

Studies on Diamondback Moth in Venezuela with Reference to other Latinamerican Countries

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Abstract

Diamondback moth is a serious pest of cruciferous crops throughout the world. The insect is also a very important pest in South America, especially in Venezuela. In Venezuela it attacks a wide range of crucifers including *Brassica* weeds. Under variable temperature (12 to 25°C) and relative humidity (45 to 96%) conditions, the mean duration of lifecycle in Venezuela was 76.14 days. One parasite, *Diadegma* sp, attacks diamondback moth larvae in Venezuela. Malathion and diazinon are widely recommended for the control of this insect. Besides Venezuela, diamondback moth also attacks crucifers in Argentina, Brazil, Chile, Colombia, Cuba, the Dominican Republic, Jamaica, Peru, and Trinidad and Tobago.

Introduction

One of the many important lepidopterous insect pests of cultivated plants is the diamondback moth (DBM), *Plutella xylostella* (L) (Lepidoptera: Yponomeutidae). This insect is widely distributed and is a serious pest of cruciferous crops in many parts of the world (Salinas 1975, 1977). The adaptability of the insect to different climatic conditions and its recognised status as a major pest in temperate and tropical regions make the study of DBM important from the economic as well as the biological point of view. Talekar et al (1985) list 1016 papers dealing with this pest published up to mid 1984.

Descriptions of egg, larval instars, prepupa, pupa, and adult stages of this insect has been illustrated by many authors and have been summarized by Salinas (1977). There are slight but insignificant variations in biological and morphological parameters of these stages at different locations. More evidence is, however, necessary before definite conclusions can be drawn. The life history of DBM has been studied in varying detail in most parts of the world from the Equatorial Tropics to the Polar Circles. Salinas (1974) gives a general summary of the ecology of various life stages of this insect in various parts of the world, as well as his data for his studies of DBM in England at constant 20°C and at variable temperatures (average 18°C).

Studies on DBM in Venezuela

Distribution

Generally speaking, DBM can be found in all parts of Venezuela where cruciferous crops are grown. The geographical limits of its distribution are as follows: Caripe, Sucre State (10° 20N; 63°30W) in the east to Rubio, Tachira State (7°40N; 72°20W)

in the west; and from Antimano, near Caracas (10°30N; 67°00W) in the north to Rubio, Tachira State in the south. The range of altitude of DBM occurrence in Venezuela also varies. We have found this insect at Maracay, Aragua State, at 400 m above sea level to Mucuchies, Merida State at 3,100 m above sea level. The range of temperatures for DBM occurrence in Venezuela is from a mean temperature of 12°C at Macuchies to 30°C at Tocuyo, Lara State.

Host plants

The range of host plants that DBM attacks in Venezuela is restricted to the members of family Cruciferae and within it exclusively to introduced cultivated species of genus *Brassica*, including wild mustard *B. juncea*, a common weed at altitudes above 1000 m. Spanish colonizers imported these crucifers to Venezuela more than 400 years ago. The most common species attacked by DBM are: *B. oleracea* var *gemmifera*, *B. oleracea* var *botrytis*, *B. oleracea* var *capitata*, *B. pe-tsai* Bailey, *B. napus*, and *Raphanus sativus* (Salinas 1967).

Life history

The life history of DBM in Venezuela has been studied under constant and variable conditions by Salinas and Pena (1976) at Merida in the Andes. The insects were collected from the highlands around Merida.

Variable conditions The temperature and relative humidity were not controlled in this case. The average temperature was 18°C (range 12-25°C) and relative humidity 70% (45-96%); main light source, 10 h/day, was 40 W fluorescent tubes. The cages, the plants and other experimental conditions are described in Salinas (1974, 1984) and Salinas and Pena (1976).

Each plant received special treatment to maintain it in the best possible condition. Adults of both sexes were placed in the cages provided with sufficient honey-water solution to maintain normal activities. The plants were observed daily and those on which eggs were deposited were separated into individual cages so that the incubation period could be recorded. When the eggs hatched, each larva was placed on a tender leaf in a small individual cage, in order to record the duration of the larval stages. The food was changed as soon as it appeared to have deteriorated. Any external disturbance was avoided. The adults from these larvae were paired in individual cages, especially made for that purpose. Every day each pair of adults was transferred to a new cage to record the number of eggs laid daily.

