Ichneumon promissorius (Erichson) (Hymenoptera: Ichneumonidae): Factors Affecting Fecundity, Oviposition, and Longevity[1]

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ABSTRACT *Ichneumon* (=*Pterocormus*) *promissorius* (Erichson) (Hymenoptera: Ichneumomidae), a native of Australia, is a pupal parasitoid which searches the soil surface for host pupation sites, burrows into a pupal gallery, and oviposits in the host pupa. Fecundity and rate of oviposition were influenced by the mating status of females, the host from which females developed, and the frequency in which females were exposed to hosts. Virgin females continued laying eggs many days after mated females had stopped. A preoviposition period of 17 d in mated females did not affect the oviposition curve or the number of eggs laid, suggesting that the oogenesis is arrested until female wasps are exposed to host pupae. Female wasps exposed to pupae for 24 h every fifth day lived longer than female wasps continuously exposed to pupae. However, females that were continuously exposed to pupae laid more eggs. Virgin females reared on *Spodoptera exigua* (Hübner) pupae laid fewer eggs than virgin females reared on *Helicoverpa zea* (Boddie) pupae. These data will be important in evaluating the potential of *I. promissorius* as a biological control agent for pest species in the United States and will be useful in developing laboratory rearing procedures for *I. promissorius*.

KEY WORDS Biological control, parasitoid, *Helicoverpa zea*.

Ichneumon (=*Pterocormus*) *promissorius* (Erichson) is a native to Australia where it has been collected from *Helicoverpa armigera* (Hübner) and *H. punctigera* Wallengren (Wilson 1983, Fitt and Daly 1990). This parasitoid searches the soil surface for host pupation sites, burrows into a pupal gallery, and oviposits into the host pupae. In limited studies in Australia, *I. promissorius* parasitized up to 20% of the *Helicoverpa* pupa found beneath cotton plants (Fitt and Daly 1990). *I. promissorius* was imported into the United States and subsequently released from quarantine for laboratory studies.

Initial studies revealed that *I. promissorius* developed on several native U. S. lepidopteran species, including *Spodoptera, Helicoverpa,* and *Heliothis* spp. but accepts *Heliothis*/*Helicoverpa* spp. more readily than other species (Carpenter et al. 1994).

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Because of similarities between the habitats and host plants of *H. zea* (Boddie) and *H. armigera,* and because no pupal parasitoid has been reported for *H. zea* (Pair and Gross 1989), Carpenter et al. (1994) suggested that the potential for colonizing *I. promissorius* in the U. S. is very good. In this study, I examined the influence of host species, host availability, and mating status on *I. promissorius* fecundity and oviposition.

Materials and Methods

Lepidopteran species used in this study were reared in 30-ml plastic cups containing a meridic diet (Burton 1969) at a photoperiod of 14:10 (L:D) h and temperature of 29: 24 ± 1°C (L:D). The laboratory colony of *I. promissorius* was reared on *H. zea* pupae except where stated otherwise. Parasitized pupae were held at a temperature of 28 ± 1°C until wasps emerged. Male and female wasps were held together in plywood cages described by Gross and Young (1984) and maintained on honey and water.

The number of eggs laid by female wasps and their daily rate of oviposition and longevity were recorded for each of the following treatments: virgin females reared on *H. zea*; mated females reared on *H. zea*; virgin females reared on *S. exigua* (Hübner); mated females exposed to host pupae for 24 h every fifth day; and mated females (reared on *H. zea*) held for a forced preoviposition period of 17 d (females can begin oviposition 1 d after emergence). Females (n = 10) in each treatment were placed in individual plastic containers (480 ml, 10 cm diam) fitted with a screened lid and were supplied with honey and water. Five *H. zea* host pupae were placed in each container for 24 h every day unless stated otherwise. All host pupae were dissected and the number of eggs laid was recorded.

