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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 10 (12): 2152-2158, 2007
ISSN 1028-8880

Population Study of *Spodoptera exigua* (Lepidoptera: Noctuidae) Larva and its Affecting Factors in Sekinchan, Selangor

A.A. Azidah
Institute of Biological Sciences, Faculty of Science,
University of Malaya, 50603 Kuala Lumpur, Malaysia

Abstract: The aim of this study is to determine the *Spodoptera exigua* larva population in the field and factor affecting their density. Population study of *S. exigua* larva and its affecting factors was carried out in Sekinchan, Selangor during 2003-2004. The larval density was found fluctuating during the study, where the highest number of larvae was an averaged of 18.17 per m^2, while the lowest number was an averaged of 1.5 per m^2. The mean number of larvae per plant also varies from 1.83 to 5.42. It was found that the larval density was influenced by the age and availability of the host plant. A total of 1881 larvae were collected, where 18.29 and 20.31% were successfully becoming female and male moths, respectively; 20.63% was being parasitized, where 7.07, 11.43, 0.11 and 2.02% were being parasitized by *Microplitis manilae*, *Chelonus* sp., *Temelucha* sp. and *Peribaea orbata*, respectively. Besides that, other biotic factors such as fungal or bacterial infection also cause death to the *S. exigua* larva, where a total of 1.91 and 10.89% were infected by them, respectively. Whilst 16.64% of the collected larvae were dead due to pesticide and 7.44% were not known cause of the death. Besides that, 3.89% of the *S. exigua* died during pupal stage or emergence. Further, climatic factor was found not influencing the larva populations. There were no correlation between the number of larva collected with the means of temperature, relative humidity and rainfall.

Key words: *Spodoptera exigua*, larva, population density, natural enemies, abiotic factor

INTRODUCTION

The beet armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae) has a worldwide distribution (Crop Protection Compendium, 2000). In Malaysia, it was first reported in Kluang, Johor in 1996 by Department of Agriculture. As the *S. exigua* has recently become a pest in Malaysia, local information on its population and mortality factors are lacking. However, information on this aspect is available elsewhere, such as Van Steenwyk and Toscano (1981) who reported that 94% of the larval population on celery in California between 1978 and 1979 was *S. exigua*. While, population study by Tingle *et al.* (1994) between July and November 1992 on cotton found that *S. exigua* larvae were predominant during September. In Malaysia, larva population study has not been conducted thoroughly. Studies by Palasubramaniam *et al.* (2000) and, Sivapragasam and Syed (2001) were just visually assessing crop damage and random sampling of host plants, respectively. While Ng *et al.* (1999) conducted a field study to screen the efficacy of several insecticides against *S. exigua* larva.

Ruberson *et al.* (1994) and Huffman *et al.* (1996) have demonstrated that a large and diverse complex of beneficial arthropods and pathogen capable of maintaining *S. exigua* populations below economically damaging levels. Ruberson *et al.* (1994) also stated that disruption of this complex contributes to the outbreaks of *S. exigua*. In Malaysia, two species of parasitoids, i.e., *Microplitis manilae* Ashmead and *Peribaea orbata* (Wiedemann) were reported by Sivapragasam and Syed (2001) and Sivapragasam *et al.* (2001). They were considered as the major larval parasitoids of *S. exigua* in Malaysia. Sivapragasam and Syed (2001) also reported that the major predators in the field are the red ant, *Solenopsis* sp. and birds. They also stated that the other potential predator is the pentatomid bug, *Cantheconidea furcellata* (Wolff), which attacks the larval stage. Hence, this study was conducted to determine the *S. exigua* larva population in the field and factors affecting their density.

MATERIALS AND METHODS

Study site: Field study was carried out in Parit 5, Sekinchan, Selangor. The site is a vegetables plantation which was located in a paddy field area and used to be a paddy field. Size of the study area is 3 acres. Crop that has been planted in this experimental area during the study was long beans, lady's finger, cucumber, brinjal and chilli. Usually there are two types of crops being planted simultaneously. For example, long beans with lady's finger or cucumber with lady's finger or cucumber with brinjal or long beans with brinjal or chilli with brinjal. The age of each crop was recorded during the field survey.