Results of this study are summarized in Table 1. The mean duration of the lifecycle of DBM under variable conditions was 76.14 days. The egg incubation period was 6.48 days. The larval duration was 21.68 days. The pupa lasted 13.38 days. The adult longevity was 35.00 days.

The adults started copulating almost immediately after emerging from the pupae. It was evident that the females produced a strong sex pheromone which attracted the males. Several males were observed trying to copulate with a piece of cotton over which a young female had just passed (Salinas 1972). The copula lasted for about 1 h 30 min. In studies in Britain the pre-oviposition period varied from less than one day for mated females in the presence of the host plant to one day in the absence of the host plant (Salinas, 1972). In Canada the pre-oviposition period ranged from 4.2 days for mated females to 8.6 days for virgin ones (Hillyer and Thorsteinson 1969). In Venezuela, the pre-oviposition period was 5 days (Salinas and Pena, 1976). The oviposition period varied from 6.4 days in Canada (Harcourt 1957) to 18.6 days in Great Britain (Salinas 1972).

Table 1. Life cycle of DBM in Venezuela

Stage	Variable temperature ^a			Constant temperature ^b		
	No. of observations	Range (days)	Time in days (mean \pm S.E.)	No. of observations	Range (days)	Time in days (mean \pm S.E.)
Egg	50	6-7	6.48 \pm 0.54	19	5-7	5.79 \pm 0.85
Larva						
1st instar	50	4-8	6.18 \pm 0.83	19	2-6	4.47 \pm 1.02
2nd instar	50	3-8	5.10 \pm 1.15	18	1-4	2.78 \pm 0.65
3rd instar	50	3-7	4.52 \pm 0.97	18	3-4	3.39 \pm 0.50
4th instar	50	3-6	4.88 \pm 0.75	18	4-6	4.50 \pm 0.71
Pupa	06	11-16	13.38 \pm 1.41	15	8-10	9.07 \pm 0.70
Adult	06	22-52	35.00 \pm 11.35	6	13-19	17.67 \pm 2.34

^a Mean 18°C. ^b 20°C.

The range in Great Britain was 5 to 27 days. In Venezuela the mean oviposition period was 14.7 days with a range from 11 to 19 days (Salinas and Pena 1976).

The longevity of the adults shows great variability from location to location. The largest range (and the extreme longevity) was recorded by Harcourt (1957) in Canada, where the males lived from 3 to 58 days (probably the record for the species) and the female lived 7 to 47 days. In Great Britain the lifecycle duration of females was 8 to 16 days in the presence of the host plant, and 11 to 27 days in the absence of the host plant (Salinas 1972). In Venezuela, Salinas and Pena (1976) found that at 18°C, the females lived 30.6 days (range 22 to 43 days) and the males 39.3 days (range 28 to 52 days); the combined average longevity was 35.0 days (range 22 to 52 days). At 20°C constant temperature the longevity was 17.7 days (range 13 to 19 days). In an experiment in which females were fed with honey solution, Salinas and Pena (1976) found that the females lived on average 49.8 days (range 29 to 57 days). The 57 day figure is probably the longest duration recorded for a female of this species. In another experiment, the same authors showed that males kept isolated and without food lasted 23.8 days (range 22 to 26 days).

The fecundity of DBM depends on many factors: genetic factors, the nutritional condition of the larvae, the nature of the host plant, the climatic conditions, the mating, and the presence or absence of host plants on which to oviposit. Mean number of eggs per female vary from 139 (range 55 to 226) in the USA at 26°C (Biever and Boldt 1971) to 246 (range 95 to 602) in Great Britain at 20°C (Salinas 1972). In Venezuela, at 18°C, the mean number of eggs per female was 162.6 (range 161 to 168) (Salinas and Pena 1976).

