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Characteristics of Oviposition of Diamondback Moth (Lepidoptera: Yponomeutidae) on Cabbage

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Narayan S. Talekar, Shu-Huei Liu, Chian-Leei Chen and Yii-Fei Yiin (1994) Characteristics of oviposition of diamondback moth (Lepidoptera: Yponomeutidae) on cabbage. *Zoological Studies* **33(1)**: 72-77. Several laboratory and field experiments were conducted to understand the oviposition behavior of the diamondback moth [*Plutella xylostella* (L.)], a destructive pest of crucifers throughout the world. Diamondback moth lay eggs mainly on cabbage plant outer leaves. On outer leaves, eggs are laid mainly on the upper leaf surface; on inner leaves they are laid on the lower leaf surface. Egg density decreased from outer to inner leaves. Within a range of 1-11 trichomes per 9 sq. mm leaf area, the number of eggs laid on Chinese cabbage leaves increased with trichome density. Most oviposition activity took place within two hours after sunset; this period coincides with maximum mating-related flying activity. During daylight hours when the diamondback moth does not normally lay eggs, initiation of darkness stimulated oviposition. However, during night when this insect normally lays eggs, artificial light did not reduce oviposition activity.

Key words: Trichomes, Oviposition periodicity, Oviposition stimulation, Oviposition location, *Plutella xylostella*.

Oviposition is the first and most important aspect of insect infestation. Insect larvae rarely, if ever, move from one plant to another. The spread of an insect infestation is therefore, strongly influenced by an adult's choice of plant parts for oviposition and other oviposition characteristics. Consequently, an understanding of oviposition helps in devising suitable control measures; these measures may include mechanical egg dislodgment, chemical control, and the use of egg parasites. Despite the voluminous literature on diamondback moths (DBM), *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae) gaps still exist in our understanding of its oviposition behavior. Its resistance to insecticides has made it impossible to control this insect with conventional measures, most of which are directed at larvae (Talekar and Griggs 1986, Talekar 1992). Any control method targeted at developmental stages other than the larval stage has the potential for integration with existing control measures to help reduce the depredation of crucifers by DBM. We therefore conducted a series of experiments in order to gain a better understanding of DBM oviposition behavior.

MATERIALS AND METHODS

Influence of leaf position on DBM oviposition

A seven-week-old common cabbage plant (cv. K.Y. Cross) was placed in each of five wooden frame rectangular cages (50 cm x 50 cm x 50 cm). Four sides, including one that could be opened and closed, and the top of each cage were covered with fine mesh nylon netting; the cage bottom, was wooden. Five pairs (five males and five females) of DBM adults that had emerged from pupae within the previous 24 hours were released in each cage. These insects were allowed to lay eggs on the cabbage plants for 24 hours, after which the plants were removed from the cages and the numbers of eggs laid on each leaf recorded. Leaves were stripped from the plants and leaf areas were measured on a Li-Cor area meter (LI-3000, Li-Cor Corporation, Lincoln, Nebraska, USA).

Influence of trichome density on DBM oviposition

The seeds of four Chinese cabbage varieties (B 288, B 777, New King, and ASVEG 1) each differing in foliar trichome density, were planted in plastic pots (7 cm diam.) and maintained in a greenhouse. Four weeks after germination, one plant of each variety was placed inside each of the five wooden frame nylon net cages, each cage being one replicate. Fifteen pairs of newly—emerged DBM adults were then released inside each cage and the number of eggs laid on each plant were recorded on the fourth day following the release.

The fourth leaf (starting from the outermost as the first leaf) of each plant was then cut, and trichomes were counted in four randomly-selected 3 mm x 3 mm areas on upper and lower leaf surfaces. The mean numbers of trichomes per unit area were then calculated.

Periodicity of DBM oviposition

Our first laboratory experiment utilized 144 one-month-old Chinese cabbage plants (cv. New King) of relatively uniform size raised in 5-cm diameter plastic pots in a DBM-free greenhouse. Three wooden frame cages were built as previously described. Two hundred DBM adults were released in each of the three cages early in the morning. Thereafter two one-month-old Chinese cabbage plants were placed in each cage every hour throughout the day (24 hours). The plants were kept inside each cage for one hour, after which they were replaced with two fresh plants. Each leaf was examined and the numbers of eggs laid on the stems and upper and lower leaf surfaces were recorded.

