Parasitism Rates in European Corn Borer (Lepidoptera: Crambidae) Larvae Collected from Six Maize Hybrids[1]

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J. Entomol. Sci. 36(4): 342-351 (October 2001)

Abstract The parasitoid complex and level of parasitism of European corn borer, *Ostrinia nubilalis* (Hübner), larvae in six maize, *Zea mays* L., hybrids was determined in Nebraska during 1995 and 1996. Three parasitoids, *Eriborus terebrans* (Gravenhorst), *Macrocentrus grandii* Goidanich, and *Lixophaga* sp., were reared from field-collected European corn borer larvae. Larvae collected from Hoegemeyer 2626 exhibited the highest percentage parasitism for the 1995 first generation in Lancaster (37.2%) and Dixon (28.6%) counties. No significant differences were identified for the 1995 second generation at both sites because of reduced sample size and high larval mortality caused by naturally-occurring entomopathogens. During 1996, there were several significant differences in percentage parasitism of larvae collected from the hybrids. Larvae collected from Northrup King N7070 exhibited the highest first-generation parasitism (23.8%), while larvae collected from Hoegemeyer 1125W exhibited the highest second-generation parasitism (46.0%) in Dixon Co. In Lancaster Co., parasitism of first-generation larvae collected from Hoegemeyer 1125W (10.3%) was only significantly greater than parasitism of larvae collected from Hoegemeyer 2626 (1.1%). Results indicate that European corn borer larval parasitism is significantly affected by the maize hybrid planted in the field; however, differences may vary among years and generations as environmental factors affect the maize phenology.

Key Words Parasitism, parasitoid, *Ostrinia nubilalis,* European corn borer, *Macrocentrus grandii, Eriborus terebrans, Lixophaga* sp., *Zea mays,* maize hybrid

The European corn borer, *Ostrinia nubilalis* (Hübner), is one of the most destructive pests of maize, *Zea mays* L., in the United States where damage and control costs may exceed $1 billion annually (Mason et al. 1996). It also is a pest of snap beans, *Phaseolus vulgaris* L.; peppers, *Capsicum annum* L.; tomatoes, *Lycopersicon esculentum* Mill.; potatoes, *Solanum tuberosum* L.; sorghum, *Sorghum bicolor* L.; onions, *Allium cepa* L.; and small grains (Showers et al. 1989).

Classical biological control programs using natural enemies of European corn borer were implemented in the 1920s, 1930s, and 1940s (Baker et al. 1949). As a result, 23 species of parasitoids were imported from Europe and Asia, six of which became established in the United States. *Eriborus terebrans* (Gravenhorst) (Hymenoptera: Ichneumonidae), *Macrocentrus grandii* Goidanich (Hymenoptera: Braconidae), and *Lydella thompsoni* Herting (Diptera: Tachinidae) are widely distributed in

[1]Received 09 October 1998; accepted for publication 13 March 2001.

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the north central states (Baker et al. 1949, Brindley and Dicke 1963). In Nebraska, only *E. terebrans* has decreased *O. nubilalis* populations in the last 30 yrs (Carpino 1977, Hill et al. 1978, Godfrey et al. 1991).

Little work has been reported to discriminate differences in the field among maize hybrids that could be causal to differential rates of parasitism of European corn borer larvae infesting maize hybrids. The purpose of our study was to assess parasitism rates of bivoltine European corn borer larvae collected from different maize hybrids. As each hybrid is composed of a different genetic background and phenotypic expression varies with environmental conditions, we hypothesized that larval parasitism would vary among maize hybrids planted in the field.

Materials and Methods

The study was conducted in 1995 and 1996 at locations in Dixon and Lancaster counties, NE. The Dixon Co. sites were at the University of Nebraska Haskel Agricultural Laboratory at Concord, and the Lancaster Co. fields were at the University of Nebraska Agronomy Research Farm near Lincoln.