The mean number of eggs laid by wasps and the mean longevity of wasps from different treatments were compared using *t* tests. The daily rate of oviposition was subjected to regression analysis (PROC GLM) using the cumulative mean number of eggs laid per day (SAS Institute 1989). Differences between the slopes of regression lines were compared using the *t*-test for unequal variances. The mean weight of 10 *H. zea* pupae and 10 *S. exigua* pupae, and the mean weight of 10 *I. promissorius* wasps reared from *H. zea* pupae and 10 *I. promissorius* wasps reared from *S. exigus* pupae were compared using the *t*-test.

Results and Discussion

Fecundity and rate of oviposition by *I. promissorius* were influenced by the mating status of females, the host from which females developed, and the frequency in which females were exposed to hosts. Virgin females laid their complement of eggs at a significantly ($t = 2.46$; df = 66; $P < 0.01$) faster rate than mated females, and virgin females continued laying eggs 12 d after mated females had stopped laying eggs (Fig. 1). As a result, significantly more eggs were produced by virgin females ($\bar{x} = 174.9$ eggs/female) than from mated females ($\bar{x} = 96.4$ eggs/female) (Table 1). Also, virgin females lived significantly longer ($\bar{x} = 43.0$ d) than mated females ($\bar{x} = 27.5$ d) (Table 2).

A preoviposition period of 17 d in mated females significantly ($t = 10.65$; df = 66; $P = 0.0001$) reduced their oviposition rate (Fig. 2) but did not significantly

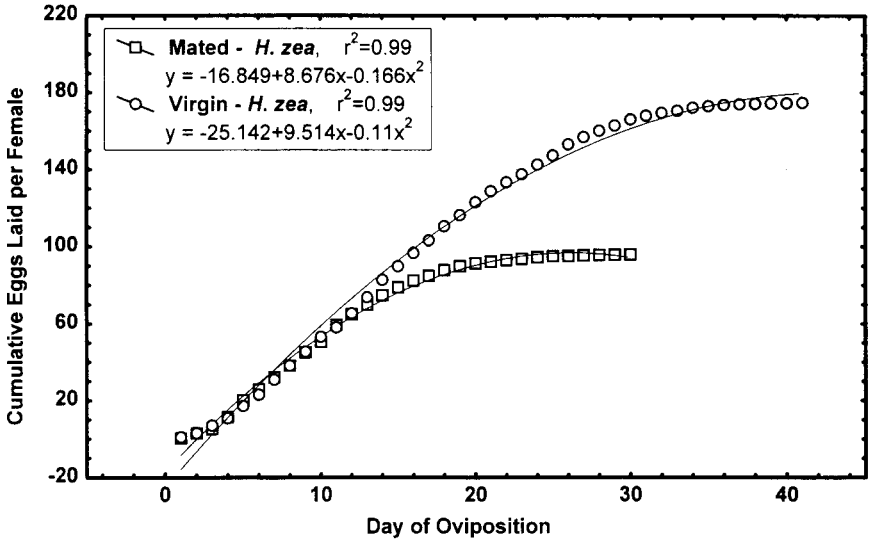

Fig. 1. Oviposition by mated and virgin *I. promissorius* when hosts were available continuously.

change the number of eggs laid per female wasp (Table 1). These data suggest that oogenesis may be arrested until female wasps are exposed to host pupae. The forced preoviposition period of 17 d significantly extended the longevity of female wasps by 23 d ($\bar{x}$ = 50.5 d) (Table 2).

Female wasps exposed to host pupae for 24 h every fifth day lived significantly longer than females continuously exposed to pupae (Table 2). However, female wasps continuously exposed to pupae laid significantly more eggs (Table 1) and laid their complement of eggs at a significantly (t = 16.18; df = 45; $P < 0.0001$) faster rate than females exposed to pupae for 24 h every 5th day (Fig. 3).

Virgin female wasps reared on *H. zea* pupae laid their complement of eggs at a significantly (t = 62.39; df = 70, $P < 0.0001$) faster rate than virgin females reared on *S. exigua* pupae, and virgin females reared on *H. zea* pupae continued laying eggs several days after virgin females reared on *S. exigua* had stopped laying eggs (Fig. 4). As a result, significantly more eggs were produced by virgin females reared on *H. zea* (174.9 eggs/female) than by virgin females reared on *S. exigua* (95.4 eggs/female) (Table 1). Also, virgin female wasps reared on *H. zea* lived significantly longer (43.0 d) than virgin female wasps reared on *S. exigua* (26.4 d) (Table 2).