In a field experiment, common cabbage (cv. K.Y. Cross) was planted in three 20 m x 9 m plots with a distance of 3 m between two adjacent plots; each plot was considered as a single replicate. Eight weeks after transplantation when the DBM population was high, a single sticky paper trap baited with 10 μg of the DBM sex pheromone; 1:1 mixture of (Z)-11-hexadecenyl acetate and (Z)-11-hexadecenyl aldehyde (Chow et al. 1977, Tamaki et al. 1977) was placed in each plot. The number of male DBM adults captured in each trap was recorded every hour throughout a 24-hour period. Simultaneously, three randomly selected plants were uprooted from each plot and the number of DBM eggs on each plant were recorded.

Effect of light/dark on DBM oviposition

For this laboratory experiment a single cabbage leaf was placed inside each of eight nylon net cages; within which a small wad of cotton dipped in syrup was placed as a food source. Five pairs of newly-emerged DBM adults were then released into each cage. Starting at 18:00, a fluorescent light source was turned on in four of the eight cages; the other four were maintained as controls. At 06:00 the following day, the lights were turned off, the cabbage leaves were removed and the number of eggs on each leaf was recorded. A fresh cabbage leaf was then placed inside each cage. Four cages were covered with black cloth to block out all light; the other four were maintained as controls. At 18:00 the same day, the leaves were removed and the number of eggs laid were recorded. Again one fresh leaf was placed in each cage; the black cloth covers were removed and the fluorescent lights again turned on in four cages. At 06:00 the next day, the leaves were removed and the numbers of eggs laid on each leaf were recorded. This experiment was repeated two days later.

Statistics

Data on the influence of leaf position on DBM oviposition and the effect of trichome density on oviposition were analyzed by simple linear regression and correlation (Little and Hills 1975). Data on the effects of photophase and scotophil phase on DBM oviposition were analyzed by Student's *t* test.

RESULTS AND DISCUSSION

Leaf position and oviposition

The results of our experiment on the oviposition preferences of the DBM on cabbage leaves are summarized in Fig. 1. DBM laid 6 to 8 times more eggs on outer leaves than on inner leaves. There was a gradual reduction in the number of eggs laid per leaf from outer to inner leaves. A significant negative correlation ($r = -0.851$, $df = 6$) was observed in the number of eggs laid from outermost (no. 1 leaf) to the innermost (no. 8 leaf). The areas of leaves nos. 1 to 8 were 22.21, 27.00, 45.22, 52.49, 62.62, 58.95, 36.74 and 22.84 sq. cm, respectively; indicating oviposition preference is not related to leaf size. The fewer eggs laid on

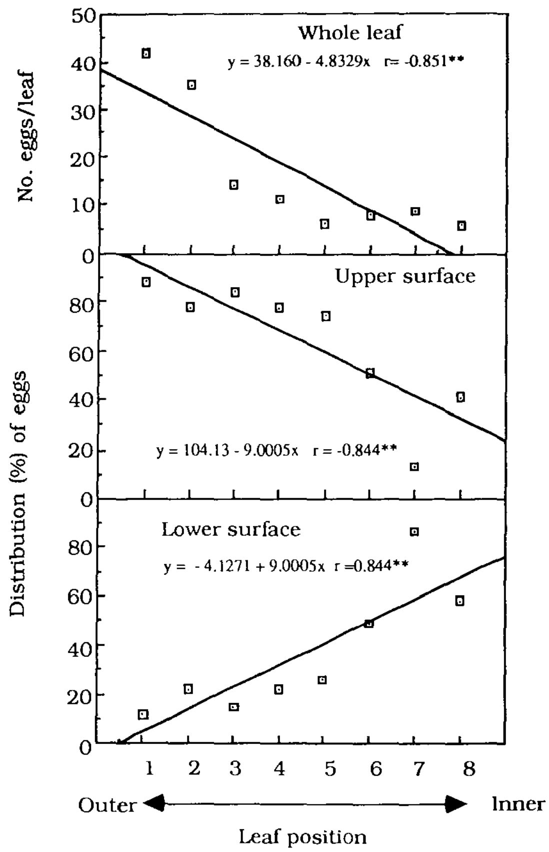

Fig. 1. Effect seven-week-old cabbage plant leaf position on the numbers of eggs laid on leaves. **Indicates regression equation significant at 1% probability level.

inner leaves is most likely related to reduced leaf accessibility for oviposition. The seven-week-old plants had not yet formed the heads and so all leaves were open. As the leaf position progressively moved from outer to inner, we observed a significant shift in leaf surface preference for DBM oviposition. On the outer leaves, most eggs were laid on the upper leaf surface; the opposite was true for the inner leaves. The outer leaves are usually fully open and, in most cases, positioned horizontal to the soil surface; this position exposes both leaf surfaces equally for oviposition. Still, the upper surface was more often preferred by the DBM for oviposition. The inner leaves become progressively erect, with their lower surfaces facing outward; they are more accessible for DBM oviposition. Certain leaf areas surrounding the petiole are almost completely inaccessible for oviposition.