Six maize hybrids with different genetic backgrounds were selected for the study. These were Hoegemeyer SCII (sweet), Hoegemeyer 1125W (white), Hoegemeyer 2626, DeKalb DK626, Northrup King N7070, and Pioneer P3417 with the following relative maturity dates: Hoegemeyer SCII-85 d, Hoegemeyer 1125W-113 to 116 d, Hoegemeyer 2626-107 to 111 d, DeKalb DK626-112 d, Northrup King N7070-113 d, and Pioneer P3417-109 d.

Seed was mechanically planted in a randomized complete block design with four replications. Each plot within a block had eight rows with the middle four rows for sampling and the two outside rows as borders. The 1995 and 1996 Dixon Co. plots were planted at a rate of 42,000 seeds/ha and were not irrigated. The plots measured 10.7 m long with approximately 44 plants per row and a 1.5 m alley between each replicate. The 1995 Dixon Co. study was planted 19 May, while the 1996 study was planted 16 May. The 1995 and 1996 Lancaster Co. plots were gravity irrigated and planted at a rate of 54,300 seeds/ha. Each plot was 5.3 m long with approximately 30 plants per row and a 0.8 m alley between each replicate. No insecticides were applied during the study.

All maize plants in the sampling rows were manually infested with laboratory-reared neonate European corn borer larvae (French Agricultural Research, Inc. Lamberton, MN) at a uniform rate of 100 larvae per plant using the "Bazooka" applicator designed by Mihm et al. (1978). During the first-generation moth flight, plants (approximately eighth through tenth leaf stage) were infested in the whorl region. During the second-generation moth flight, plants (approximately anthesis) were infested with 50 neonate European corn borer larvae at the node above the ear and at the ear node (100 larvae total).

Each field was monitored weekly after manual infestation to determine presence of peak numbers of fifth instars. When the majority of the larvae reached the fifth stadium, entire maize plants in their respective treatments were systematically dissected and examined for borers (larvae or pupae) and larval parasitoids (pupae). First-generation larval collections continued until approximately 30 to 40 larvae were collected or 40 plants had been destructively sampled. Second-generation collections were continued until approximately 35 to 50 larvae were collected or all plants were destructively sampled. Because larval density and disease incidence varied among sites and borer generations, the collection thresholds at each site and generation were varied accordingly. All collected insects (including European corn borer pupae and parasitoid pupae) were individually placed in vials and transported to the laboratory in insulated boxes containing ice.

Upon arrival at the laboratory, collected insects were immediately dipped in a phenylmercuric nitrate solution (0.1g/liter H_2O) and immediately blotted dry (CIMMYT 1987) in an attempt to surface sterilize the larvae and prevent secondary pathogen growth. Larvae were then placed into individually labeled 4-dram vials containing a wheat germ meridic diet (CIMMYT 1987) and plugged with nonabsorbent cotton. Vials were held at 25.0°C, 16:8 [L:D] (first generation) or 24:0 [L:D] (second generation) photoperiod, and 75.0% relative humidity in environmental chambers until emergence of moths or parasitoids. The second-generation larvae were placed in 24:0 [L:D] photoperiod to terminate diapause. A fresh meridic diet plug was placed into the vial when the old diet plug began to dessicate prior to parasitoid or moth emergence. Vials were checked daily, and emerged moths or parasitoids were identified and recorded. Dead or injured individuals and cause of death (if known) also were recorded. Observations continued until all insects had emerged or died. Individuals that died during the collection process or as a result of secondary pathogens were eliminated from parasitism rate analysis.

Data were analyzed using contrasts of maximum-likelihood estimates (chi-square statistic) to detect individual and pooled parasitism rate differences among larvae inhabiting different maize hybrids. Maximum-likelihood chi-square and probability values were calculated for each comparison using the CATMOD program (SAS Institute 1990). The significance level selected was $\alpha = 0.05$ for all statistical tests.

