34

Life Table of Diamondback Moth and Its Egg Parasite *Trichogrammatoidea bactrae* in Thailand

P. Keinmeesuke, A. Vattanatangum[1], O. Sarnthoy[2], B. Sayampol[2], T. Miyata[3], T. Saito[3], F. Nakasuji[4], and N. Sinchaisri[2]

Entomology and Zoology Division, Department of Agriculture, Bangkhen, Bangkok 10900, Thailand. [1]Planning and Technology Division, Department of Agriculture, Bangkhen, Bangkok 10900, Thailand. [2]Department of Entomology, Kasetsart University, Bangkhen, Bangkok 10900, Thailand. [3]Faculty of Agriculture, Nagoya University, Nagoya 464, Japan. [4]Faculty of Agriculture, Okayama University, Okayama 700, Japan.

Abstract

The life table study of diamondback moth, *Plutella xylostella* (L.), in a naturally infested plot was carried out in 1985-89 in the highland area of Petchaboon Province (1985-86) and the lowland areas of Nakornprathom Province (1987-88) and Kanchanaburi Province (1988-89). The estimated number of generations of diamondback moth equals 17 and 25.5 per year in the highland and lowland areas, respectively. In highland areas, the survival rates in the hot and dry seasons were higher than that in the wet season. In the lowland areas the survival rate in the dry season was higher than that in wet season. Mortality of diamondback moth is due to rainfall and parasites. The parasites found in the highland area are egg parasite (*Trichogramma confusum*), larval parasite (*Cotesia plutellae* Kurdjumov) and pupal parasite (*Diadromus collaris* Gravenhorst). In the lowland areas, egg parasite (*Trichogrammatoidea bactrae* Nagaraja) was found for the first time attacking diamondback moth eggs in Thailand. Its parasitism was 16.2-45.2%. Larval parasite (*C. plutellae*) was also found in the lowland area parasitizing 6.1-32.4% of diamondback moth larvae. In the 1989-90, laboratory study on the insecticide toxicity to adults of *T. bactrae* indicated that fenvalerate, cycloprothrin, ethofenprop, abamectin, chlorfluazuron and *Bacillus thuringiensis* had low toxicity but phenthoate, fenvalerate, ethofenprox and benfuracarb had high toxicity to diamondback moth eggs parasitized by *T. bactrae*.

Introduction

The diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), is one of the most serious insect pests of cruciferous crops in Thailand. Farmers normally protect the crops from DBM only by spraying insecticides. The insecticide usage becomes not only useless but also harmful when DBM develops resistance. It is therefore most desirable to establish an integrated pest management (IPM) system which is not completely dependent on synthetic insecticides. The development of a life-table is indispensable for the development of an IPM program. The study of factors contributing to DBM survival both for highland and lowland areas in Thailand began in 1985, leading to the development of a DBM life table. *Trichogrammatoidea bactrae* Nagaraja, one of the important egg parasites, was found for the first time during the life table experiment. The Department of Agriculture in Thailand has been successful in mass rearing *T. bactrae*. Hassan et al. (1988) proposed a four-class harmful index to judge the toxicity of various insecticides to *Trichogrammatoidea*. According to this index, class one is harmless = mortality < 50%; class two is slightly harmful = mortality 50-79%, class three is moderately harmful = mortality 80-99%, and class four is harmful = mortality > 99%. We used these indices to judge the toxicity of commonly used insecticides in Thailand to *T. bactrae*.

Materials and Methods

Three tentative locations were prepared for the study in naturally DBM infested plots: Khao Khor, Petchaboon Province, was selected as the highland area to carry out the experiment during 1985-86; Nakornprathom and Kanchanaburi provinces were selected as the lowland areas to carry out the experiment in 1987-89. Cabbages were planted every 2 months in an area of about 400 m^2. Twenty-four plants were sampled randomly at each crop growth stage and examined for all stages of DBM at 10-day intervals. For Nakornprathom, the plants were planted in the 300 m^2 field. Thirty plants were sampled randomly every other day. The living larvae were separated into small groups (about 10 individuals) and were kept with a piece of cabbage leaf in a plastic container. Pupae were separated and placed one per vial. The insects were reared at 25°C, and parasitism was recorded. Egg, larval and pupal parasites of DBM were separated and placed individually in vials.

One-day-old adult *T. bactrae* were prepared for the toxicological experiment. A filter paper (1 × 3 cm) was dipped in the insecticide solution for about 10 sec, air-dried, then put into a glass vial (2 × 5 cm), and 10 *T. bactrae* adults were released inside. The mortality was observed at 24, 48, and 72 hours after treatment. Temperature was maintained at 25°C.