Trichome density and oviposition

In an earlier unpublished study, we found

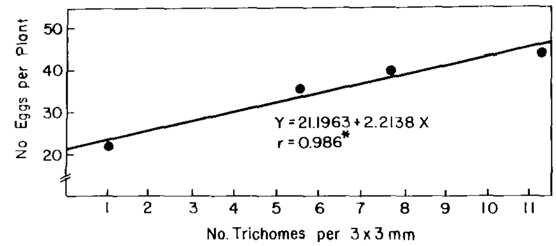

Fig. 2. Influence of trichome density of Chinese cabbage leaves on oviposition of the DBM. *Indicates regression equation significant at 5% probability level.

that DBM prefers to lay eggs on Chinese cabbage over common cabbage; the former crop was therefore used in our experiments. The four-week-old seedlings (of all four varieties) used in this study were of similar size. We observed a significant positive correlation (r = 0.986, df = 2) between trichome density and the number of eggs laid (Fig. 2). This implies that plants with glabrous leaves are likely to be more resistant to the pest. In cotton, increased glabrousness reduces fleahopper population (Cowan and Lukefahr 1970). It must be pointed out, however, that in our study the trichome range was limited to between 1 and 11 per 9 sq. mm of leaf area; consequently whether the trichomes themselves are directly involved in reducing oviposition or other plant characteritics linked to trichomes are responsible is uncertain. In crops such as beans and cotton, excessive as well as extremely low trichome densities adversely affect infestation by certain pests – presumably via reduced oviposition (Dunnam and Clark 1939, Pollard and Saunders 1956, Mound 1965, Lin 1979, Talekar et al. 1988).

Oviposition periodicity

The number of eggs laid by DBM on Chinese cabbage leaves over a 24-hour period are shown in Fig. 3. Most (65%) of the eggs were laid between 18:00 and 22:00 with a peak (36%) between 19:00 and 20:00. Sunset during our experimental period was at 18:30. Harcourt (1956), Sakanoshita and Yanagita (1972), and Pivnick et al. (1990) all reported observing egg laying activity before midnight. Our study results reveal an oviposition peak approximately 1 to 2 hours after sunset. Among the total of 896 eggs observed on Chinese cabbage in this study, 60% were laid on upper leaf surfaces, 37% on lower leaf surfaces, and 3% on stem surfaces (Fig. 4). Previously-published observations are inconclusive on this point; Ghesquiere (1939),

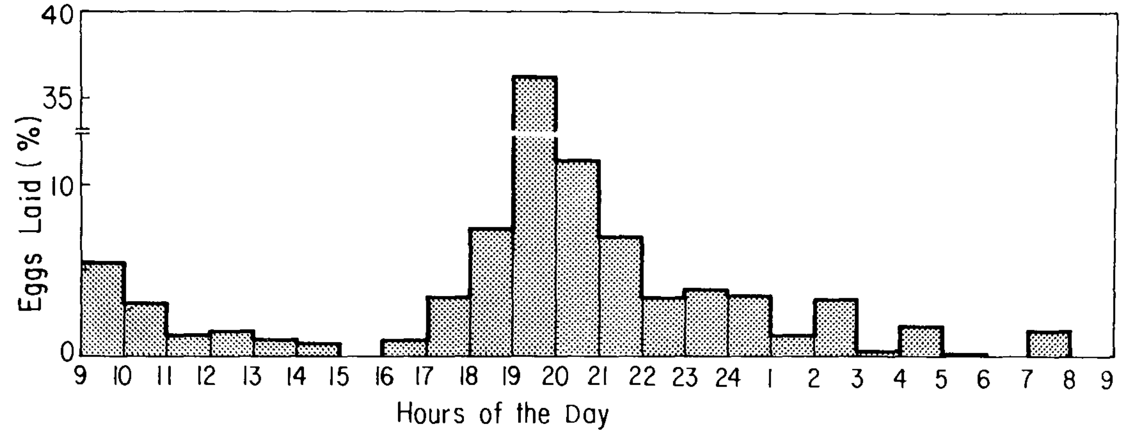

Fig. 3. Hourly periodicity of oviposition by the DBM on Chinese cabbage leaves.

Hassanein (1958), and Tabashnik and Mau (1986) all reported egg laying on lower surfaces only, while Gunn (1917) reported oviposition on the upper leaf surface and Harcourt (1957) reported 50% on the upper and 50% on the lower surface leaf surfaces. These differences may be due to different plant species and/or specific postion of the oviposited leaves on the plant. Based on our study, at least for Chinese cabbage, most eggs were laid on the upper leaf surfaces.