Mannion et al. (1994) found that there was a significant positive relationship between host pupal weight and weight of adult *I. promissorius*. In this study,

Table 1. Effect of host species, host availability, mating status, and preoviposition period on the fecundity of *Ichneumon promissorius*.

Treatment comparisons*	n	Number of eggs laid: Mean ± S.D.	Range	df	T	Prob > |T|
1-d-old mated wasps	10	96.4 ± 50.6	34 - 176	18	0.6737	0.5091
17-d-old mated wasps	10	84.0 ± 28.8	38 - 144			
Virgin wasps reared on *S. exigua*	9	95.4 ± 47.4	7 - 163	17	-3.5285	0.0026
Virgin wasps reared on *H. zea*	10	174.9 ± 50.4	102 - 258			
Continuous	10	96.4 ± 50.6	34 - 176	9.4**	4.2209	0.0021
Every 5th day	10	28.2 ± 7.2	15 - 39			
Mated wasps reared on *H. zea*	10	96.4 ± 50.6	34 - 176	18	-3.4772	0.0027
Virgin wasps reared on *H. zea*	10	174.9 ± 50.4	102 - 258			

* 1-d-old mated = mated female wasps (reared on *H. zea*) that were given a continuous supply of *H. zea* pupae after a 1-d preoviposition period.
17-d-old mated = mated female wasps (reared on *H. zea*) that were given a continuous supply of *H. zea* pupae after a 17-d preoviposition period.
Continuous = mated female wasps (reared on *H. zea*) that were given a continuous supply of *H. zea* pupae after a 1-d preoviposition period.
Every 5th day = mated female moths (reared on *H. zea*) were exposed to *H. zea* pupae for 24 h every 5th day.
** Variances are unequal, $F = 49.9$, df = (9,9), Prob. > $F = 0.00001$.

Table 2. Effect of host species, host availability, mating status, and preoviposition period on the longevity of *Ichneumon promissorius* female wasps.

Treatment comparisons*	n	Number of days lived: Mean ± S.D.	Range	df	T	Prob > |T|
1-d-old mated wasps	10	27.5 ± 8.5	15 - 39	18	-5.6968	0.0001
17-d-old mated wasps	10	50.5 ± 9.5	35 - 69			
Virgin wasps reared on *S. exigua*	9	26.4 ± 7.1	15 - 36	17	-3.9561	0.0010
Virgin wasps reared on *H. zea*	10	43.0 ± 10.6	24 - 60			
Continuous	10	27.5 ± 8.5	15 - 39	18	-5.0781	0.0002
Every 5th day	10	43.0 ± 4.6	37 - 51			
Mated wasps reared on *H. zea*	10	27.5 ± 8.5	15 - 39	18	-3.6173	0.0020
Virgin wasps reared on *H. zea*	10	43.0 ± 10.6	37 - 51			

* 1-d-old mated = mated female wasps (reared on *H. zea*) that were given a continuous supply of *H. zea* pupae after a 1-d preoviposition period.
17-d-old mated = mated female wasps (reared on *H. zea*) that were given a continuous supply of *H. zea* pupae after a 17-d preoviposition period.
Continuous = mated female wasps (reared on *H. zea*) that were given a continuous supply of *H. zea* pupae after a 1-d preoviposition period.
Every 5th day = mated female moths (reared on *H. zea*) were exposed to *H. zea* pupae for 24 h every 5th day.