DBM and *Corcyra cephalonica* eggs were collected and fixed on the card (2 × 2 cm), and exposed to the UV light for 0.5 hour. Egg cards were put into the vial (2 × 10 cm) which contained *T. bactrae* adults. After parasitism, egg cards were dipped in insecticide solutions for 10 sec and the mortalities of eggs and emerged parasite adults were noted.

Results and Discussion

The numbers of eggs, larvae and pupae observed at different crop growth stages were recorded, and the total incidence of insects was calculated (Table 1).

In order to estimate the actual number (N) of insects in each stage, the following method (Kiritani and Hokyo, 1962) was used:

$$N = I.n/D$$

where:

N = Estimate the actual number
I = Census interval
n = Total incidence
D = Developmental period of each stage

The developmental period of the immature stage was estimated by the regression equation between the developmental velocity (V) and temperature (T). The calculated regression equations for each stage are as follows:

Egg; $V (= 1/D) = 0.0120T\ 0.0155$ ($r = 0.993$)
Larva; $V (= 1/D) = 0.0065T\ 0.0574$ ($r = 0.966$)
Pupa; $V (= 1/D) = 0.0136T\ 0.1233$ ($r = 0.991$).

Table 1. Estimation of the number of DBM at each stage using population monitoring data in naturally infested plots in three provinces, 1985-89.

Developmental stage	Petchaboon Province (January - December 1985)									Nakornprathom Province (July 1987 - January 1988)								
	Period study																	
	Mar. - Apr.			May - Jun.			Nov. - Dec.			July			Oct.			Jan.		
	D	n	N	D	n	N	D	n	N	D	n	N	D	n	N	D	n	N
Eggs	3.64	389	1068.68	3.64	964	2648.35	4.91	3824	7788.19	2.95	1582	1072.5	3.16	418	264.6	3.50	8432	4835.4
Larvae	10.02	564	562.87	10.02	542	540.92	16.33	5222	3197.80	7.44	825	221.8	8.15	277	68.0	9.45	4667	987.7
Pupae	4.86	77	58.44	4.86	40	82.31	8.01	1103	1377.02	3.60	146	81.1	3.95	67	33.9	4.59	1285	559.9
Temp.(°C)	24.19			24.19			18.26			29.5			27.7			25.1		

Developmental stage	Kanchanaburi Province (July 1988 - June 1989)								
	Period study								
	Mar - Apr.			Jul. - Aug.			Nov. - Dec.		
	D	n	N	D	n	N	D	n	N
Eggs	2.77	521	1880.86	2.94	191	649.65	3.57	392	1098.03
Larvae	7.14	217	303.02	7.69	60	78.02	10.00	680	680.00
Pupae	3.33	39	117.12	3.70	4	10.81	4.76	133	279.41
Temp. (°C)	31.85			30.00			25.15		

D= Estimated developmental perod (D,Day); n = Incidence; N = Estimated number.

The life tables were developed on the basis of the estimated number of insects in each stage (Tables 2, 3 and 4). The number of living insects/plant in each stage (Ix) is given. The parasitism was evaluated from the rearing of collected insects. Since the actual emergence rate of adults was not observed in the field, the number of adults emerged may probably be overestimated. The survival rate of DBM from egg to adult emergence was highest in the dry season and lowest in the wet season. The low survival rate in the wet season may be due mainly to parasites and rainfall. Sivapragasam (1986) developed life tables of DBM at Nagoya, Japan. He evaluated the effect of rainfall on eggs and showed that 38% mortality resulted from wash-off of the eggs by the rain. The survival rates in the highland Khao Khor was high especially in the dry season and the hot season. The rates were 13.9% and 13.3% with average temperatures of 18.3°C and 24.2°C respectively. However, the survival rates in the lowland Kanchanaburi were high only in the dry season. The survival rates were low during the hot season (6.2%) with average temperature of 31.9°C. High temperatures in the hot season may affect the survival of immature stages and reduce the adult fecundity. The rates of egg hatching, pupation and adult emergence were relatively high at 17.5-27.5°C and low at 30 and 32°C (Koshihara 1986). In the highlands parasitism by *T. confusum* and *C. plutellae* was highest in the wet season, but that by pupal parasite (*D. collaris*) was highest in the dry season. In the lowlands parasitism by *T. bactrae* ranged from 16.2 to 45.2% and that by *C. plutellae* 6.1 to 32.4%. These rates were highest in the wet season.

From the life cycle of DBM at different crop growth stages, it was found that the life cycle in the cool dry season (Nov.-Dec.) was the longest (29.25 days) at Petchaboon Province, and the shortest in the hot season (Mar.-Apr.) (13.24 days) at Kanchanaburi Province. Estimated numbers of generations of DBM were equal to 17 and 25.5 per year at Petchaboon and Kanchanaburi provinces , respectively. The average lowest temperatures in the dry season (Nov.-Dec.) were 18.3°C and 25.2°C at Petchaboon and Kanchanaburi, respectively. The mean temperature year-round was 22.2 and 29.1°C at Petchaboon and Kanchanaburi, respectively. The wet season in Thailand lasts from May to October. The highest precipitation is during July August.

