SHORT COMMUNICATION

Mortality of *Plutella xylostella* (Lepidoptera, Plutellidae) by parasitoids in the Province of Santa Fe, Argentina

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ABSTRACT. Mortality of *Plutella xylostella* (Lepidoptera, Plutellidae) by parasitoids in the Province of Santa Fe, Argentina. *Plutella xylostella* (Linnaeus, 1758) (Lepidoptera, Plutellidae) larvae cause severe economic damage on cabbage, *Brassica oleracea* L. variety *capitata* (Brassicaceae), in the horticultural fields in the Province of Santa Fe, Argentina. Overuse of broad spectrum insecticides affects the action of natural enemies of this insect on cabbage. The objectives of this work were to identify the parasitoids of *P. xylostella* and to determine their influence on larva and pupa mortality. Weekly collections of larvae and pupae were randomly conducted in cabbage crops during spring 2006 and 2007. The immature forms collected were classified according to their developmental stage: L1 and L2 (Ls = small larvae), L3 (Lm = medium larvae), L4 (Ll = large larvae), pre-pupae and pupae (P). Each individual was observed daily in the laboratory until the adult pest or parasitoid emergence. We identified parasitoids, the number of instar and the percentage of mortality of *P. xylostella* for each species of parasitoid. Parasitoids recorded were: *Diadegma insulare* (Cresson, 1875) (Hymenoptera, Ichneumonidae), *Oomyzus sokolowskii* (Kurdjumov, 1912) (Hymenoptera, Eulophidae), *Cotesia plutellae* (Kurdjumov, 1912) (Hymenoptera, Braconidae) and an unidentified species of Chalcididae (Hymenoptera). Besides parasitoids, an unidentified entomopathogenic fungus was also recorded in 2006 and 2007. In 2006, the most successful parasitoids were *D. insulare* and *O. sokolowskii*, while in 2007 only *D. insulare* exerted a satisfactory control and it attacked the early instars of the pest.

KEYWORDS. *Brassica oleracea* cv. *capitata*; *Cotesia plutellae*; *Diadegma insulare*; diamondback moth (DBM); *Oomyzus sokolowskii*.

RESUMO. Mortalidade de *Plutella xylostella* (Lepidoptera, Plutellidae) por parasitóides na Província de Santa Fé, Argentina. *Plutella xylostella* (Linnaeus, 1758) (Lepidoptera, Plutellidae) causa danos econômicos severos em repolho, *Brassica oleracea* variedade *capitata* L. (Brassicaceae), na área de horticultura localizada na Província de Santa Fé, Argentina. O uso excessivo de inseticidas de largo espectro afeta a ação dos inimigos naturais de *P. xylostella* em repolho. O presente trabalho teve como objetivo identificar os parasitóides de *P. xylostella* e determinar sua influência na mortalidade de larvas e pupas em Santa Fé, Argentina. Coletas semanais de larvas e pupas em culturas de repolho foram realizadas aleatoriamente na área durante a primavera de 2006 e 2007, registradas pelo estágio de desenvolvimento: L1 e L2 (Ls = larvas pequenas), (Lm = larvas médias) L3, L4 (Ll = larvas grandes) pré-pupa e pupa (P). Cada indivíduo foi observado diariamente no laboratório até a emergência dos adultos da praga ou dos parasitóides. Foram identificadas as espécies de parasitóides o número de instars e a porcentagem de mortalidade. Os parasitóides registrados foram: *Diadegma insulare* (Cresson, 1875) (Hymenoptera, Ichneumonidae), *Oomyzus sokolowskii* (Kurdjumov, 1912) (Hymenoptera, Eulophidae), *Cotesia plutellae* (Kurdjumov, 1912) (Hymenoptera, Braconidae) e uma espécie não identificada pertencente à família Chalcididae. Além dos parasitóides, um fungo entomopatogênico não identificado foi registrado. Em 2006, os parasitóides mais bem sucedidos foram *D. insulare* e *O. Sokolowskii*; enquanto que em 2007 apenas *D. insulare* exerceu um controle satisfatório, atacando os instares iniciais da praga.