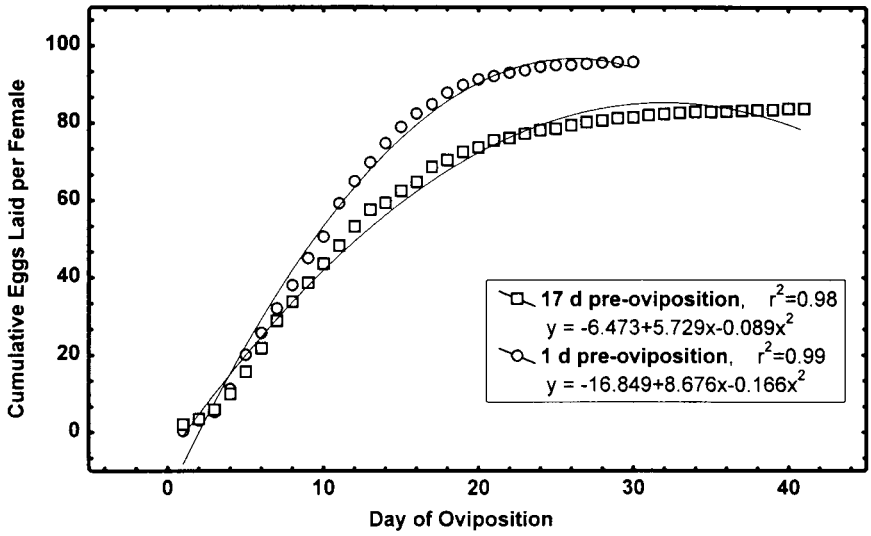

Fig. 2. Oviposition by *I. promissorius* following preoviposition periods of 1 d and 17 d.

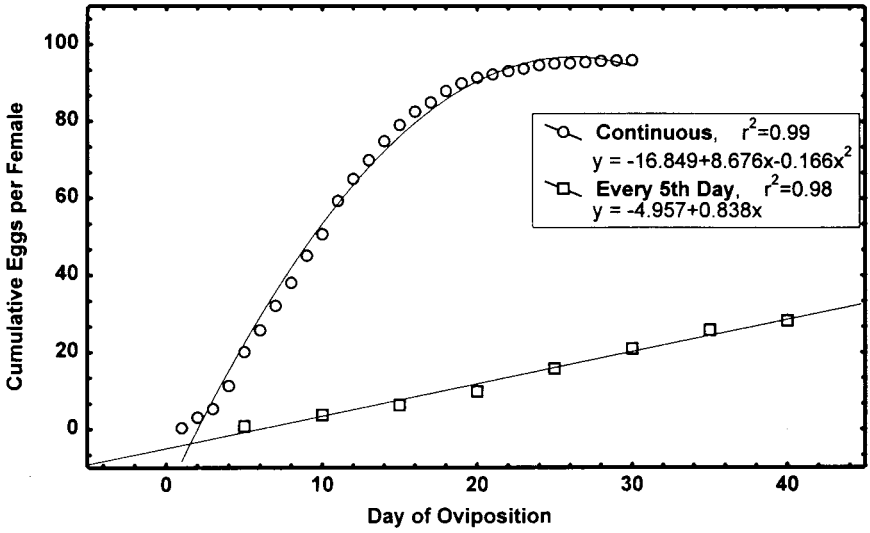

Fig. 3. Oviposition by *I. promissorius* when hosts were available for 24 h every 5th day and when hosts were available continuously.

