

Effects of Age and Host Number on Reproductive Biology of *Allorhogas pyralophagus* (Hymenoptera: Braconidae) Attacking the Mexican Rice Borer (Lepidoptera: Pyralidae)

JACQUE L. HARBISON,¹ JESUSA CRISOSTOMO LEGASPI, STEPHANIE L. FABRITIUS,¹
R. R. SALDAÑA, B. C. LEGASPI, JR., AND A. ENKEGAARD²

Texas Agricultural Experiment Station, The Texas A&M University System, 2415 East Highway 83, Weslaco, TX 78596

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ABSTRACT Laboratory studies were conducted to determine the effects of parasitoid age and number of hosts available on selected attributes of parasitoid reproduction. Newly emerged mated females of the gregarious parasitoid *Allorhogas pyralophagus* Marsh were divided into groups ranging in age from 5 to 12 d. For each age class, individual females were exposed to one, two, four, and eight hosts of the Mexican rice borer, *Eoreuma loftini* (Dyar), over a 24-h period. For each age class, number of eggs laid and hosts attacked were fitted to nonlinear oviposition models and type II functional response curves, respectively. Numbers of eggs laid per female per day were highest at ≈ 20 eggs per day in 6-d-old females, declining to ≈ 5 per day in 12-d-old females. The functional response curves showed declining attack rates with time, from ≈ 2.0 hosts per day in 5-d-old females, to ≈ 1.0 in 12-d-old parasitoids. Percentage of progeny emergence was not affected by either parasitoid age or number of hosts available. Percentage of female progeny also was not affected by parasitoid age, remaining female-biased.

KEY WORDS *Allorhogas pyralophagus*, *Eoreuma loftini*, functional response, reproduction

THE MEXICAN RICE borer, *Eoreuma loftini* (Dyar), injures $\approx 20\%$ of sugarcane internodes in south Texas, causing estimated annual losses of between \$10 and 20 million (Legaspi et al. 1999). Growers do not treat sugarcane with insecticides, because these are largely perceived as ineffective and uneconomical. To mitigate losses, >20 parasitoid species have been released as biological control agents against *E. loftini* since 1982 (Legaspi et al. 1997), but current seasonal parasitism levels are only $\approx 6\%$ (Meagher et al. 1998). Smith et al. (1987) released over 2 million *Allorhogas pyralophagus* Marsh imported from Mexico, and reported consistent recoveries, even after December freezes. Other common parasitoids of *E. loftini* larvae in south Texas include two indigenous braconids, *Chelonus sonorensis* Cameron and *Digonogastra solitaria* Wharton & Quicke, and an exotic braconid, *Alabagrus stigma* (Brullé) (from Bolivia). Despite historical lack of success, biological control agents for Mexican rice borer control continue to receive much interest, in part because insecticides are not considered a viable control option.

Allorhogas pyralophagus is a gregarious, external larval parasitoid of *E. loftini* (Smith et al. 1993) and other stalkboring pyralids, e.g., *Diatraea saccharalis* (F.), and *D. grandiosella* Dyar (Overholt and Smith 1990a, 1990b). Under natural conditions, the female parasitoid locates larvae feeding within the cane stalk, and lays its eggs on the host by drilling into the plant tissue with its ovipositor. *Allorhogas pyralophagus* is unable to recognize hosts unless they are enclosed within a stem or artificial substitute, such as drinking straws or corrugated cardboard (Smith et al. 1993). Melton and Browning (1986) studied the life history and reproductive biology of *A. pyralophagus* as a parasitoid of *E. loftini*. Fecundity ranged from 68.0 to 82.3 eggs per female from 20 to 32°C. Median life span for ovipositing females was 57.4, 24.0, and 32.5 d at 20, 26, and 32°C, respectively.

We examined the effects of parasitoid age and number of hosts available on the number of hosts attacked, eggs laid, progeny emergence, and progeny sex ratio in *A. pyralophagus* attacking *E. loftini*. The information should prove useful in designing optimal mass rearing or biological control programs.

Materials and Methods

Insect Cultures. *Eoreuma loftini* larvae were reared at the Texas Agricultural Experiment Station in Weslaco, TX, using an artificial diet (Martinez et al. 1988). The culture of *A. pyralophagus* was reared using *E. loftini* as hosts in paper straws and maintained in the

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¹ Department of Biology, Southwestern University, 1001 E. University Avenue, Georgetown, TX 78626.

² Department of Crop Protection, Danish Institute of Agricultural Sciences, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark.

laboratory under ambient environmental conditions. The parasitoid oviposits through the paper straw into the larval hosts (Smith et al. 1993). A honey solution is used for adult parasitoid nutrition. Stalkborer colonies were collected originally from the field and maintained in the laboratory for ≈ 1 yr. The parasitoid colony is ≈ 3 yr old, although field material is periodically infused at ≈ 12 -mo intervals. Voucher specimens for both species are deposited at the Department of Entomology, Texas A&M University, College Station, TX.