PALAVRAS-CHAVE. *Brassica oleracea* var. *capitata*; *Cotesia plutellae*; *Diadegma insulare*; *Oomyzus sokolowskii*; traça-das-crucíferas.

The Diamondback moth (DBM), *Plutella xylostella* (Linnaeus, 1758) (Lepidoptera, Plutellidae), is a cosmopolitan pest of wild and cultivated Brassicaceae plants (Mussury *et al.* 2002; Ulmer *et al.* 2002). It is adapted to different climatic conditions (Martínez-Castillo *et al.* 2002) and causes serious economic losses worldwide (Jankowska & Wiech 2006).

DBM presents high genetic variability (Garcia Campos *et al.* 2006), large number of annual generations, and high fertility (Ulmer *et al.* 2002), which facilitate the development of resistance to insecticides. Cross-resistance for organophosphates and pyrethroids has been observed (Yun Cheng 1985). Sarfraz & Keddie (2005) reported the physiological capacity of *P. xylostella* to detoxify glucosinolates, the natural defense system of Brassicaceae.

DBM integrated pest management combines adequate pesticide use, biological control, floristic diversity in the field and trapping crops. Biological control can be very effective if control agents are available. There are over 90 parasitoid species recorded attacking the DBM larvae and pupae in integrated pest management programs for commercial cabbage production (Jankowska & Wiech 2006; Furlong *et al.* 2004).

Parasitoids attack the pest in different developmental stages. It is relevant to determine the association between biological control agents and specific stages of the pests to improve biological control strategies.

Despite the importance of DBM in Argentina and the frequent insecticide applications for its control, few studies have been conducted to determine natural mortality factors. The aim of this study was to survey the parasitoid species attacking DBM in different developmental stages and to determine their mortality impact on DBM in cabbage.

Field samples were taken in a commercial farm located in the horticultural region of the Province of Santa Fe (60°50'W, 31°25'S), where the climate is temperate with dry winters, according to Köppen classification. The average annual temperature is 18°C, with average minimum temperature of 6.6°C in July and maximum of 31.6°C in January. The average annual rainfall is 750 mm. The main crop surveyed was *Brassica oleracea* var. *capitata* L., where weekly collections of larvae and pupae of DBM were made during spring 2006 and 2007.

Since the identification of discrete pest generations is difficult because overlapping, sampling was based on estimates of total density of larvae and pupae of the pest and of parasitoids in a given period, using graphic methods by Southwood & Jepson (1962). When high pest population level was observed (more than three individuals per plant), random sampling of apparently healthy immature started. The insects collected were separated into four groups (Mills 1992) in laboratory, base on size: small larvae (Ls) for instars L1 and L2; medium larvae (Lm) for L3; large larvae (Ll) for L4; and pre-pupae and pupae (P). The specimens were placed individually in Petri dishes of 5.5 cm diameter, reared at 22 ± 2°C and 60 ± 5% RH. Larvae were fed daily with pieces of fresh cabbage leaves. The dishes were checked daily for emergence of either moths or parasitoids and for insect mortality. Adult parasitoids were placed individually in ethanol at 70° until identification. Total parasitism rate for each species and year were determined. Larvae lost by handling were not included in the analysis.

The parasitoid species identified in our work were all Hymenoptera attacking larvae and pupae of DBM: *Diadegma insulare* (Cresson, 1865) (Ichmeumonidae), *Cotesia plutellae* (Kurdjumov, 1912) (Braconidae) and *Oomyzus sokolowskii* (Kurdjumov, 1912) (Eulophidae).

Diadegma sp. is a primary parasitoid of first larval instar, but death occurs in the pupal stage after the formation of the cocoon. Guilloux *et al.* (2003) observed a significant increase in parasitism (p d•0.01) from L2 to L3 by other species of this genus, *D. leontiniae* (Bret). The Eulophidae *O. sokolowskii* is a worldwide gregarious parasitoid that attacks immature forms, but prefers third and fourth instar larvae (Talekar & Hu 1996) and pre-pupae and pupae (Nakamura & Noda 2001). On the other hand, *C. plutellae* can attack all instars; however, parasitism decreases with age of the host.