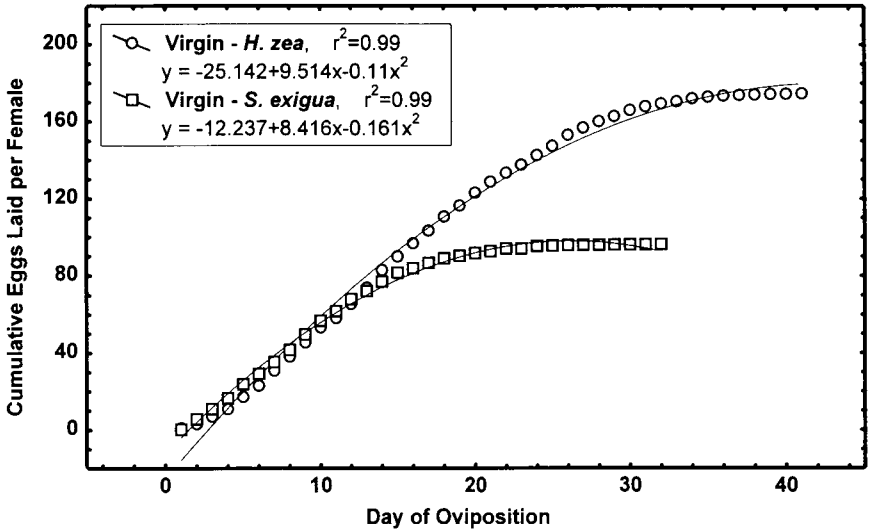

Fig. 4. Oviposition of *I. promissorius* when wasps reared on *Helicoverpa zea* and *Spodoptera exigua* were exposed to hosts continuously.

mean (± S.D.) pupal weight of *S. exigua* (157 ± 0.018 mg) was less than the mean (± S.D.) pupal weight of *H. zea* (510 ± 019 mg) ($t = 46.7$; $P < 0.0001$), and mean (± S.D.) weight of *I. promissorius* wasps reared from *S. exigua* pupae (28.7 ± 0.005 mg) was less than the mean (± S.D.) weight of *I. promissorius* wasps reared from *H. zea* pupae (61.0 ± 0.002 mg) ($t = 15.4$; $P < 0.0001$). Therefore, host size as well as host species may have contributed to the differences in weight of *I. promissorius* wasps and ultimately contributed to the differences in fecundity, longevity, and oviposition between wasps reared on *S. exigua* and *H. zea* pupae.

Data from this study suggest that *I. promissorius* females budget their energy expenditures and regulate oogensis to maximize their reproductive potential. Virgin females are more fecund and longer lived which increases the chance that they will find a mate, even if it is with their sons. In the absence of host pupae for mated females (e.g., between host generation cycles), longevity of wasps is extended and oviposition is delayed without a reduction in fecundity. Longevity also is extended in mated *I. promissorius* females that have infrequent encounters with host pupae.

Data from these studies will be useful in developing laboratory rearing procedures for *I. promissorius*. These data also will be important in evaluating the potential of *I. promissorius* as a biological control agent against pest species in the United States.

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References Cited

Burton, R. L. 1969. Mass rearing the corn earworm in the laboratory. U. S. Dep. Agric. Res. Serv. ARS (Ser.) 33-134, Washington, DC.

Carpenter, J. E., S. D. Pair and G. P. Fitt. 1994. *Ichneumon promissorius* (Erich) (Hymenoptera: Ichneumonidae): development on North American hosts. J. Econ. Entomol. 87: 929-932.

Fitt, G. P. and J. C. Daly. 1990. Abundance of overwintering pupae and the spring generation of *Helicoverpa* spp. (Lepidoptera: Noctuidae) in northern New South Wales, Australia: implications for pest management. J. Econ. Entomol. 83: 1827-1836.

Gross, H. R., Jr. and J. R. Young. 1984. *Archytus marmoratus* (Diptera: Tachinidae): screened-cage evaluations of selected densities of adults against larval populations of *Heliothis zea* and *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on whorl and tassel stage corn. Environ. Entomol. 13: 157-161.

Mannion, C. M., J. E. Carpenter, B. R. Wiseman and H. R. Gross. 1995. Effect of host corn earworm (Lepidoptera: Noctuidae) reared on meridic diet containing silks from a resistant corn genotype on *Archytus marmoratus* (Diptera: Tachinidae) and *Ichneumon promissorius* (Hymenoptera: Ichneumonidae). Environ. Entomol. (in press).

Pair, S. D. and H. R. Gross. 1989. Seasonal incidence of fall armyworm (Lepidoptera: Noctuidae) pupal parasitism in corn by *Diapetimorpha introita* and *Cryptus albitarsis* (Hymenoptera: Ichneumonidae). J. Entomol. Sci. 24: 339-343.

SAS Institute Inc. 1989. SAS/Stat User's Guide, Version 6, Fourth Ed., Volume 1. SAS Institute Inc., Cary, NC. 943 pp.

Wilson, A. G. L. 1983. Abundance and mortality of overwintering *Heliothis* spp. J. Aust. Ent. Soc. 22: 191-199.