Experimental Procedure. Newly emerged *A. pyralophagus* males and females were confined together in glass cages to allow mating. Females were divided into age classes at 1-d intervals, ranging from 5 to 12 d old, inclusive. For each age class, individual parasitoids were exposed to one, two, four, or eight, fourth- or fifth-instar borer hosts. Each age \times total number combination was replicated eight times. Therefore, a total of 256 replicates was required (8 age classes \times 4 host densities \times 8 replicates). Each replicate was performed in a glass vial measuring 2.5 by 10.2 cm, except for those requiring eight hosts, in which case 3.2 by 15.2-cm vials were used. Borer larvae were weighed before experimentation, and inserted into paper drinking straws (2.54 cm long) (Melton and Browning 1986, Smith et al. 1993); the straw ends were plugged with artificial diet. One female parasitoid of the appropriate age was placed in each vial, which was then plugged with a cotton ball. Parasitoids selected for experimentation were used only once. Parasitoids were allowed 24 h for parasitization, after which they were removed from the vials using an aspirator.

The straws containing the larvae were then cut lengthwise and examined under a microscope. All newly laid parasitoid eggs were counted and recorded. Straws containing eggs with host larvae were placed in covered 18.5-ml plastic cups, and monitored for emergence. Straws without eggs were discarded. The number and sex of parasitoids that emerged were recorded. All experiments were conducted under ambient laboratory conditions, which were $22 \pm 2^\circ\text{C}$, $60 \pm 5\%$ RH, and a photoperiod of 12:12 (L:D) h.

Data Analysis. Total number of eggs laid and hosts attacked were analyzed separately for each parasitoid age class. The number of eggs laid was fitted to the oviposition model of Enkegaard (1993): $egg_mean = aN \exp(-eN)$, where egg_mean is mean total number of eggs laid, N is number of hosts available, and a and e are parameters. The number of hosts attacked was fitted to type II functional response curves (Holling 1959): $N_a = (a'NT)/(1+a'T_hN)$, where N_a is mean number of hosts attacked, a' is instantaneous attack, T is searching time ($T = 1.0$ for 1 d), N is hosts available and T_h is handling time. Curves were fitted using least squares nonlinear regression.

The combined effects of parasitoid age and host number on the number of eggs laid were fitted to the model: $egg_mean = (a + (bA)) N \exp(-eAN)$, where A is parasitoid age, N is hosts available, and a , b , and e are parameters (Enkegaard 1993). Percentage emergence was calculated as (the number of parasitoids emerging/number of eggs laid) $\times 100$. Percentage of females was calculated as (numbers of females/total emergent parasitoids) $\times 100$. The effects of parasitoid age and number of hosts available on numbers of hosts attacked, total number of eggs laid, eggs laid per host, percentage emergence and female sex ratio were analyzed using two-way analysis of variance (ANOVA). The effects of parasitoid age and weight of host larvae on number of eggs laid per borer, percentage emergence and percentage of female progeny were analyzed using multiple regression. Percentage data were transformed using the arcsine-square root method, but are presented as nontransformed means (Sokal and Rohlf 1995).

Results

The Enkegaard model was found to represent the number of eggs laid as a function of hosts available (Fig. 1; Table 1); with the exception of 7-d-old females, corrected R^2 -values were 0.61–0.97. The number of eggs laid tended to increase as the number of hosts available was increased from one to four, and then reached a plateau or declined slightly at eight hosts. Maximal oviposition rate was ≈ 20 eggs per day in 6-d-old females (Fig. 1B). The oviposition curves also were lower in the older parasitoids, indicating a tendency to lay fewer eggs in older females (9–12 d old). Parasitoids that were 12 d old laid only approximately five eggs daily (Fig. 1H). *Allorhogas pyralophagus* also displayed typical type II functional response curves, reaching an upper asymptote of approximately two hosts attacked per day in younger females, declining to approximately one per day in 12-d-old parasitoids (Fig. 2). The decline in total number of eggs laid is reflected in the number of hosts attacked (Table 2).

Results

The combined effects of parasitoid age and number of hosts available on the mean number of eggs laid was described by the equation: $egg_mean = (10.4556 - (0.27893A)) N \exp(-0.02772AN)$, where egg_mean is the mean number of eggs laid, A is parasitoid age, and N is number of hosts available (standard error of parameter estimates 1.87855, 0.2237, 0.00324, respectively; corrected $R^2 = 0.57$). The surface generated and mean egg number illustrate the decline in the number of eggs laid by older parasitoids, as well as the nonlinear increase in oviposition due to increasing host density (Fig. 3).

