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Occurrence of the Diamondback Moth and its Parasitoids in the Lower Rio Grande Valley of Texas

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ABSTRACT

Field surveys were performed during the 1991 - 1992, and Spring 1999 cabbage seasons to estimate population levels of the diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) in the Lower Rio Grande Valley of Texas on pesticide-free cabbage (*Brassica oleracea* L.). In the 1991 - 1992 survey, *P. xylostella* populations greatly exceeded the 0.3 larvae per plant threshold, especially during the months of January to March. From 1993 to 1998, *P. xylostella* populations declined, and the moth ceased to be a pest of interest in south Texas. The resurgence of population levels in the late 1990's generated renewed research interest in *P. xylostella*. In Spring 1999, populations persisted through April, subsequently declining by May. Percentage parasitism often fluctuated between 20 to 60%, reaching maximum levels of about 90%. *Diadegma insulare* (Cresson) (Hymenoptera: Ichneumonidae) was the predominant endemic parasitoid, accounting for >98% of the parasitoids reared from field-collected host larvae. *Microplitis brassicae* Muesebeck (Hymenoptera: Braconidae) accounted for only 1.6% of the endemic parasitoid community. Despite high levels of parasitism, *D. insulare* does not exert appreciable biological control of *P. xylostella* in the Valley. Economic suppression of this host will require additional pest management techniques, possibly including biopesticides or an exotic egg parasitoid.

RESUMEN

Se realizaron muestreos de campo en plantaciones de col (*Brassica oleracea* L.) durante las temporadas de 1991 - 1992 y primavera de 1999 para estimar los niveles de la población de la palomilla dorso de diamante, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) en el Bajo Valle del Río Grande en Texas. Las poblaciones de *P. xylostella* excedieron considerablemente el umbral de 0.3 larva por planta, especialmente durante los meses de enero a marzo en el muestreo de 1991-1992. Las poblaciones de *P. xylostella* disminuyeron de 1993 a 1998 y la palomilla dejó de ser una plaga de interés en el sur de Texas. El resurgimiento de los niveles poblacionales en los finales de la década de 1990 generó renovado interés en la investigación sobre *P. xylostella*. En la primavera de 1999, las poblaciones persistieron durante abril, y declinaron subsecuentemente en mayo. El porcentaje de parasitismo fluctuó frecuentemente entre 20 a 60%, alcanzando unos niveles máximos de cerca del 90%. *Diadegma insulare* (Cresson) (Hymenóptera: Ichneumonidae) fue el parasitoide endémico dominante, que constituyó más del 98% de los parasitoides liberados de las larvas de los hospederos colectadas en campo. *Microplitis brassicae* Muesebeck (Himenóptera: Braconidae) constituyó sólo el 1.6% de la comunidad parasitoide endémica. A pesar de los altos niveles de parasitismo, *D. insulare* no ejerce un control biológico apreciable de *P. xylostella* en el área. La supresión económica de esta plaga requerirá técnicas adicionales de manejo de plagas, que posiblemente incluyan biopesticidas o un parasitoide exótico de huevecillos.

The diamondback moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) is the most destructive pest of cruciferous crops in the world, causing annual management costs estimated at US$ 1 billion (Talekar and Shelton 1993). The pest status of *P. xylostella* in most parts of the world is attributed to the absence of effective natural enemies, especially parasitoids, because the moth is better able to establish on newly planted crucifers than its natural enemies. The effectiveness of the control agents is further hampered by mortality due to widespread use of broad spectrum insecticides against *P. xylostella*, coupled with the moth's resistance to a wide range of synthetic and bacterial insecticides (see Shelton et al. 1993). The first documented occurrence of resistance to synthetic insecticides in North America was reportedly in the Lower Rio Grande Valley (LRGV) of Texas (Magaro and Edelson 1990). *Plutella xylostella* has a long history of eventual resistance to every insecticide used extensively, including Bt-toxins (Talekar and Shelton 1993). Indeed, as of 1998, *P. xylostella* was the only insect known to have developed resistance to Bt-toxins in the field (Shelton et al. 1998).