Results and Discussion

Three parasitoid species, *E. terebrans, M. grandii,* and *Lixophaga* sp. (Diptera: Tachinidae), were collected from these study sites (Tables 1, 2). *Eriborus terebrans* and *M. grandii* caused the greatest level of parasitism at both fields during both years. The occurrence of *E. terebrans* was not unexpected in that it was previously reported from Nebraska (Carpino 1977, Hill et al. 1978). The occurrence of *M. grandii* parasitism was, however, unexpected in that this species had not been reported from Nebraska since its initial release in 1950 (Hill et al. 1978). In fact, parasitism levels of *M. grandii* in second-generation European corn borer larvae collected from Dixon Co. in 1996 were the highest levels recorded for any parasitoid species throughout the entire study (Table 2). This result is contrary to prior reports indicating that the importance of *M. grandii* as a parasitoid of European corn borer is declining throughout the region (Hill et al. 1978, Lewis 1982, Siegal et al. 1987, Landis and Haas 1992). A native parasitoid, *Lixophaga* sp., also was observed at the Lancaster Co. site (Table 1); however, parasitism remained low (0.0 to 1.8%).

First-generation European corn borer larvae collected from Hoegemeyer 2626 in Dixon Co. in 1995 showed a significantly higher level of parasitism by *E. terebrans* than larvae collected from Hoegemeyer SCII ($\chi^2 = 4.53$; df = 1; $P \leq 0.033$) (Table 1). At the Lancaster Co. site *M. grandii* parasitized significantly more larvae collected from DeKalb DK626, Hoegemeyer 2626, and Hoegemeyer 1125W than Pioneer P3417 ($\chi^2 = 6.33$; df = 1; $P \leq 0.012$, $\chi^2 = 6.41$; df = 1; $P \leq 0.011$ and $\chi^2 = 5.08$; df = 1; $P \leq 0.024$, respectively) and Hoegemeyer SCII ($\chi^2 = 12.94$; df = 1; $P \leq 0.000$, $\chi^2 = 12.99$; df = 1; $P \leq 0.000$ and $\chi^2 = 11.50$; df = 1; $P \leq 0.001$, respectively). Larvae collected from the Northrup King N7070 hybrid also had significantly greater *M. grandii* parasitism than those collected from Hoegemeyer SCII (χ^2 = 4.79; df = 1; $P \leq$ 0.029). No species-specific parasitism rate differences were detected for second-generation larvae or the minor parasitoid species from either study site in 1995. However, high mortality of the second-generation larvae was caused by *Beauveria bassiana* Verillemin (Balsamo) and *Nosema pyrausta* (Paillot).

Analysis of pooled parasitism data for all species revealed significant differences in the first-generation larvae only. At the Dixon Co. site, parasitism of larvae collected from Hoegemeyer 2626 was significantly greater than that of larvae from Pioneer P3417 (χ^2 = 4.45; df = 1; $P \leq$ 0.035) and Hoegemeyer SCII (χ^2 = 6.45; df = 1; $P \leq$ 0.011), while larvae collected from DeKalb DK626 had significantly greater parasitism than those collected from Hoegemeyer SCII (χ^2 = 5.01; df = 1; $P \leq$ 0.025) (Table 1). Parasitism rates for larvae collected from Hoegemeyer 2626 in Lancaster Co. was significantly greater than larvae collected from Northrup King N7070 (χ^2 = 4.64; df = 1; $P \leq$ 0.031), Pioneer P3417 (χ^2 = 12.32; df = 1; $P \leq$ 0.000), and Hoegemeyer SCII (χ^2 = 19.08; df = 1; $P \leq$ 0.000) (Table 1). Larvae collected from DeKalb DK626 and Hoegemeyer 1125W had significantly higher parasitism levels than larvae collected from Pioneer P3417 (χ^2 = 6.88; df = 1; $P \leq$ 0.009, χ^2 = 5.22; df = 1; $P \leq$ 0.022) and Hoegemeyer SCII (χ^2 = 12.72; df = 1; $P \leq$ 0.000, χ^2 = 10.57; df = 1; $P \leq$ 0.001). Larvae collected from Northrup King N7070 had significantly greater parasitism than Hoegemeyer SCII (χ^2 = 6.43; df = 1; $P \leq$ 0.011). The first generation pooled parasitism rate trends at both sites were identical in terms of raw parasitism rate differences but varied in terms of statistical separation (Table 1). No significant differences were observed for pooled second generation data due to circumstances previously described.

