (Telenga), were introduced into Western Australia during 1983 (Michael 1989), where lucerne fields were successfully used for establishment releases of the parasitoids (P. Michael pers. comm.).

Both parasitoids were subsequently introduced into eastern Australia during 1991 (Murray *et al.* 1992, Ridland *et al.* 1993). Additional parasitoids are being reared in the insectary for field release in an endeavour to ensure establishment of the parasitoids throughout eastern Australia. Under the field release program, *Helicoverpa* spp. infestations on field crops have been targeted to release the parasitoids. As chickpea flowers set in spring (September-November) and are an important host for the first spring generation of *Helicoverpa* spp. in southern Queensland, there was an opportunity to make the first releases after winter on chickpea. Sorghum, sunflower, cotton and soybean were considered the most important summer crops for releases later in the season. However, in glasshouse experiments, lower levels of parasitism of *H. armigera* larvae by the native *Microplitis demolitor* Wilkinson (Hymenoptera: Braconidae) were found on chickpea compared to those on summer crops (Murray unpubl.). If the exotic larval parasitoids respond to host plants in a similar way, then releases to establish them on chickpea may be unsuccessful. We therefore investigated the effect of chickpea and other potential host crops on parasitism of *H. armigera* larvae by *H. didymator* and *C. kazak*.

## Materials and methods

**Parasitoid and host cultures.** Laboratory cultures of *H. didymator* and *C. kazak* were established from field collections of parasitised *Helicoverpa* spp. larvae on lucerne in Western Australia during February-March 1991. The cultures were initially maintained on *H. armigera*, but since November 1991, *H. didymator* has mostly been reared in *Spodoptera litura* (F.) and *C. kazak* in *Chrysodeixis argentifera* Guenee. Parasitoid culture methods were similar to those of Powell and Hartley (1987). The colony of *H. armigera* used in these tests had been cultured on artificial diet since 1986 using techniques similar to those of Teakle and Jensen (1985).

**Host plant tests.** Two experiments were conducted—the first used *H. didymator* and the second used *C. kazak*. In each experiment there were six types of host plant replicated six times. Host plants (and varieties) used in each experiment were sorghum (Prize), sunflower (Advance), cotton (Siokra 1-4), soybean (Mannark), pigeonpea (Quest) and chickpea (Barwon). Plants were grown in a glasshouse in 10 L plastic pots filled with sterilised soil, sand and peat moss mixed in the ratio 3:2:1. About six seeds were sown into each pot and, after establishment, plants were hand-thinned to three per pot.

When all plants had begun flowering (about 60 d after sowing), a wire frame 50 cm diameter and 100 cm high was placed over each pot. This wire frame was covered with a terylene fabric sleeve cage open at one end and with a 60 cm zipper down its length to allow access to the plants inside the cage. The open end of the sleeve was firmly secured to the pot using a large rubber band. Where the cages had to be raised to accommodate taller host plants such as sorghum and sunflower,

the open end was firmly secured around the plant stalks to prevent escape of larvae and parasitoids.

Twenty, second-instar *H. armigera* were placed on the plants within each cage. After 24 h, three pairs of 3-5 d old mated, inexperienced parasitoids were released into each cage. Parasitoids were removed after 24 h, and the number and sex of live adults were recorded. *H. armigera* larvae were then recovered from each cage by careful examination of all plant material, the inner surface of the terylene cover and the soil surface of the pot. Larvae were placed singly on artificial diet in 24-cell Costar trays for 24 h and then parasitism determined by dissection in saline to record the number of parasitoid eggs and/or first instars in each host larva. Parasitism was calculated as the percentage of the total number of larvae recovered. Dead larvae were included in calculations as immature stages of parasitoids were readily detected during dissections of dead hosts. Data on wasp survival, larval recovery, parasitism and number of eggs per host were analysed using a standard ANOVA F-test (Steel & Torrie 1980). Least significant differences were tested at $P = 0.05$.