Parasitoid age and number of hosts available both significantly affected the number of hosts attacked (respectively, $F = 5.73$; $df = 7, 229$; $P < 0.01$; $F = 26.94$; $df = 3, 229$; $P < 0.01$; age \times hosts: $F = 1.14$; $df = 21, 229$; $P = 0.30$). Number of hosts attacked declined with age and increased with the number of hosts available. Total number of eggs laid was significantly affected by parasitoid age ($F = 11.34$; $df = 7, 229$; $P < 0.01$) and number of hosts ($F = 8.80$; $df = 3, 229$; $P < 0.01$) (age \times hosts: $F = 0.63$; $df = 21, 229$; $P = 0.89$). Total number of eggs laid declined with age and increased with the number of hosts available. The number of eggs laid per host declined with parasitoid age ($F = 9.65$; $df = 7, 229$; $P < 0.01$) and number of hosts available ($F = 22.14$;

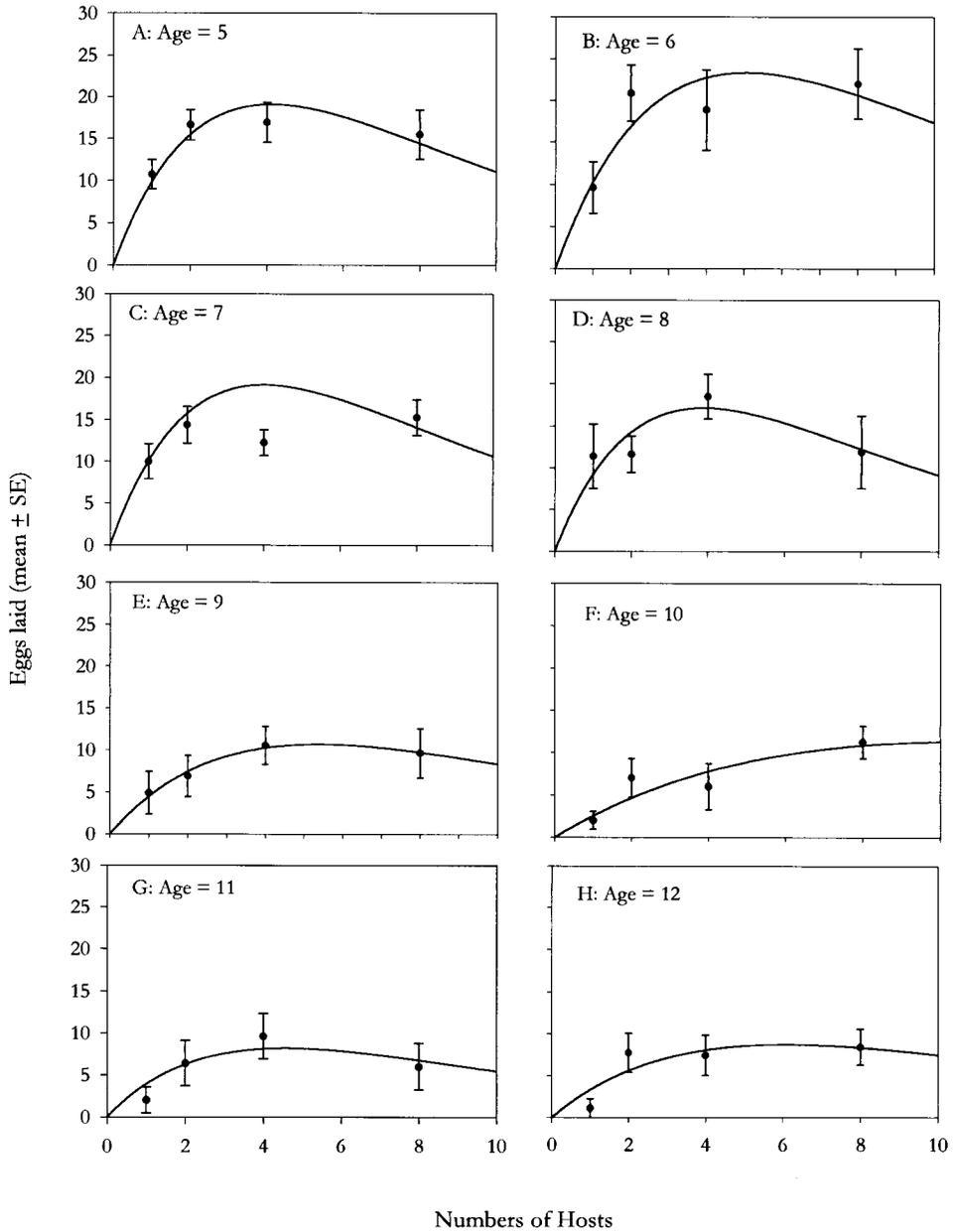


Fig. 1. Mean total number of eggs laid by female *A. pyralophagus* ranging in age from 5 to 12 d, on different numbers of host *E. loftini* larvae. The curve drawn is given by the equation $egg_mean = aH \exp(-eH)$, where egg_mean is mean number of eggs laid, H is number of hosts available, and a and e are parameters (based on Enkegaard 1993). Parameter estimates are given in Table 1.