The preference for location of oviposition in the experiments was as follows: 110.6 eggs (range 79 to 131 eggs) on the glass walls of the cages, and 52.0 eggs (range 30 to 80 eggs) on the host plant leaves. The overall sex ratio was male:female = 1:1.5.

Constant conditions The experiments under constant conditions were carried out in a Gallenkamp IH-330 incubator. The temperature was maintained at $20 \pm 1^\circ\text{C}$ and 75% relative humidity. There was total darkness inside the incubator. The eggs and later the larvae were observed directly in the incubator. Once a day, the cages with eggs and/or larvae were taken outside the incubator for detailed observations or for replacement of the food (leaves). The cages and other materials and methods were similar to those described for the variable conditions experiments. The results are summarized in Table 1.

The mean duration of the lifecycle of DBM under constant conditions was 47.08 days. The egg incubation period was 5.79 days, larval duration was 15.14 days, and the pupal stage lasted 9.07 days. The adult longevity was 17.67 days.

Discussion

From the above results, it can be seen that an increase in temperature results in a decrease in the developmental time of all the different stages from egg to adult. This agrees with the observations made in other countries. The smallest difference was found in the fourth instar: 4.88 days at 18°C variable temperature and 4.50 days at 20°C constant temperature. The largest difference was found in the adult stage: 35.00 days at 18°C variable temperature and 17.67 days at 20°C constant temperature. The number of eggs per female also decreased with increasing temperatures.

There seems to be little doubt that an increase in temperature, even as little as 1 or 2°C, can be highly significant in shortening the developmental time of the different stages of DBM. The most probable reason for this decrease is an increase of the metabolic rate with rising temperatures; as metabolic rate increases life processes accelerate. The use of energy to cope with the increased metabolic functions probably explains the differences in fecundity as expressed by the number of eggs per female. The more the energy used in going from one stage to the next, for example from egg to larva or from pupa to adult, the less of it is left to develop all the potential eggs in the female.

Parasites

In general, DBM has few parasites, although some of them can be highly effective depending on specific conditions. This is best illustrated by the results of Salinas (1972) in England, who found *Nythobia* (= *Horogenes*) *eucerothaga plutellae* Kurdj (Hymenoptera: Ichneumonidae), as being responsible for 60% of pupal mortality in some instances, and yet for no mortality at all in some other instances in the same year and in the same field.

In Venezuela, Salinas and Pena (1976) reports that a parasite, *Diadegma* sp (Hymenoptera: Ichneumonidae), lays its eggs in DBM larvae and, after completing its larval stage inside the larvae emerges from the DBM cocoon.

Chemical Control

There is a great deal of information published on the chemical control of DBM around the world and every year more information appears on new products and methods. This is probably due to the species becoming resistant to insecticides. In fact, as early as 1953 DBM was the first Lepidoptera reported to be resistant to DDT and probably the first crop pest reported to be so. This was just a few years after the commencement of the commercial use of DDT (Anskersmit 1953).

In Venezuela there are no records of the first products used in DBM control, but probably inorganic products such as the arseniates were used by the 1930s and DDT after 1946. In 1957 TDE and DDT, both organo-chlorines of long persistence, were recommended as dusting powder at dosages of 30 kg/ha. Gonzalez et al (1973) reported on the same product but increased the dose to 35 kg/ha, and also recommended DDT 25EC at 1% in water (0.25% AI) or endrin 19.5EC at 0.33% in water (0.07% AI), spraying any of them at 500 l/ha of the emulsion.

In experiments using several products, in the states of Aragua and Lara in Venezuela (1965-1968), and later in the state of Merida in the Venezuelan Andes (1973-1983), we have found (Salinas, unpublished data) good results with the use of malathion 50EC sprayed at dosages of 0.1-0.2% AI, and diazinon 60EC sprayed at dosages of 0.2-0.3% AI. Those products and dosages are still in use and are widely

recommended by private as well as public agricultural agencies. In the Trujillo state, also in the Andean region of Venezuela, there have been some experiments on the use of synthetic pyrethroid insecticides, with the best results obtained using permethrin 5EC at the rate of 0.07%.