## Results

**Survival and recovery.** Adult *H. didymator* survival was significantly lower ($P < 0.05$) on chickpea than on each of the other crop hosts (Table 1). Survival of *C. kazak* adults averaged 52.7%, and although survival was lowest on chickpea, it was not significantly different ($P > 0.05$) to that on each of the other crop hosts. In the *H. didymator* experiment, recovery of *H. armigera* larvae averaged 86.8%. Apart from sorghum, larval recovery was high from all crop hosts. In the *C. kazak* experiment, *H. armigera* larval recovery averaged 86.7%, and was high for all crop hosts.

**Parasitism.** Parasitism of *H. armigera* larvae by *H. didymator* was significantly lower ($P < 0.05$) on chickpea than on any other crop host (Table 1). Similarly, *C. kazak* parasitised fewer *H. armigera* on chickpea than on each of the other crop hosts, but these differences were significant ($P < 0.05$) only from sorghum, sunflower and cotton. Significantly more ($P < 0.05$) *H. didymator* eggs were laid in parasitised hosts on sunflower than in those on any other host plant. There were significantly fewer ($P < 0.05$) *H. didymator* eggs laid in parasitised hosts on chickpea than on each of the other crop hosts except sorghum. For *C. kazak* there were no significant differences ($P > 0.05$) between crops in the number of eggs laid per parasitised host.

## Discussion

The low survival of *H. didymator* wasps on chickpea may have effectively reduced parasitism of *H. armigera* larvae. However, even where survival on chickpeas was higher for *C. kazak*, the parasitism level was still low. Low survival of *H. didymator* on chickpea is considered to be a direct result of interaction between the host plant and the parasitoid. Chickpea leaflets produce an extremely acidic exudate which is apparently detrimental to parasitoid survival and performance (Greathead and Girling 1982; Jalali *et al.* 1988). If malic acid is the disruptive agent, plant breeding to reduce or even eliminate malic acid secretion on leaflets may improve the suitability of chickpea for parasitoid activity. Some caution is needed as removal of malic acid may increase the suitability of chickpea for other pests.

Dissection of larval hosts 24 h after recovery from test cages was carried out to reduce host mortality which invariably occurred when rearing hosts to determine whether or not they were parasitised. Our parasitoid cultures were sometimes infected with the microbial pathogen *Streptococcus faecium* Orla-Jensen. As *S. faecium* can be transmitted to the host during oviposition

**Table 1.** Effect of host plant on survival of *H. didymator* and *C. kazak* adults, and recovery and parasitism of second-instar *H. armigera* in cage experiments (20 larvae exposed to three parasitoid pairs for 24 h).