df = 3, 229; $P < 0.01$) (age \times hosts: $F = 1.93$; df = 21, 229; $P < 0.05$) (Table 3). The highest mean number of eggs per host was found in 5-d-old parasitoids exposed to a single host (10.8 eggs per host). Increasing parasitoid age and number of hosts available resulted in a decline to 1.05 eggs per host in 12-d-old parasitoids given eight hosts (Table 3).

The effects of parasitoid age and number of hosts available on percentage emergence and progeny sex

ratio are summarized in Table 3. Percentage emergence was not affected by either parasitoid age ($F = 1.78$; df = 7, 170; $P = 0.09$) or number of hosts available ($F = 0.88$; df = 3, 170; $P = 0.45$) (age \times hosts: $F = 1.0$; df = 21, 170; $P = 0.46$). Progeny sex ratio was not affected by parasitoid age ($F = 1.07$; df = 7, 153; $P = 0.38$), but was affected by the number of hosts available ($F = 4.0$; df = 3, 153; $P < 0.01$) (age \times hosts: $F = 1.18$; df = 21, 153; $P = 0.28$). At host densities of one,

Table 1. Parameter estimates for oviposition model using different ages of *Allorhogas pyralophagus* attacking *Eoreuma loftini*

Age, d	<i>a</i>	SE (<i>a</i>)	<i>e</i>	SE (<i>e</i>)	corr R ²
5	12.59911	1.61985	0.24274	0.02727	0.69
6	12.55713	2.92662	0.19789	0.04442	0.65
7 ^a	13.00000	—	0.25000	—	—
8	11.97141	2.26388	0.25707	0.04156	0.61
9	5.38604	0.36161	0.18648	0.01247	0.97
10	2.79320	1.09959	0.09037	0.06103	0.79
11	4.86272	1.38209	0.21832	0.05681	0.78
12	3.90582	1.43263	0.16476	0.06502	0.72

The model is $egg_mean = aH \exp(-eH)$ where *egg_mean* is mean numbers of eggs laid, *H* is numbers of hosts available, and *a* and *e* are parameters (based on Enkegaard 1993).

^a Estimated by visual inspection; regression model did not converge.

two, four, and eight borers, pooled sex ratio was 77.6% ± 3.6 (mean ± SE; *n* = 33), 74.3% ± 3.0 (*n* = 47), 82.0% ± 2.1 (*n* = 58), and 70.5% ± 3.4 (*n* = 47) female, respectively (all ranges, 0–100).

Number of eggs laid per host decreased as a function of parasitoid age, but increased with host weight: $Y = 3.66831 - 0.47351A + 58.12795W$; where *Y* is number of eggs laid, *A* is parasitoid age, and *W* is weight of the host (g) (standard error values 1.18, 0.07, and 17.94, respectively; *t*-values = 3.11, 6.72, and 3.24, respectively; *P* values all < 0.01; regression $F = 27.0$, $P < 0.01$). Percentage of progeny emergence was not affected by either parasitoid age, nor weight of the larval hosts ($F = 0.025$, $P = 0.98$). Percentage of female progeny also was not affected either by parasitoid age or host weight ($F = 0.24$, $P = 0.79$).

Discussion

Allorhogas pyralophagus was imported from Mexico in 1981 as part of a biological control program against *E. loftini* in Texas sugarcane. In field cage experiments conducted in Weslaco, TX, Hawkins et al. (1987) found that *A. pyralophagus* parasitized ≈25% of *E. loftini* hosts available. However, complete control was deemed unlikely because the parasitoid could not penetrate deep into the sugarcane stalks. Continued recovery of the parasitoid, albeit at low levels, indicates establishment (Legaspi et al. 1997, Meagher et al. 1998). Additionally, *A. pyralophagus* has been considered for control of other stalkboring lepidopterous pests of graminaceous crops (Melton and Browning 1986). However, evaluations in commercial corn fields in the Texas High Plains resulted in <4% annual parasitism of the southwestern corn borer, *D. grandiosella* (Overholt and Smith 1990b). About 24,000 individuals of *A. pyralophagus* were released in corn and sorghum fields in south Texas in 1983, and ≈85,000 in 1984–1985 against several species of stalkboring Pyralidae (Youm et al. 1990). Only six borers were determined to be parasitized by *A. pyralophagus*, from over 640 recovered. Because the parasitoid has achieved some level of establishment and significant biological control is unlikely, releases of *A. pyralophagus* in south Texas

sugarcane fields were halted after 1997. The intent of this study was more for understanding the biology of *A. pyralophagus*, rather than as an evaluation of a potential biological control agent.