In 1996, the first-generation larvae collected from Northrup King N7070 had the highest *E. terebrans* parasitism rate which was significantly greater than that of larvae from Hoegemeyer SCII (χ^2 = 5.60; df = 1; $P \leq$ 0.018) (Table 2). Second-generation larvae collected from the Hoegemeyer 1125W and DeKalb DK626 hybrids had significantly greater parasitism by *M. grandii* than those collected from Hoegemeyer SCII (χ^2 = 11.40; df = 1; $P \leq$ 0.001, χ^2 = 5.29; df = 1; $P \leq$ 0.021), Hoegemeyer 2626 (χ^2 = 9.85; df = 1; $P \leq$ 0.002, χ^2 = 3.94; df = 1; $P \leq$ 0.047), Northrup King N7070 (χ^2 = 9.16; df = 1; $P \leq$ 0.003, χ^2 = 3.84; df = 1; $P \leq$ 0.050), and Pioneer P3417 (χ^2 = 11.05; df = 1; $P \leq$ 0.001, χ^2 = 5.58; df = 1; $P \leq$ 0.018) (Table 2). No significant individual species comparisons were observed at the Lancaster Co. site which was characterized by low parasitism rates for both *M. grandii* and *E. terebrans* during the first generation (Table 2) and high disease mortality during the second generation (769 of 903 collected individuals died from either *B. bassiana* or *N. pyrausta* infection). The 134 survivors had an overall parasitism rate of 11.2%, but no significant differences were observed. The parasitism rates for individual species were 4.5%, 6.0%, and 0.8% for *E. terebrans, M. grandii,* and *Lixophaga* sp., respectively

Three of the four sampling arenas in 1996 had significant parasitism rate differences between corn hybrids when data were pooled for all parasitoid species. At the Dixon Co. site, individual comparisons for the first-generation larvae indicated that those collected from Northrup King N7070 had a significantly greater percentage parasitism than those collected from Pioneer P3417 (χ^2 = 4.80; df = 1; $P \leq$ 0.028) and Hoegemeyer SCII (χ^2 = 10.27; df = 1; $P \leq$ 0.001), while parasitism of larvae from Hoegemeyer 1125W was significantly greater than those from Hoegemeyer SCII (χ^2 = 5.54; df = 1; $P \leq$ 0.019) (Table 2). The second-generation larvae collected from

Table 1. Percentage first and second generation European corn borer larval parasitism by parasitoids in six maize hybrids during 1995