| | Sunflower | Soybean | Cotton | Sorghum | Pigeonpea | Chickpea |
|---|---|---|---|---|---|---|
| *H. didymator* | | | | | | |
| % Wasp survival ± SE, n = 6 | 97.2 ± 2.8 a | 86.1 ± 8.0 ab | 97.2 ± 2.8 a | 75.0 ± 13.4 ab | 66.7 ± 9.6 b | 5.6 ± 3.5 c |
| % Larval recovery ± SE, n = 6 | 97.5 ± 1.7 a | 82.5 ± 9.7 a | 89.2 ± 4.7 a | 62.5 ± 12.0 b | 94.2 ± 1.5 a | 95.0 ± 2.2 a |
| % Parasitism ± SE, n = 6 | 85.0 ± 2.7 a | 82.1 ± 6.4 a | 64.7 ± 13.3 ab | 57.6 ± 7.7 b | 50.1 ± 3.9 b | 5.4 ± 2.0 c |
| No. eggs per parasitised host ± SE (range) | 2.8 ± 0.1 a (1-8) *n = 101 | 2.1 ± 0.2 bc (1-4) n = 83 | 2.2 ± 0.2 bc (1-7) n = 70 | 1.6 ± 0.2 cd (1-5) n = 45 | 2.2 ± 0.3 b (1-8) n = 57 | 1.3 ± 0.3 d (1-2) n = 6 |
| *C. kazak* | | | | | | |
| % Wasp survival ± SE, n = 6 | 69.4 ± 10.0 | 46.7 ± 9.4 | 58.3 ± 7.1 | 55.6 ± 7.0 | 47.2 ± 10.9 | 38.9 ± 5.6 |
| % Larval recovery ± SE, n = 6 | 91.7 ± 3.8 | 81.7 ± 1.7 | 85.8 ± 2.7 | 86.7 ± 3.1 | 83.3 ± 6.0 | 90.8 ± 4.0 |
| % Parasitism ± SE, n = 6 | 54.8 ± 11.7 ab | 26.6 ± 6.3 bcd | 44.5 ± 9.8 abc | 55.3 ± 13.8 a | 25.7 ± 8.3 cd | 11.8 ± 7 d |
| No. eggs per parasitised host ± SE (range) | 1.2 ± 0.1 (1-3) *n = 62 | 1.6 ± 0.3 (1-4) n = 26 | 1.7 ± 0.2 (1-5) n = 45 | 1.7 ± 0.3 (1-7) n = 58 | 1.4 ± 0.2 (1-4) n = 25 | 1.8 ± 0.7 (1-2) n = 12 |

Means within rows not followed by the same letter differ significantly ($P < 0.05$).
No letters within a row indicate no significant difference ($P > 0.05$).
*n = number of larvae dissected

and results in death of the host 2-4 d later, dissection circumvented host mortality that may have jeopardised a successful experiment. Dissection of larvae also provided information on the frequency distribution of parasitoid eggs. As has been shown for *M. demolitor*, if host larvae were reared through to determine parasitism levels, usually only one parasitoid developed per host even though more than one parasitoid egg may have been deposited per host (Strand *et al.* 1988). Dissection thus provided additional information on successful encounters between parasitoids and hosts. Some larvae were observed moving off the plant host onto the cage. While these larvae might be more frequently encountered by parasitoids, and thus more likely to have multiple eggs laid in them, the number of parasitised eggs per host was not significantly higher ($P > 0.05$) for either soybean or chickpea plants (Table 1) which had the most dense foliage in contact with the terylene cage cover.

While multiple eggs per host may reflect more encounters between parasitoids and host larvae, it is also possible that more than one egg was deposited during some host encounters. For example, *M. demolitor* laid 1-3 eggs per oviposition attempt in *Heliothis virescens* (F.) larvae (Strand *et al.* 1988). Multiple eggs per host may also suggest that neither *H. didymator* nor *C. kazak* differentiated between parasitised and unparasitised hosts. The high host and parasitoid densities used in these cage experiments probably resulted in far more encounters resulting in multiple oviposition than would normally occur under field conditions.

Inoculative releases of these introduced larval parasitoids into *Helicoverpa* spp. infested chickpea are unlikely to be successful. However, the data indicate the suitability of each of the major summer crops—sorghum, sunflower, cotton and soybean—as targets for exotic parasitoid releases. Pigeon pea is also suitable, but it is a relatively minor summer crop in Queensland. It must be emphasised that the levels of parasitism recorded on different host crops under cages may not be a reliable indicator of field performance as various long-range factors (Nordlund *et al.* 1989) not tested in cages could ultimately influence parasitism in the field. However, as indicated by parasitoid performance in the cage studies, releases would be best directed against *Helicoverpa* spp. in unsprayed summer crops, of which the majority would be sorghum and sunflower (McGahan *et al.* 1991). Parasitised *H. armigera* larvae have been consistently recovered immediately following (about 7 d later) releases of *C. kazak* into sorghum in southern Queensland (Murray unpubl.). With the adoption of sorghum midge-resistant varieties and the associated reduction in insecticide usage (Franzmann 1993), there is greater scope for improving biological control of *H. armigera* on sorghum through an increase in the mortality of middle-instar larvae caused by larval parasitoids.