With the exception of 7-d-old females, the oviposition patterns of *A. pyralophagus* were adequately described by the Enkegaard (1993) model. The Enkegaard model was initially used to describe oviposition rates as a function of time, rather than host numbers as in this article. The model allowed for declines in oviposition rates in older parasitoids, while maintaining the biological reality of forcing the curve through the origin. Oviposition rates of *A. pyralophagus* were found to increase with host numbers, reaching an age-specific maximum. The Enkegaard model described these patterns adequately, as well as cases wherein oviposition rates appeared to decline at a host density of eight (e.g., ages 8 and 11 d). These results are similar to those of Melton and Browning (1986) who reported maximal oviposition rates of 4–12 eggs/female/d within the first 5 d of emergence at temperatures of 26 and 32°C. As cautionary notes, the oviposition surface (Fig. 3) should not be extrapolated beyond the given data set, otherwise parasitoids of age 0 would have high levels of fecundity. Larger vials were also used to accommodate eight straws, as opposed to four or fewer; although the difference should not affect the results materially.

Allorhogas pyralophagus exhibited a typical type II functional response, reaching a maximum of ≈2.0 hosts attacked per 24-h period in females aged 5–8 d. In older parasitoids, the maximum number attacked was ≈1.0 hosts per 24-h period, with the exception of 10-d-old parasitoids (which also attacked ≈2.0 hosts). The attack parameter *a'* tended to decrease with host density, whereas the handling time *T_h* tended to increase (Table 2). Both effects combine to reduce attack rates, as previously show by the oviposition models. Overholt and Smith (1990a) also described a type II functional response for *A. pyralophagus* attacking *D. grandiosella*. However, direct comparison with this study is complicated by the different experimental protocols employed as Overholt and Smith (1990a) conducted a field study using enclosures.

Number of eggs laid per host was variable. Melton and Browning (1986) found a mean of 6.97 eggs per host, with a range of 1–44. We found a mean of 4.25 eggs per host (SE = 0.3; range, 0–26; *n* = 261) over all treatments. For those females presented with single hosts, the mean number of eggs laid per host was 6.54 (SE = 0.94; range, 0–26; *n* = 63).

Percentages of progeny emergence and sex ratio showed no effects due to parasitoid age or number of hosts available, except for some variations in sex ratio due to number of hosts available (Table 3). However, no consistent trend was found resulting in either decreasing or increasing female progeny with hosts available. Overall, *A. pyralophagus* exhibited female-biased progeny sex ratios, supporting the observation of Overholt and Smith (1990a) who reported 69.4% female progeny.