In 1990, an integrated pest management (IPM) program, relying heavily on biological control agents, was initiated in

the LRGV (Biever et al. 1994). In collaboration with a commercial insectary (Biofac, Mathis, TX), scientists mass released *Cotesia plutellae* Kurdjumov and *Diadegma insulare* (Cresson) (Hymenoptera: Ichneumonidae) against *P. xylostella* in eight cabbage fields comprising 53 ha. *Cotesia marginiventris* (Cresson) and *Trichogramma pretiosum* Riley (Hymenoptera: Trichogrammatidae) were released against the cabbage looper, *Trichoplusia ni* (Hübner) (Lepidoptera: Noctuidae). The predatory lacewing, *Chrysoperla rufilabris* Burmeister (Neuroptera: Chrysopidae) was released against other lepidopterans, whiteflies and aphids. The average cost of the biologically-intensive IPM program was $395/ha, compared to $390/ha for fields treated with chemical insecticides. Average damage in the IPM fields was 0.6%, compared to 1.4% in the chemically-treated fields (Biever et al. 1994).

In this paper, we report the population dynamics of *P. xylostella* and its endemic parasitoids in untreated cabbage fields in the Lower Rio Grande Valley of Texas.

MATERIALS AND METHODS

1991 - 1992 Seasons. Two cabbage plantings (‘Grand Slam’) were performed in each year, and are referred to as early- or mid- season plantings, depending on plating date. Each field measured about 1000 m^2, and were located in the southeast block of the Texas Agricultural Experiment Station in Weslaco, designated as a pesticide-free area. At approximately weekly intervals, 25 plants were collected from each planting. The plants were sampled destructively; all aboveground plant material was placed into large plastic bags and brought to the laboratory. All *P. xylostella* larvae and pupae were removed. Larvae were classified as small, medium, or large. Larvae and pupae collected were then placed separately in plastic diet cups and held under laboratory conditions until emergence of adult parasitoid or host, or death. Percentage parasitism was calculated using numbers of insects emerging as adult parasitoids divided by total numbers of insects (parasitoids + hosts) that emerged successfully. Sampling efforts were discontinued from 1993 to 1998 due to reduced populations as the moth ceased to be a pest of interest in south Texas. A resurgence of population levels in the late 1990’s generated renewed research interest in *P. xylostella*.

Spring, 1999. Eight plots of cabbage (‘Fortuna’) were planted on 7 December 1998. Each treatment plot measured 10 m in length and consisted of two rows of cabbage plants, spaced at 30 cm apart. The experimental plots were separated with sorghum (*Sorghum bicolor* [L.] Moench) windbreaks and a 3 m alleyway. From each plot, one head of cabbage was randomly selected for destructive sampling (n = 8). The aboveground plant biomass was harvested, placed inside a large plastic bag, and brought into the laboratory. Using a fine brush, all *P. xylostella* larvae and cocoons were collected and placed into glass vials (2.5 x 9.5 cm) that were plugged with cotton, and separated by life stage (small larvae, large larvae, and pupae). Empty cocoons were counted but not collected. Larvae were provided with fresh plant material, which was replaced as needed. The vials were held under ambient laboratory conditions to determine the outcome of development: adult moth, adult parasitoid, or death during the development process. Emergent parasitoids were studied under a stereomicroscope to determine sex. Sampling was performed weekly for 4 weeks starting from 15 April and ending 06 May 1999.

RESULTS

1991 - 1992 Seasons. Field counts of *P. xylostella* are shown in Fig. 1, divided by life stage (cocoons were not counted), and shown on a per plant basis. A total count is shown, indicating the sum of all life stages, also on a per plant basis (Fig. 1E). Population numbers were generally high early in the year, declining during the summer, and increasing again during the winter. Total counts easily exceeded the threshold level of 0.3 larvae per plant set by Cartwright et al. (1987). The results of rearing the field-collected larvae and pupae are shown in Fig. 2 (per plant basis), according to numbers that emerged as adult moths (Fig. 2A), or adult *D. insulare* (Fig. 2B). Decreased population numbers between field sampling (Fig. 1) and adult emergence (Fig. 2) are due to mortality or loss incurred during the rearing process. The predominant parasitoid species reared from field-collected *P. xylostella* larvae was *D. insulare*, which peaked at over 2.4 per plant (Fig. 2B). Parasitism by *D. insulare* was quite high early in the year, often between 20 to 60% (Fig. 2C) and continued later in the year, although at lower levels.