Biological Control

Biological control has been attempted in Venezuela only with the use of Dipel, a commercial product containing *Bacillus thuringiensis*. The results have been good but the price is too high compared to the chemical products (malathion and diazinon).

No predators or parasites have been introduced in Venezuela for the control of DBM, although this approach is being experimented in Trinidad, West Indies, a few miles from Venezuela, with some positive results.

DBM in South America

There are relatively few references to DBM in the neo-tropical area and even fewer for South America.

Argentina

This country marks the southernmost limit of DBM occurrence in the New World. Brethes (1923) gives a very short description of the species. Bourquin in 1939 described the lifecycle of DBM. Chiesa-Molinari (1953) reported the presence of DBM on cruciferous crops. Margheritis and Rizzo (1965) referred to the lifecycle but without data, and described the damage, mainly to cabbage, kale, rape, and so on; they also cite *Apanteles alexanderi* (Brethes) and *Angitia leontiniae* (Brethes) as parasites.

Brazil

Bertels (1956) reported DBM infesting cabbage in southern Brazil and gave description of the damage and the different life stages. He mentions six generations of this insect per year, approximately 35 days a generation: egg, 6 to 7 days; larva, 14 to 18 days; pupa, 12 to 14 days. Bondar (1928) could be regarded as the second author to write about DBM in South America, when he reported it as a serious pest of cabbage in Bahia, in northeast Brazil. Costa-Lima (1936) mentioned DBM on kale and cabbage in Bahia State, Minas Gerais and Rio de Janeiro. The same author, in his 1945 work on the insects of Brazil written in 11 volumes, gives the general characteristics of the family Plutellidae, citing that 200 to 300 species are described; he describes the adult and the damage of DBM on cruciferous plants.

Chile

Gonzalez et al (1973) report DBM in Chile as a pest of cauliflower, rape, cabbage and brussels sprouts.

Colombia

Posada et al (1970) mention DBM damaging *Brassica* sp in Colombia.

Cuba

Cook and Horne (1908), as far as we know, were the first authors to write about DBM in the Neotropics, when they published a paper on 'Insects and Diseases of Vegetables' in Cuba. They briefly described larva, pupa and adult, and mentioned that the insect was abundant on cabbage and rape, where it caused considerable yield loss.

Dominican Republic

Salinas and Pena (1976) stressed the importance of DBM in Venezuela and in the Dominican Republic. In their paper they indicate that the most serious damage to cruciferous crops is in the area of Constanza de la Vega. Santoro (1960) mentions DBM as a pest of cruciferous crops in the Dominican Republic. He refers to the parasites of that species, namely *Angitia fenestralis* Holm (Hymenoptera: Ichneumonidae). and *Diadromus subtilicornis* Grav (Hymenoptera: Ichneumonidae) and *Apanteles ruficornis* Nees (Hymenoptera: Braconidae). Unhappily he does not mention the country from where those parasites were recorded and it is dubious that they were from the Dominican Republic.

Jamaica

Edwards (1930) referred to DBM in Jamaica, but he misnamed the species as 'the small green cabbage worm, *Plutella cruciferarum* Zell.'

Peru

Wille (1952) reports incidence of DBM on cauliflower, radish, mustard and other crucifers in Peru. He describes the adult and the damage, and mentions important economic losses in seedbeds and newly planted fields. In dry and hot weather the insect also attacks the older plants. The author cites that in Lima there are eight generations a year; in summer there are four generations of about 18 days each. He estimates 300 eggs per female. The same author cites two parasites: *Angitia* (*A. plutellae* ?) and *Meteorus* sp.

Trinidad and Tobago

The Commonwealth Institute of Biological Control (CIBC) in Trinidad has been carrying out research on parasites of DBM, which is a very important pest of cruciferous crops, mainly cabbage and cauliflower, in that island. The work includes the introduction and release of parasites from other countries as well as their shipment to other countries; for example *Tetrastichus sokolowskii* from India, and *Apanteles plutellae* to Barbados (CIBC 1977).

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