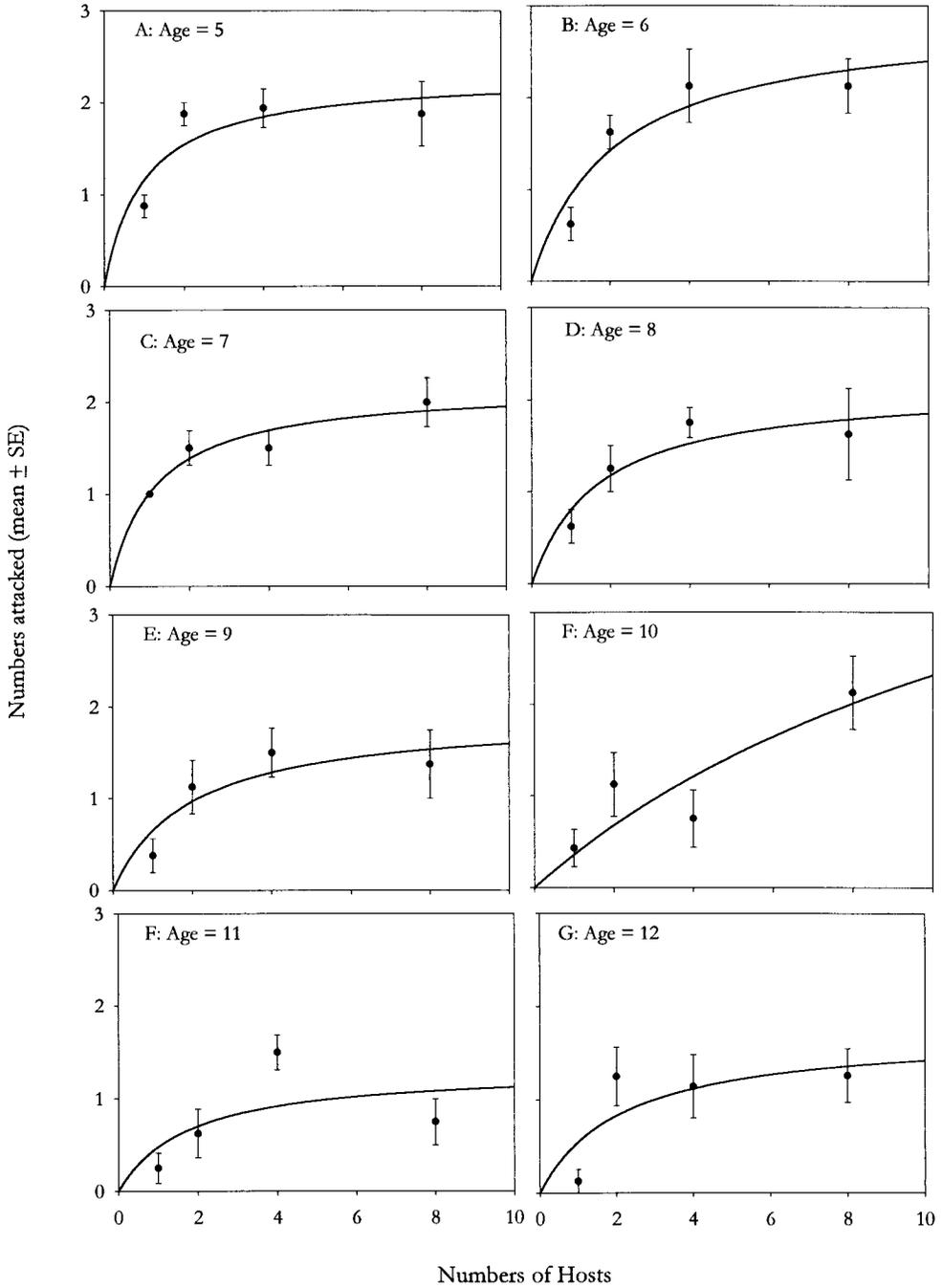


Fig. 2. Age-specific functional response curves of *A. pyralophagus* on *E. loftini*. Females ranged in age from 5 to 12 d, and were presented with one, two, four, or eight hosts over 24 h. The curves drawn are type II responses (Holling 1959) showing fewer hosts attacked by older females. Parameter estimates of the functional response equations are given in Table 2.

The analysis of the effects of host weight yielded only one significant effect: parasitoids laid more eggs on heavier hosts. Host weight was not found to affect progeny emergence or sex ratio. These results differ

from numerous studies showing significant effects of host size on parasitoid progeny. To cite a few examples, *Lespesia archippivora* (Riley) (Diptera: Tachinidae), a gregarious endoparasitoid of *Spodoptera exigua*

Table 2. Parameter estimates for type II functional response using different ages of *Allorhogas pyralophagus* attacking *Eoreuma loftini*

Age, d	a'	SE (a')	T_h	SE (T_h)	corr R ²
5	2.34368	1.45656	0.43513	0.09006	0.71
6	1.40685	0.63481	0.34643	0.08316	0.85
7	1.90322	0.61614	0.45943	0.05472	0.88
8	1.29127	0.56623	0.46332	0.09500	0.85
9	0.97675	0.58554	0.52186	0.16178	0.77
10	0.38167	0.25889	0.17001	0.27826	0.73
11	0.75268	1.12066	0.75390	0.54257	0.38
12	0.80497	0.78477	0.57995	0.30910	0.60

The model is $N_a = (a'NT) / (1 + a'T_hN)$, where N_a is mean numbers of hosts attacked, a' is instantaneous attack, T is searching time ($T = 1.0$ for 1 d), N is hosts available and T_h is handling time.

(Hübner) (Lepidoptera: Noctuidae) displayed differing percentages of parasitoid emergence, depending on the host instar it parasitizes (second-fifth and prepupae tested) (Stapel et al. 1997). The ectoparasitoid *Bracon mellitor* Say (Hymenoptera: Braconidae) produces predominantly female progeny when parasitizing large larvae of the boll weevil *Anthonomus grandis grandis* Boheman (Coleoptera: Curculionidae), and predominantly male progeny on small hosts (Tillman and Cate 1993). The same result was found for *Chrysocharis nephereus* (Walker) (Hymenoptera: Eulophidae) attacking the leafminer *Cameraria jacintoensis* (Lepidoptera: Gracillariidae) (Heinz 1996). These results are consistent with evolutionary theory that a female parasitoid should allocate female offspring to large hosts to maximize reproductive fitness (Opp and Luck 1986, and references cited). We detected no measurable effects of host size in this study, most likely because we limited hosts selected for experimentation to third and fourth instars.