			Dixon County Site		
Maize hybrid	n	Deaths	*M. grandii*	*E. terebrans*	All species
First Generation					
Hoegemeyer SCII	84	15	2.9 ± 2.6 a	8.7 ± 2.9 b	11.6 ± 4.4 c
Hoegemeyer 1125W	104	17	6.9 ± 2.9 a	16.1 ± 3.1 ab	23.0 ± 1.9 abc
Hoegemeyer 2626	88	11	6.5 ± 2.4 a	22.1 ± 3.7 a	28.6 ± 5.8 a
Northrup King N7070	86	9	7.8 ± 5.4 a	10.4 ± 6.1 ab	18.2 ± 11.4 abc
DeKalb DK626	72	13	11.9 ± 5.3 a	15.3 ± 4.2 ab	27.1 ± 7.8 a
Pioneer P3417	92	16	4.0 ± 2.3 a	10.5 ± 3.4 ab	14.5 ± 5.1 bc
Totals	526	81	6.5	13.9	20.5
Second Generation					
Hoegemeyer SCII	107	41	0.0 ± 0.0 a	7.6 ± 1.2 a	7.6 ± 1.2 a
Hoegemeyer 1125W	97	47	2.0 ± 1.7 a	6.0 ± 2.3 a	8.0 ± 2.9 a
Hoegemeyer 2626	104	46	0.0 ± 0.0 a	0.0 ± 0.0 a	0.0 ± 0.0 a
Northrup King N7070	84	39	0.0 ± 0.0 a	0.0 ± 0.0 a	0.0 ± 0.0 a
DeKalb DK626	103	42	0.0 ± 0.0 a	4.9 ± 3.4 a	4.9 ± 3.4 a
Pioneer P3417	96	57	2.6 ± 2.3 a	0.0 ± 0.0 a	2.6 ± 2.3 a
Totals	591	272	0.6	3.5	4.1

Table 1. Continued.

			Lancaster County Site			
Maize hybrid	n	Deaths	*M. grandii*	*E. terebrans*	*Lixophaga* sp.	All species
First Generation						
Hoegemeyer SCII	111	11	4.0 ± 1.9 c	5.0 ± 4.7 a	0.0	9.0 ± 3.6 e
Hoegemeyer 1125W	102	9	21.5 ± 5.2 a	5.4 ± 2.6 a	1.1 ± 1.0 a	28.0 ± 6.3 abc
Hoegemeyer 2626	107	13	23.4 ± 8.3 a	8.5 ± 3.8 a	5.3 ± 0.8 a	37.2 ± 6.5 a
Northrup King N7070	102	9	12.9 ± 3.0 ab	8.6 ± 2.0 a	1.1 ± 1.0 a	22.6 ± 4.8 bcd
DeKalb DK626	109	17	23.9 ± 3.7 a	3.3 ± 2.1 a	3.3 ± 1.2 a	30.4 ± 3.8 ab
Pioneer P3417	105	13	9.8 ± 2.1 bc	4.4 ± 1.9 a	0.0	14.1 ± 1.6 de
Totals	636	72	15.8	5.9	1.8	23.4
Second Generation						
Hoegemeyer SCII	53	28	4.0 ± 1.7 a	4.0 ± 3.9 a	0.0	8.0 ± 5.9 a
Hoegemeyer 1125W	77	32	13.3 ± 11.1 a	2.2 ± 1.7 a	2.2 ± 1.7 a	17.8 ± 10.3 a
Hoegemeyer 2626	55	26	3.5 ± 3.5 a	3.5 ± 2.8 a	3.5 ± 3.5 a	10.3 ± 6.9 a
Northrup King N7070	83	43	5.0 ± 3.4 a	0.0	0.0	5.0 ± 3.4 a
DeKalb DK626	60	23	8.1 ± 4.9 a	0.0	0.0	8.1 ± 4.9 a
Pioneer P3417	30	15	6.7 ± 3.6 a	0.0	0.0	6.7 ± 3.6 a
Totals	358	167	7.3	1.6	1.1	10.0

Parasitism rate means within a column followed by the same letter are not significantly different ($P \geq 0.05$) based on contrasts of maximum-likelihood (χ^2) estimates.

Table 2. Percentage first and second generation European corn borer larval parasitism by parasitoids in six maize hybrids during 1996