In the field, most flying activity, related to mating and oviposition, took place between 18:00 and 20:00; at this time the maximum number of male adults were captured in our sex pheromone traps (Fig. 5). This peak flying activity coincided with the observed peak oviposition period, confirming earlier laboratory results where insects laid the maximum number of eggs between 18:00 and 20:00. This flying and oviposition periodicity has been found to be very helpful in timing sprinkler irrigation in order to reduce DBM infestation, presumably via the disruption of mating and oviposition activity (Talekar et al. 1986).

Photoperiod effect on oviposition

Within a 24-hour day, the insects lay very few or no eggs during the 12-hour photophase. However, when darkness was artificially induced during the photophase, substantial numbers of eggs were laid (Table 1). Tabashnik and Mau (1986) also reported stimulation of oviposition by inducing of darkness during the normal photophase. The regular 12-hour scotophil phase of a 24-hour day appears to be the actual DBM egg- laying period. During this time, the introduction of artificial light did not significantly reduce DBM oviposition ac-

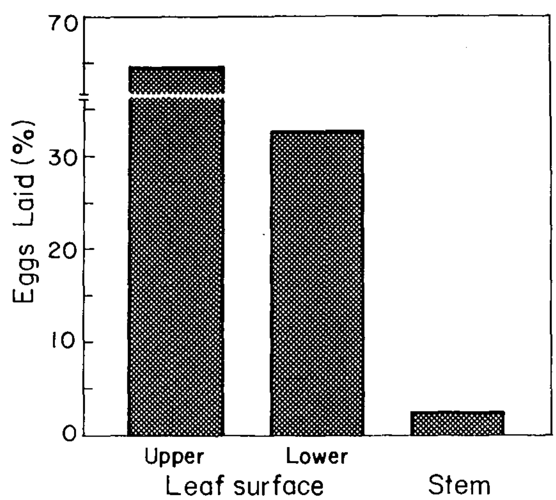

Fig. 4. The distribution of DBM eggs on Chinese cabbage leaves.

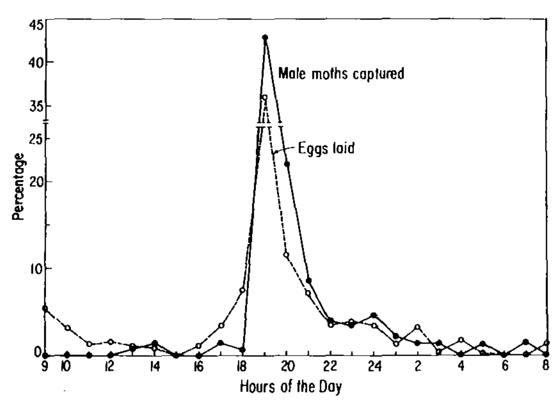

Fig. 5. The periodicity of DBM flying activity and oviposition in a given 24-hour period.

Table 1. Influence of lightness/darkness during daylight and night on oviposition of diamondback moth

Day or night	Light or dark	No. eggs/plant (mean ± SD)	
		Experiment 1	Experiment 2
Day	light	0	9.00 ± 6.88
	dark	37.25 ± 19.57	45.75 ± 22.43
	t^1	3.785**[2]	3.133*
	df^3	6	6
Night	light	53.25 ± 39.39	42.50 ± 28.55
	dark	44.25 ± 20.12	23.50 ± 28.50
	t	0.407NS[4]	0.942NS
	df	6	6

[1]Student's *t*-test.
[2]*t* values significant at 1% (**) or 5% (*) probability levels.
[3]Degree of freedom.
[4]Not significant.

tivity. Thus the onset of darkness may not be the only criterion for the initiation of oviposition; other unknown factors seem to influence the initiation of DBM oviposition during a scotophil phase.

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小菜蛾在甘藍上之產卵研究

Talekar, N.S. 劉淑惠 陳千蕾 尹怡斐

本文乃針對十字花科蔬菜害蟲小菜蛾之產卵行爲，在室內及田間作一系列之研究。小菜蛾主要產卵在甘藍之外葉，其產卵數由外至內葉逐漸減少。在白菜葉片絨毛密度每9平方公釐爲1－11根之間時，產卵數隨絨毛密度之增加而增加。小菜蛾產卵之主要時間乃在日落後之兩小時內，這段時間亦是其交尾之盛期。在一天中正常之光照下通常不產卵，其產卵行爲乃因黑暗所刺激。然而，當其在一天中黑暗之情形下產卵時，即使給予光照處理，亦不會降低其產卵數。

關鍵詞：絨毛, 產卵時期, 產卵刺激, 產卵位置, 小菜蛾。