These findings may have application in mass rearing or field release strategies using *A. pyralophagus* as a biological control agent. Oviposition and attack rates in this parasitoid are highest in young adult females ≈ 6 d old. Progeny sex ratio is predominantly female-biased. Although young females laid ≈ 20 eggs daily,

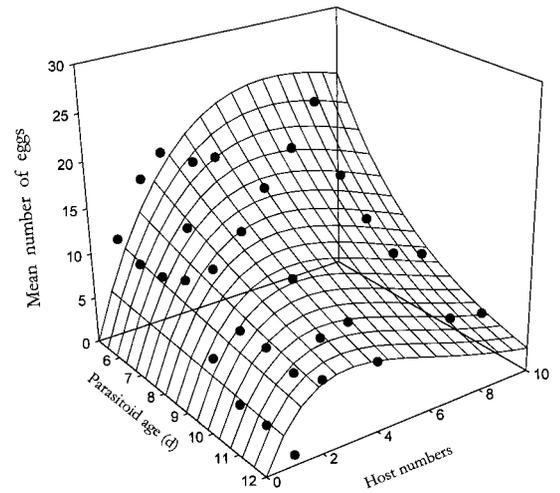


Fig. 3. Mean number of eggs laid by *A. pyralophagus* in 24 h as a function of parasitoid age and number of hosts presented. The surface equation is as follows: $egg\ mean = (10.4556 - (0.27893A)) N (\exp(-0.02772AN))$, where $egg\ mean$ is mean number of eggs laid, A is parasitoid age, and N is number of hosts available (corrected $R^2 = 0.57$) (based on Enkegaard 1993).

maximal attack rate was only approximately two hosts daily, suggesting that the parasitoid may be ineffective as a sole control agent unless very high numbers are used and may require complementary pest suppression techniques.

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Table 3. Effects of parasitoid age and number of hosts available on percentages of parasitoid emergence and female progeny (mean \pm SE; initial $n = 8$)

Age, d	Hosts	Eggs/host	Emergence	Progeny (φ)	Age, d	Hosts	Eggs/host	Emergence	Progeny (φ)
5	1	10.75 \pm 1.74	93.6 \pm 5.3	82.0 \pm 3.8	9	1	4.88 \pm 2.53	64.8 \pm 20.9	82.5 \pm 11.8
	2	8.31 \pm 0.90	58.2 \pm 9.7	72.9 \pm 6.6		2	3.44 \pm 1.22	51.9 \pm 17.5	77.5 \pm 8.6
	4	4.23 \pm 0.60	75.7 \pm 7.1	81.6 \pm 2.8		4	2.62 \pm 0.56	71.3 \pm 11.2	83.5 \pm 4.4
6	8	1.94 \pm 0.36	82.2 \pm 3.5	71.0 \pm 8.8	10	8	1.20 \pm 0.36	84.4 \pm 10.6	68.8 \pm 8.4
	1	9.62 \pm 3.08	71.7 \pm 8.2	79.4 \pm 6.4		1	2.0 \pm 1.05	75 \pm 25	47.6 \pm 23.8
	2	10.44 \pm 1.69	69.5 \pm 10.8	73.5 \pm 8.4		2	3.5 \pm 1.14	97.5 \pm 2.5	84.5 \pm 4.1
7	4	4.72 \pm 1.20	73.2 \pm 9.3	86.8 \pm 5.3	11	4	1.5 \pm 0.68	73.7 \pm 24.6	86.1 \pm 1.4
	8	2.75 \pm 0.53	49.7 \pm 13.8	79.8 \pm 4.7		8	1.41 \pm 0.24	53.5 \pm 14.6	57.5 \pm 14.9
	1	10.0 \pm 2.10	75.6 \pm 11.8	79.9 \pm 10.3		1	2.0 \pm 1.51	95.8 \pm 4.2	78.4 \pm 3.4
8	2	7.18 \pm 1.09	62.0 \pm 10.0	74.1 \pm 11.2	12	2	3.18 \pm 1.35	69.9 \pm 11.6	73.0 \pm 8.4
	4	3.06 \pm 0.38	68.6 \pm 13.2	79.8 \pm 2.9		4	2.41 \pm 0.68	52.6 \pm 13.8	87.8 \pm 6.6
	8	1.90 \pm 0.26	63.0 \pm 8.2	80.8 \pm 3.9		8	0.75 \pm 0.35	69.7 \pm 19.1	50.9 \pm 18.1
8	1	11.38 \pm 3.84	96.2 \pm 2.3	81.5 \pm 2.5	12	1	1.12 \pm 1.12	44.4 \pm 0.0	75.0 \pm 0.0
	2	5.81 \pm 1.08	86.3 \pm 5.6	76.2 \pm 4.8		2	3.88 \pm 1.16	62.0 \pm 17.2	63.4 \pm 13.2
	4	4.62 \pm 0.66	83.7 \pm 10.2	66.6 \pm 10.1		4	1.86 \pm 0.60	61.9 \pm 15.5	92.7 \pm 4.5
	8	1.48 \pm 0.54	82.2 \pm 6.3	69.4 \pm 3.9		8	1.05 \pm 0.27	52.3 \pm 17.2	81.0 \pm 2.3