Spring, 1999. Larval counts well exceeded the 0.3 larvae per plant damage threshold (Table 1). When the numbers of empty cocoons were added, total estimated counts of *P. xylostella* per plant were >20 on three of the four sampling occasions. Larval populations declined at the end of April, and the sampling program was halted in early May due to low numbers of insects collected. As in the previous field seasons, the parasitoid population was comprised almost exclusively of *D. insulare*. Percentage parasitism was 66.7% (58 parasitoids / 87 parasitoids + unparasitized), 91.9% (57 / 62), 66.7 (10 / 15) and 0% (0 / 0) on 15, 22, 29 April and 06 May, respectively (Table 1). The ratio of ♀:♂ in parasitoid progeny was 46.6%

Table 1. Per plant counts (x± SE, n=8) of *P. xylostella* and *D. insulare* in the Lower Rio Grande Valley of Texas, Spring, 1999.

						D. insulare		
Date	Small	Large	Pupae	Cocoons	Total[1]	♂♂	♀♀	Unparasitized[2]
15 April	5.1 ± 1.1	3.4 ± 1.3	6.7 ± 1.2	10.4 ± 1.9	25.8 ± 4.4	31	27	29
22 April	0.4 ± 0.2	1.6 ± 0.6	8.2 ± 1.1	17.2 ± 3.5	27.5 ± 3.5	39	18	5
29 April	0 ± 0	0.2 ± 0.2	2.8 ± 0.9	17.6 ± 2.4	20.6 ± 3.3	3	7	5
06 May	0 ± 0	0 ± 0	0.4 ± 0.3	12.5 ± 2.1	12.9 ± 2.1	0	0	0

[1]Indicates sum of field counts of larvae, pupae and cocoons.

[2]Excludes larval mortality incurred prior to adult emergence.