Dixon County Site					
Maize hybrid	n	Deaths	*M. grandii*	*E. terebrans*	All species
First Generation					
Hoegemeyer SCII	126	21	0.0	5.7 ± 2.6 b	5.7 ± 2.6 c
Hoegemeyer 1125W	107	17	3.3 ± 1.0 a	13.3 ± 2.8 ab	16.7 ± 3.6 ab
Hoegemeyer 2626	87	16	0.0	12.7 ± 2.7 ab	12.7 ± 2.7 abc
Northrup King N7070	79	16	6.4 ± 4.1 a	17.5 ± 4.0 a	23.8 ± 5.7 a
DeKalb DK626	79	11	4.4 ± 2.8 a	7.4 ± 2.7 ab	11.8 ± 3.8 abc
Pioneer P3417	76	9	0.0	9.0 ± 4.9 ab	9.0 ± 4.9 bc
Totals	554	90	2.1	10.6	12.7
Second Generation					
Hoegemeyer SCII	141	55	15.1 ± 4.1 b	3.5 ± 2.2 a	18.6 ± 2.4 c
Hoegemeyer 1125W	151	77	36.4 ± 8.9 a	9.5 ± 4.7 a	46.0 ± 5.4 a
Hoegemeyer 2626	167	65	16.7 ± 6.5 b	11.8 ± 6.4 a	28.4 ± 3.4 bc
Northrup King N7070	177	96	16.1 ± 2.2 b	12.4 ± 3.0 a	28.4 ± 2.2 bc
DeKalb DK626	153	82	28.2 ± 9.5 a	4.2 ± 2.6 a	32.4 ± 10.4 ab
Pioneer P3417	144	77	13.4 ± 5.2 b	4.5 ± 3.8 a	17.9 ± 7.1 c
Totals	933	452	20.6	7.9	28.5
Lancaster County Site					
Maize hybrid	n	Deaths	*M. grandii*	*E. terebrans*	All species
First Generation					
Hoegemeyer SCII	70	15	0.0	7.7 ± 2.9 a	7.7 ± 2.9 ab
Hoegemeyer 1125W	72	14	5.9 ± 2.2 a	4.4 ± 2.5 a	10.3 ± 3.7 a
Hoegemeyer 2626	113	21	0.0	1.1 ± 0.8 a	1.1 ± 0.8 b
Northrup King N7070	82	13	0.0	2.9 ± 1.5 a	2.9 ± 1.5 ab
DeKalb DK626	79	12	3.0 ± 1.7 a	3.0 ± 1.6	6.0 ± 2.3 ab
Pioneer P3417	98	19	0.0	2.5 ± 2.2 a	2.5 ± 2.2 ab
Totals	534	94	1.4	3.4	4.8

Parasitism rate means within a column followed by the same letter are not significantly different ($P \geq 0.05$) based on contrasts of maximum-likelihood (χ^2) estimates.

Hoegemeyer 1125W had a significantly greater percentage parasitism than larvae collected from Hoegemeyer SCII ($\chi^2 = 13.94$; df = 1; $P \leq 0.000$), Hoegemeyer 2626 ($\chi^2 = 5.95$; df = 1; $P \leq 0.015$), Northrup King N7070 ($\chi^2 = 5.30$; df = 1; $P \leq 0.021$), and Pioneer P3417 ($\chi^2 = 12.52$; df = 1; $P \leq 0.000$) (Table 2). Also, larvae collected from DeKalb DK626 had significantly greater percentage parasitism than larvae collected from Hoegemeyer SCII ($\chi^2 = 4.34$; df = 1; $P \leq 0.037$) and Pioneer P3417 ($\chi^2 = 4.13$;

df = 1; $P \leq 0.042$). The pooled parasitism rate of 46.0% (±5.4%) for Hoegemeyer 1125W was the highest rate observed for any hybrid throughout the entire study (Table 2). One significant difference was observed at the Lancaster Co. site for pooled data during the first generation where the larval parasitism rate from Hoegemeyer 1125W was significantly greater than Hoegemeyer 2626 ($\chi^2 = 5.52$; df = 1; $P \leq 0.034$) (Table 2). As was the case for individual species comparisons, high mortality of larvae collected from the Lancaster Co. site resulted in these data being excluded from statistical analysis.