In 2006, sampling started on October 18th, when it was recorded the maximum pest density and it was followed weekly until November 22nd. In 2007, DBM sampling was performed from August 21st to November 28th.

Among the 1077 individuals of DBM collected in 2006 (Table I), 28.8% reached the adult stage, while 11.1% were killed by entomopathogenic fungi, and 60.3% by parasitoids. The highest rate of adult emergence were when Ll individuals were parasitized (43.1%) even when this group had the highest entomopatogenic fungus mortality (28.4%) compared to Lm (17.6%) and Ls (17.9%).

In 2007, from 684 immature individuals collected, 50.4% reached the adult stage 21.9% died by entomopathogenic fungi; and 27.7% by parasitoids. Adult's emergence trend was similar to that observed in the year before, with Ll parasitized larvae resulting in the highest rate, 27.2%, which was lower than in 2006. No specimens of Chalcididae were collected in this period (Table I).

Table I. Natural factors of mortality on each developmental stage of *Plutella xylostella* (DBM), in cabbage crop in Santa Fe, Argentina, in 2006 and 2007.

Groups	DBM adults emerged	Number of adults emerged					Total
		Cotesia plutellae	*Oomyzus sokolowskii*	*Diadegma insulare*	*Entomopathogenic fungi*	Chalcididae	
2006							
Ls*	50	11	9	13	33	0	116
Lm*	68	39	37	38	39	0	221
Ll*	90	28	66	36	48	0	268
P*	102	2	288	69	0	11	472
Total	310	80	400	156	120	11	1077
2007							
Ls*	58	28	0	3	43	0	132
Lm*	69	55	4	3	62	0	193
Ll*	94	48	5	10	44	0	201
P*	124	0	25	8	1	0	158
Total	345	131	34	24	150	0	684

* Ls = L1 + L2; Lm = L3; Ll = L4 and prepupae, P = pupae.

In September 2007, heavy rains were recorded (Table II), which favored an increase in entomopathogenic fungus attack. Therefore, parasitoids effects on DBM, longevity and reproductive performance on infected hosts were significantly reduced (Schuld *et al.* 1999).

Table II. Rainfall during sampling periods of parasitism on *Plutella xylostella* in cabbage crop in Santa Fe, Argentina, in 2006 and 2007.

Year	Month	Rainfall (mm)
2006	August	7.1
	September	4.5
	October	77.2
	November	101.8
2007	August	22.6
	September	99.8
	October	124.2
	November	13.2

In 2006, *O. sokolowskii* caused 37.1% of total larval mortality, followed by parasitism by *D. insulare* (14.5%). Mortality rate increased from Ls to Ll.

Nevertheless, in Ls, the mortality of both *D. insulare* and *C. plutellae* (11.2 and 9.5% mortality rate, respectively) was higher than that caused by *O. sokolowskii*. In Lm, the three species of parasitoids had the same impact (17%). In Ll and P, *O. sokolowskii* caused the highest mortality (48.5% and 61%, respectively).

In 2007, the highest DBM mortality was caused by *C. plutellae* (19.1%) in all stages, followed by *O. sokolowskii* (4.9%) and *D. insulare* (3.5%) and the mortality rate also increased from Ls to Ll. *O. sokolowskii* caused the highest mortality in P individuals (16%), although it was very low in Lm and Ll (2% for each). The highest mortality rate by *D. insulare* was for the Ll group (5%).

No clear explanations can justify the prevalence of one parasitoid species over the other. In the field, competition may occur when several parasitoids coexist under suitable environmental conditions (Wang *et al.* 1999). This competition could be related with host initial density, parasitoid searching efficiency or aggressiveness (Ayalew & Ogol 2006).

In Santa Fe horticultural region, biological control with this complex of parasitoid species help to reduce DBM population and it should be taken into account for integrated pest management programs (Furlong *et al.* 2004). However, long-term studies would provide to a better understanding of the evolution of pests, parasitoids competition and entomopathogenic fungus impacts.

ACKNOWLEDGMENTS

Financial support for this study was provided by the Universidad Nacional del Litoral (Argentina).

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Received 2231/2011; accepted 7/8/2011
Editor: Sonia Maria Noemberg Lázzari