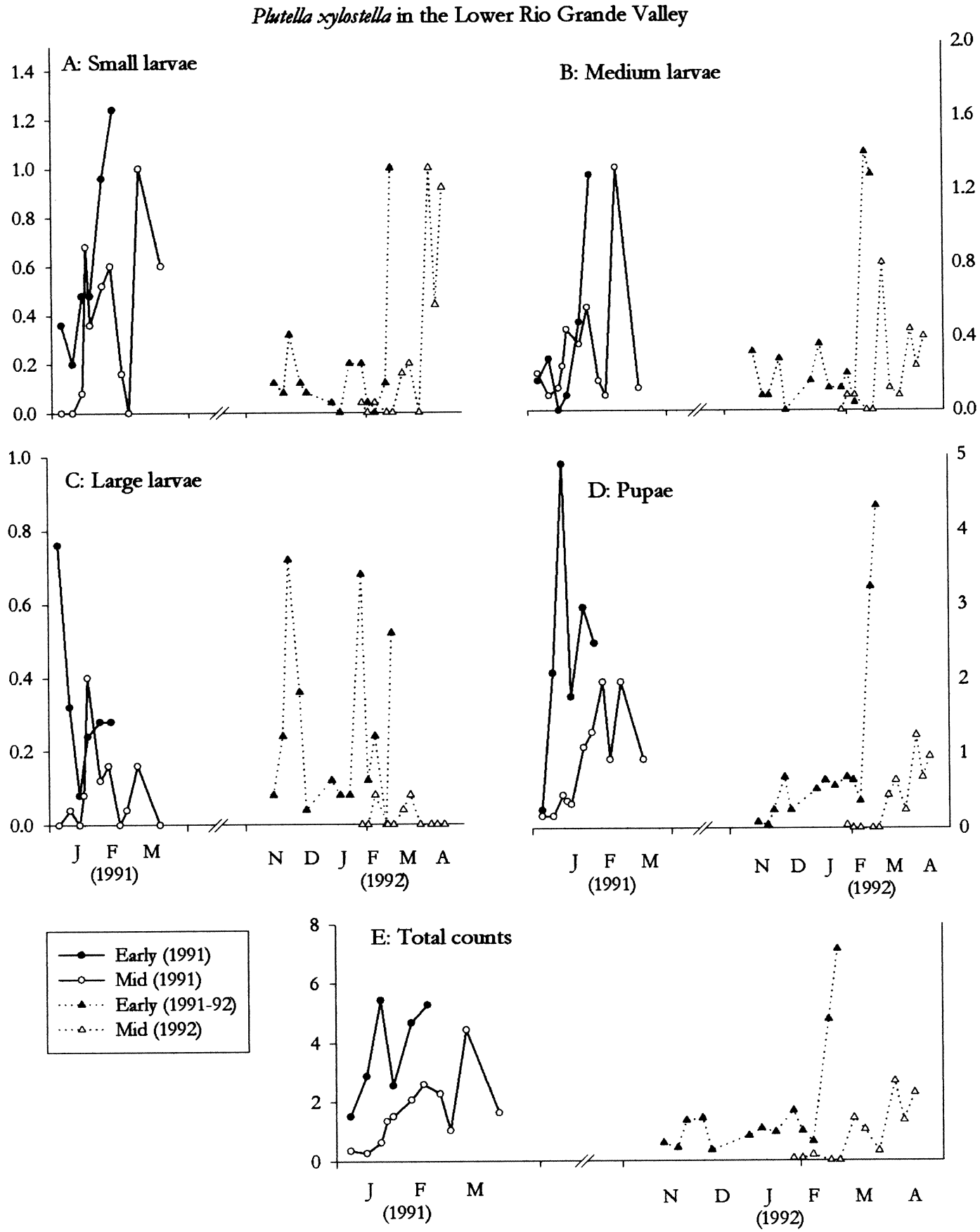

Fig. 1. Field counts of *P. xylostella* per plant (n = 25) in the Lower Rio Grande Valley of Texas (1991-1992 planting seasons). A) Small larvae; B) Medium larvae; C) Large larvae; D) Pupae; and, E) Total counts (cocoons were not counted).