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References Cited

- Enkegaard, A. 1993. The poinsettia strain of the cotton whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae), biological and demographic parameters on poinsettia (*Euphorbia pulcherrima*) in relation to temperature. *Bull. Entomol. Res.* 83: 535–546.
- Hawkins, B. A., H. W. Browning, and J. W. Smith, Jr. 1987. Field evaluation of *Allorhogas pyralophagus* [Hym.: Braconidae], imported into Texas for biological control of the stalkborer *Eoreuma loftini* [Lep.: Pyralidae] in sugar cane. *Entomophaga* 32: 483–491.
- Heinz, K. M. 1996. Host size selection and sex allocation behaviour among parasitoid tropic levels. *Ecol. Entomol.* 21: 218–226.
- Holling, C. S. 1959. Some characteristics of simple types of predation and parasitism. *Can. Entomol.* 91: 398–398.
- Legaspi, J. C., B. C. Legaspi, Jr., E. G. King, and R. R. Saldaña. 1997. Mexican rice borer, *Eoreuma loftini* (Lepidoptera: Pyralidae) in the Lower Rio Grande Valley of Texas: its history and control. *Subtrop. Plant Sci.* 49: 53–63.
- Legaspi, J. C., B. C. Legaspi, Jr., J. E. Irvine, J. Johnson, R. L. Meagher, Jr., and N. Rozeff. 1999. Stalkborer damage on yield and quality of sugarcane in the Lower Rio Grande Valley of Texas. *J. Econ. Entomol.* 92: 228–234.
- Martinez, A. J., J. Baird, and T. Holler. 1988. Mass rearing sugarcane borer and Mexican rice borer for production of parasites *Allorhogas pyralophagus* and *Rhacanotus roslinensis*. U.S. Dep. Agric.-APHIS-PPQ, APHIS 83–1.
- Meagher, R. L., Jr., J. W. Smith, Jr., H. W. Browning, and R. R. Saldaña. 1998. Sugarcane stem borers and their parasites in southern Texas. *Environ. Entomol.* 27: 759–766.
- Melton, C. W., and H. W. Browning. 1986. Life history and reproductive biology of *Allorhogas pyralophagus* (Hymenoptera: Braconidae), a parasite imported for release against *Eoreuma loftini* (Lepidoptera: Pyralidae). *Ann. Entomol. Soc. Am.* 79: 402–406.
- Opp, S. B., and R. F. Luck. 1986. Effects of host size on selected fitness components of *Aphytis melinus* and *A. lingnanensis* (Hymenoptera: Aphelinidae). *Ann. Entomol. Soc. Am.* 79: 700–704.
- Overholt, W. A., and J. W. Smith, Jr. 1990a. Comparative evaluation of three exotic insect parasites (Hymenoptera: Braconidae) against the southwestern corn borer (Lepidoptera: Pyralidae) in corn. *Environ. Entomol.* 19: 1155–1162.
- Overholt, W. A., and J. W. Smith, Jr. 1990b. Colonization of six exotic parasites (Hymenoptera) against *Diatraea grandiosella* (Lepidoptera: Pyralidae) in corn. *Environ. Entomol.* 19: 1889–1902.
- Smith, J. W., Jr., H. W. Browning, and F. D. Bennett. 1987. *Allorhogas pyralophagus* [Hym.: Braconidae], a gregarious external parasite imported in Texas, USA, for biological control of the stalkborer *Eoreuma loftini* [Lep.: Pyralidae] on sugarcane. *Entomophaga* 32: 477–482.
- Smith, J. W., Jr., R. N. Wiedenmann, and W. A. Overholt. 1993. Parasites of Lepidopteran stem borers of tropical gramineous plants. ICIPE Science, Nairobi, Kenya.
- Sokal, R. R., and F. J. Rohlf. 1995. *Biometry*. Freeman, San Francisco, CA.
- Stapel, J. O., J. R. Ruberson, H. R. Gross, Jr., and W. J. Lewis. 1997. Progeny allocation by the parasitoid *Lespesia archippivora* (Diptera: Tachinidae) in larvae of *Spodoptera exigua* (Lepidoptera: Noctuidae). *Environ. Entomol.* 26: 265–271.
- Tillman, P. G., and J. R. Cate. 1993. Effect of host size on adult size and sex ratio of *Bracon mellitor* (Hymenoptera: Braconidae). *Environ. Entomol.* 22: 1161–1165.
- Youm, O., F. E. Gilstrap, and H. W. Browning. 1990. Parasitism of stem borers (Lepidoptera: Pyralidae) associated with corn and sorghum in the Lower Rio Grande Valley of Texas. *J. Econ. Entomol.* 83: 84–88.

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