Table 2. Life table of DBM in a naturally infested plot at Petchaboon Province 1985.

x	dxF	Wet season May-June lx	dx	%	Dry season Nov.-Dec. lx	dx	%	Hot season Mar.-Apr. lx	dx	%
Egg		110.35			324.51			44.53		
	Egg parasite[a]		17.05	15.45		7.21	2.22		0	0
	Unknown		70.76	64.12		183.98	66.69		21.08	47.34
	Total		87.81	79.57		191.19	68.91		21.08	47.34
Larva		22.54			133.24			23.45		
	Larval parasite[b]		4.82	21.38		15.14	11.36		3.49	14.89
	Unknown		14.29	63.40		60.72	45.57		13.36	56.97
	Total		19.11	84.78		75.86	56.93		16.85	71.86
Pupa		3.43			57.38			6.60		
	Pupal parasite[c]		0.17	4.96		12.03	20.98		0.77	11.69
	Unknown		?	?		?	?		?	?
	Total		≥0.17	≥4.96		≥12.03	≥20.97		≥0.77	≥11.69
Adult		≤3.26			≤45.35			≤5.90		
Survival rate (%) (Egg-Adult)				≤2.95			≤13.97		≤13.25	

[a]*Trichogramma confusum*; [b]*Cotesia plutellae*; [c]*Diadromus collaris*.

Table 3. Major mortality factors of DBM in naturally infested plot at Nakornprathom Province (1987-88).

x	dxF	Wet season May-June lx	dx	%	Dry season Nov.-Dec. lx	dx	%	Hot season Mar.-Apr. lx	dx	%
Egg		35.75			8.82			161.18		
	Egg parasite[a]		5.79	16.2		3.99	45.2		32.56	20.2
	Unknown		22.57	63.1		2.99	33.9		95.70	59.4
	Total		28.36	79.3		6.98	79.4		128.26	79.6
Larva		7.39			2.66			32.92		
	Larval parasite[b]		0.45	6.1		0.85	32.4		4.51	13.7
	Physiological death		0.89	12.1		0.67	25.5		2.50	7.5
	Unknown		3.35	45.3		0.01	0.4		7.25	22.0
	Total		4.69	63.5		1.53	58.3		14.26	43.2
Pupa		2.70			1.13			18.56		
	Physiological death		0.56	20.6		0.25	22.4		2.35	12.6
	Unknown		?	?		?	?		?	?
	Total		≥0.56	≥20.6		≥0.25	≥22.4		≥2.35	≥12.6
Adult		≤2.14			≤ 0.88			≤16.31		
Survival rate (%) (Egg-Adult)		≤5.9			≤10.0			≤10.2		

[a]*Trichogrammatoidea bactrae* Nagaraja; [b]*Cotesia plutellae* Kurdj.

Table 4. Major mortality factors of DBM in a naturally infested plot, Kanchanaburi Province (July 1988-June 1989).

x	dxF	Wet season I May-June lx	dx	%	Dry season II Nov.-Dec. lx	dx	%	Hot season Mar.-Apr. lx	dx	%
Egg		27.06			45.75			78.36		
	Egg parasite[a]		4.25	15.70		0.11	0.24		3.87	4.93
	Unknown		19.57	72.32		16.94	37.02		61.83	78.90
	Total		23.82	88.02		17.05	37.26		65.70	83.83
Larva		3.24			28.70			12.66		
	Larval parasite[b]		0.32	9.87		0	0		0.37	2.92
	Unknown		2.47	76.25		17.06	59.44		10.54	83.25
	Total		2.79	86.1		17.06	59.44		10.91	86.17
Pupa		0.45			11.64			1.75		
	Physiological death		0	0		0	0		0	0
	Unknown		?	?		?	?		?	?
	Total		≥0	≥0		≥0	≥0		≥0	≥0
Adult		≤0.45			≤11.64			≤1.75		
Survival rate (%) (Egg-Adult)				≤1.67			≤25.44			≤6.23

[a]*Trichogrammatids*, [b]*Cotesia plutellae*.

Table 5 shows that the percent mortality of adults of *T. bactrae* was high for phenthoate and benfuracarb but was low for fenvalerate, cycloprothrin, ethofenprox, *B. thuringiensis* and abamectin.

Additional experiments were performed in 1990 to include more insecticides used by farmers in some areas. Among those insecticides (chlorfluazuron, mevinphos, cartap and prothiofos), chlorfluazuron showed low toxicity to the adults of *T. bactrae*.