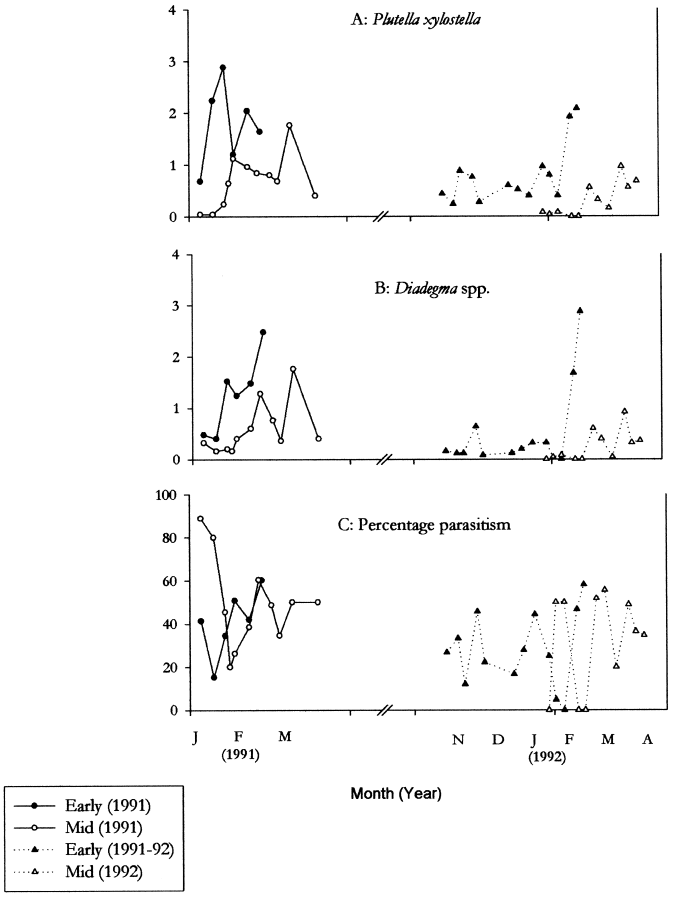

Fig. 2. Adult emergence of field-collected *P. xylostella* larvae in the Lower Rio Grande Valley of Texas (1991-1992 planting seasons; per plant basis; *n*=25). A) Emergence of adult *P. xylostella* moths; B) Emergence of adult *Diadegma insulare* parasitoids; and, C) Percentage parasitism, calculated as number of adult parasitoids divided by total number of adult moths and parasitoids (exludes mortality or loss incurred during the rearing process).

(27: 31), 31.0% (18: 39), and 70.0% (7: 3) in samples collected from 15, 22, and 29 April, respectively. In addition to *D. insulare*, two specimens of *Microplitis brassicae* Muesebeck (Hymenoptera: Braconidae) were also reared from field-collected *P. xylostella* larvae. However, *M. brassicae* accounted for only 1.6% (2 / 127) of the endemic parasitoid community sampled.

DISCUSSION

Several cruciferous crops attacked by *P. xylostella* are important components of Texas agriculture. In 1997, Texas ranked 3rd nationally in the production of broccoli (*Brassica oleracea* L.var. 'italica'), with 1,300 acres planted and a production of 87,000 cwt (hundred pounds) (TASS 1999). Texas also ranked 5th for both fresh cabbage (B. *oleracea* var. 'capitata'; 9,300 acres, 2,890,000 cwt yield) and cauliflower (B. oleracea var. 'botrytis', 700 acres, 63,000 cwt). In 1998, the fresh market value for broccoli was $2,238,000, while that for cabbage was $69,360,000. In 1997, the cauliflower crop was valued at $1,429,000 (TASS 1999). Crucifers accounted for 16.4% of revenues from commercial vegetable production in Texas in 1997, rising to 21.2% in 1998. In the LRGV, fresh market cabbage is also an important crop, with an average of 14,500 acres harvested yearly in 1983 and 1984 (Cartright et al. 1987). In the 1992 LRGV growing season, producer revenue from broccoli, cabbage, cauliflower and lettuce exceeded $17 million. *Plutella xylostella*, beet armyworm [*Spodoptera exigua* (Hübner)], and cabbage looper are the most important cabbage pests in Texas.

Harding (1976) conducted a systematic 4-yr survey of parasites of *P. xylostella* in the LRGV from 1969 - 1973. He recorded seven Hymenopteran parasites: *Cotesia* (=*Apanteles*) *epinotiae* Vier. (Braconidae), *C. marginiventris*, *Cotesia* sp. (unidentified), *D. insulare*, *Haltichella xanticles* (Walker) (Chalcididae), *Spilochalcis side* (Walker) (Chalcididae) and *Catolaccus aenoviridis* (Girault) (Pteromalidae). Subsequently, Anciso and Quick (1990) reported *D. insulare* and *Microplitis plutellae* (=*brassicae*) (Muesebeck). Percentage parasitism on the sampling date was 18.6%.

In the 1991 - 1992 survey, *P. xylostella* populations greatly exceeded the 0.3 larvae per plant threshold, especially during the months of January to March. In Spring 1999, populations persisted through April, subsequently declining by May. Percentage parasitism often fluctuated between 20 to 60%, reaching maximum levels of about 90%. *Diadegma insulare* was the predominant endemic parasitoid, accounting for >98% of the parasitoids reared from field-collected host larvae. Despite high levels of parasitism, *D. insulare* does not exert appreciable biological control of *P. xylostella* in the Lower Rio Grande Valley. Economic suppression of this host will require additional pest management techniques, possibly including biopesticides or an exotic egg parasitoid.

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