Significant parasitism rate differences were observed in European corn borer larvae collected from the difference maize hybrids evaluated in 5 of 7 field × generation combinations examined, when data for all parasitoid species were pooled. The 1995 Lancaster and Dixon Co. experiments were exceptions during the second generation. The Lancaster Co. experiment was characterized by low European corn borer larval densities and high disease mortality, while the Dixon Co. experiment had high disease mortality. Reduced sample sizes made detection of larval parasitism differences among the corn hybrids impossible for the two plots during the 1995 second generation. At locations where hybrid differences in larval parasitism rates were observed, the results varied between years and European corn borer generations. The exception was during the first generation in 1995 in which two study plots had identical parasitism rate trends for the corn hybrids evaluated.

Larvae collected from maize hybrids from individual parasitism rate comparisons yielded significant differences for the primary parasitoid recovered in 4 of 7 field × generation combinations examined in the study. Two of the 3 field × generation combinations that did not have significant differences were in the 1995 Dixon and Lancaster Co. experiments during the second generation. These were characterized by high larval mortality and, in one case, low larval density per corn plant (Lancaster Co.). The third field × generation combination (1996 Lancaster Co., first generation) without individual species differences was characterized by low parasitism [3.4% for *E. terebrans* and 1.4% for *M. grandii* (Table 2)] making statistical analysis impossible without a larger sample size.

When sample sizes were large enough to elucidate significant parasitism rate differences between larvae collected from the corn hybrids, general but not absolute trends were observed. European corn borer larvae collected from Hoegemeyer 1125W and Dekalb DK626 always had the highest percentage parasitism where significant parasitism rate differences were observed. Meanwhile, larvae collected from Hoegemeyer 2626 and Northrup King N7070 had percentage parasitism rates that were not significantly different from that of larvae collected from Hoegemeyer 1125W and DeKalb DK626 in three of the five field × generation combinations where significant percentage parasitism rate differences were found. Larvae collected from Pioneer P3417 and Hoegemeyer SCII had the lowest percentage parasitism in all field × generation combinations where significant percentage parasitism was observed. The Hoegemeyer SCII results are consistent with an earlier observation by Udayagiri and Jones (1992a) who reported that volatiles from sweet-corn backgrounds are qualitatively less attractive to the larval parasitoid *M. grandii* than volatiles from field-corn cultivars.

A possible explanation for parasitism rate differences for larvae collected from the hybrids is differing host density. Many classical biological control studies state that increasing parasitism rates are a function of increasing host density. This relationship was examined in a separate study (Clark 1997) during the 1996 season, but results indicated no significant correlation of corn hybrid larval density per plant with percentage parasitism. This result was consistent with other studies that indicated that larval density per plant was not correlated with percentage parasitism of the larval parasitoid *E. terebrans* (Baker et al. 1949, Landis and Haas 1992, Pavuk and Stinner 1992).

This study indicated that parasitism rates at any given location and/or European corn borer generation may be influenced by the type of maize hybrid planted in a given field. Yet, a lack of significant parasitism rate consistency among years, generation, and maize hybrids indicated that many factors may be influencing larval parasitism. As components like attractive plant volatiles, landscapes, beneficial weed communities, and maize hybrid preferences that comprise this complex system are discovered to have a positive influence on larval parasitoid effectiveness, researchers can develop agricultural systems that include all or some of these factors to increase biological control efforts. This is especially true for European corn borer because larval parasitism rates for this insect have been historically low.

Acknowledgments

We thank C. Reimers, J. Echtenkamp, H. Ikten, B. Johnson, K. Maline, and D. Dougherty for assistance in conducting field work, N. D'Croz-Mason for land acquisition and helpful comments, Hoegemeyer Hybrids, DEKALB Genetics Corporation, and Pioneer Hybrid for supplying maize seed, and E. A. Heinrichs and S. D. Danielson for critical review of the manuscript and suggestions. This paper is Journal Series No. 12,223 of the Agricultural Research Division, University of Nebraska-Lincoln.

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