The toxicity of insecticides to parasitized egg and nonparasitized egg of *C. cephalonica* and DBM is shown in Table 6. Phenthoate and benfuracarb showed higher toxicity to parasitized eggs. The emergence of *T. bactrae* from parasitized DBM eggs was low in phenthoate, fenvalerate, ethofenprop and benfuracarb treatments. The results showed that cycloprothrin,

Table 5. Contact toxicity of the insecticides to the adult of *T. bactrae* (1989-90).

Insecticides	Dilution time	1989 % Mortality 24	48	72 hours
Phenthoate 50EC	200	42.5	97.5	100.0
	2000	7.5	17.5	45.0
Fenvalerate 20EC	200	0	5.0	7.5
	2000	0	5.0	10.0
Cycolprothrin 10EC	200	0	2.5	10.0
	2000	0	7.5	10.0
Ethofenprox 20EC	200	17.5	22.5	27.5
B. thuringiensis	2000	12.5	17.5	25.0
A+K WP	200	2.5	5.0	5.0
	2000	0	2.5	5.0
Abamectin 1.8EC	200	0	0	7.5
	2000	0	2.5	5.0
Benfuracarb 20EC	200	45.0	75.0	97.5
	2000	15.0	57.5	85.0
Control	–	0	0	0

Insecticides	Dilution time	1990 % Mortality 24	48	72 hours
Chlorfluazuron 5EC	200	5.0	5.0	7.5
	2000	0	10.0	12.5
Cartap 50SP	200	55.0	80.0	100.0
	2000	7.5	42.5	80.0
Mevinphos 24EC	200	100.0	100.0	100.0
	2000	62.5	92.5	100.0
Prothiofos 50EC	200	85.0	100.0	100.0
	2000	15.0	65.0	85.0
Control	–	0	0	5.0

Table 6. Toxicity of insecticides to unparasitized and *T. bactrae* parasitized eggs of *Corcyra cephalonica* and DBM.

Insecticides	Dilution time	1989 *C. cephalonica* % Egg parasite emerged from parasitized eggs	1989 *C. cephalonica* % Egg hatch from non-parasitized eggs	1990 DBM % Egg parasite emerged from parasitized eggs	1990 DBM % Egg hatched from non-parasitized eggs
Phenthoate 50EC	200	20.0	25.0	0	52.5
	2000	60.0	45.0	7.5	75.0
Fenvalerate 20EC	200	57.5	20.0	0	22.5
	2000	77.5	62.5	25.0	52.5
Cycolprothrin 10EC	200	77.5	57.5	62.5	47.5
	2000	72.5	70.0	77.5	75.0
Ethofenprox 20EC	200	42.5	10.0	5.0	50.0
	2000	72.5	25.0	5.0	82.5
B.t.A+K WP	200	65.0	55.0	77.5	72.5
	2000	72.5	77.5	95.0	90.0
Abamectin 1.8EC	200	57.5	27.5	77.5	65.0
	2000	70.0	52.2	85.0	87.5
Benfuracarb 20EC	200	25.0	0	0	15.0
	2000	30.0	0	0	70.0
Control	–	87.5	80.0	97.5	100.0

B. thuringiensis and abamectin had low toxicities, but phenthoate, fenvalerate, ethofenprop and benfuracarb had high toxicities to parasitized eggs of DBM.

It can be concluded that if these insecticides are used in the cabbage field, DBM larvae may or may not be killed depending upon whether or not DBM has developed resistance to these chemicals. However, some of these insecticides show low toxicity to egg parasites while others are highly toxic. Therefore, for effective control of DBM, the selective insecticides that are safer for the egg parasite should be carefully considered.

Reference

Hassan, S. A., Bigler, F., Bogenschutz, H., Boller, E., Brun, J., Chiverton, P., Edwards, P., Mansour, F., Naton, E., Oomen, P.A., Overmeer, W.P.J., Polgar, L., Rieckmann, W., Samsoe-Petersen, L., Stanubli, A., Sterk, G., Tavares, K., Tuset, J.J., Viggiani, G., and Vivas, A.G., 1988. Results of the fourth joint pesticide testing programme carried out by the IOBC/WPRS-Working Group "Pesticides and Beneficial Organism". J. Appl. Entomol., 105, 321-329.

Kiritani, K., and Hokyo, N. 1962. Studies on life table of the southern green sting bug, *Nezara viridula*. Jpn. J. Appl. Entomol. Zool, 6, 124-140.

Sivapragasam,A. 1986. Population dynamics of *Plutella xylostella* (L.) in cabbage field. MS Thesis, Faculty of Agriculture, Nagoya University, Japan, 129 p.

Koshihara, T. 1986. Diamondback moth and its control in Japan. *In* Talekar, N. S., and Griggs, T. D. (ed.) Diamondback moth management, proceedings of the first international workshop. Asian Vegetable Research and Development Center, Shanhua, Taiwan, 43-53.