## Acknowledgments

This project was partly funded by the Cotton Research and Development Corporation and the Grains Research and Development Corporation. Ms Debra Webster assisted with larval dissections.

## References

FRANZMANN, B. A. (1993). Ovipositional antixenosis to *Contarinia sorghicola* (Coquillett) (Diptera: Cecidomyiidae) in grain sorghum. J. Aust. ent. Soc. 32: 59-64.

GREATHEAD, D. J. and GIRLING, D. J. (1982). Possibilities for natural enemies in *Heliothis* management and the contribution of the Commonwealth Institute of Biological Control. *In* Reed, W. & Kumble, V. (eds). Proceedings of the international workshop on *Heliothis* management, pp. 147-158. ICRISAT: Patancheru.

JALALI, S. K., SINGH, S. P., KUMAR, P. and BALLAL, C. R. (1988). Influence of the food plants on the degree of parasitism of larvae of *Heliothis armigera* by *Cotesia kazak*. Entomophaga 33: 65-71.

MCGAHAN, P., LLOYD, R. J. and RYNNE, K. P. (1991). The cost of *Heliothis* in Queensland crops. *In* Twine, P. H. and Zalucki, M. P. (eds). A review of Heliothis research in Australia, pp. 11-28. QDPI Conference and Workshop Series QC91006: Brisbane.

MICHAEL, P. J. (1989). Importation and establishment of new natural enemies of *Heliothis* spp. (Lep.: Noctuidae) in Australia. *In* King, E. G. and Jackson, R. D. (eds). Proceedings of the workshop on biological control of heliothis: increasing the effectiveness of natural enemies, pp. 363-373. Far Eastern Regional Research Office, U.S. Department of Agriculture: New Delhi.

MURRAY, D., RYNNE, K. and COLE, P. (1992). Exotic partners imported to help take on our local grubs. Australian Grain 2: i-ii.

NORDLUND, D. A., LEWIS, W. J. and TUMLINSON, J. H. (1989). Habitat and host location behaviour of *Microplitis croceipes*. Southwestern Ent. Suppl. 12: 39-48.

POWELL, J. E. and HARTLEY, G. G. (1987). Rearing *Microplitis croceipes* (Hymenoptera: Braconidae) and other parasitoids of Noctuidae with multicellular host-rearing trays. J. econ. Ent. 80: 968-971.

RIDLAND, P. M., SMITH, A. M., MCDONALD, G. and COLE, P. G. (1993). Pest management of *Helicoverpa punctigera* (Wallengren) (Lepidoptera: Noctuidae) in field peas. *In* Corey, S. A., Dall, D. J. and Milne, W. M. (eds). Pest control and sustainable agriculture, pp. 229-232. CSIRO: Australia.

STEEL, R. G. D. and TORRIE, J. H. (1980). Principles and procedures of statistics, 2nd edition. McGraw-Hill: New York.

STRAND, M. R., JOHNSON, J. A. and CULIN, J. D. (1988). Developmental interactions between the parasitoid *Microplitis demolitor* (Hymenoptera: Braconidae) and its host *Heliothis virescens* (Lepidoptera: Noctuidae). Ann. ent. Soc. Am. 81: 822-830.

TEAKLE, R. E. and JENSEN, J. M. (1985). *Heliothis punctigera*. *In* P. Singh and R. F. Moore (eds). Handbook of insect rearing, 2: 313-322. Elsevier: Amsterdam.

ZALUCKI, M. P., DAGLISH, G., FIREMPONG, S. and TWINE, P. (1986). The biology and ecology of *Heliothis armigera* (Hübner) and *H. punctigera* Wallengren (Lepidoptera: Noctuidae) in Australia: what do we know? Aust. J. Zool. 34: 779-814.

(Accepted 4 October 1994)