These crops were planted according to the farmers selection due to the market price. The study was carried out in the farmer's fields, so that population trend of both pest and natural enemies under realistic farm conditions could be determined.

Larval sampling: The *S. exigua* larva was sampled manually from 28 January 2003 until 5 April 2004 in an area of 3 acres. For every ten bed of crop planting, 5 plots of 1×1 m were sampled randomly. The collected larvae were put in a respective plastic container [9.5 cm (top diameter) ×6.5 cm (bottom diameter)×12.5 cm (height)] with a hole (4 cm diameter) on the top cover which was covered with muslin cloth and, labeled with date of sampling, plot and replication number. Each of the plastic containers was filled with the host plant leaves for the larvae to feed on before reaching the laboratory.

In the laboratory, the larva was then separated individually in a plastic container and labeled with date of sampling, plot and replication number. This is to ensure the outcome of each individual larva is either as *S. exigua* or parasitoids, or died due to fungal or bacterial infection etc. Each of the outcomes was recorded. The larva was given fresh cabbage leaf every day to feed on until it pupated. The emerged parasitoids were kept in a vial specimen filled with 90% alcohol for identification. Identification was made by referring to the taxonomic keys (Achterberg, 1993; Austin and Dangersfield, 1993; Crosskey, 1976; Gauld, 1984; Shima, 1981). They were then sent to the Natural History Museum, London for verification.

Weather records on temperature, relative humidity and rainfall were obtained from the Meteorological Department at Petaling Jaya. The data were actually gathered from a meteorological station at the Pusat Pertanian, Tanjung Karang.

Data analysis: Relationship between the number of larva and larval density either with percentage of parasitism or percentage of larva infected by pathogen were analyzed with correlation analyses, respectively. Correlation analyses were also performed to find out the relationship between the larval populations with the abiotic factors.

RESULTS

Larva density (i.e., number of larva per m^2) of *S. exigua* in the field fluctuated during the study (Table 1). The highest number of larvae was an averaged of 18.17 per m^2 on 28 January 2004, while the lowest number was an averaged of 1.5 per m^2 on 16 January 2004. The mean number of larvae per plant also varies from 1.83 to 5.42 (Table 2). The number of larvae per plant was evaluated from lady's finger because the plant stand was definite, i.e., in m^2, there were three plants.

Table 1: No. of larvae per m^2, percentage of parasitism and disease incidence

Date of sampling	Larval density (mean±SE)	Percentage of parasitism	Percentage of disease incidence
28/1/03	8.00±1.260	22.92	45.84
4/3/03	7.38±1.630	13.54	11.46
19/6/03	16.26±3.510	8.09	24.27
25/7/03	6.84±2.240	42.31	8.46
29/8/03	11.04±2.250	33.74	5.76
25/9/03	5.50±2.170	15.91	14.77
19/12/03	18.00±12.81	3.17	3.17
16/1/04	1.50±0.500	0.00	0.00
28/1/04	18.17±2.610	36.38	5.19
20/2/04	12.65±2.490	12.85	14.62
5/4/04	2.00±0.000	0.00	0.00

Table 2: No. of larvae per plant collected from lady's finger

Date of sampling	No. of larvae per plant (mean±SE)
28/1/03	2.67±0.42
4/3/03	2.46±0.54
19/6/03	5.42±1.17
25/7/03	2.28±0.75
29/8/03	3.20±0.83
25/9/03	1.83±0.72

The level of parasitism fluctuated between 0 and 42.31% (Table 1). The averaged percentage of parasitism was 17.17%. There is no correlation (r = 0.2773) between the number of larva and percentage of parasitism. This result suggested that the number of larva did not influence the percentage of parasitism (Fig. 1). Similar result was also shown by the larval density and the percentage of parasitism (r = 0.2276).

Figure 2 shows the level of apparent larva mortality due to pathogen. The percentage of disease incidence is very variable, i.e., from 0 to 45.84% (Table 1). The averaged percentage of disease incidence was 12.14%. There was no relationship (r = 0.06) between the number of larva and rate of disease. Hence, the result suggested that the number of larva did not influence the percentage of larva infected by disease (Fig. 2). The larval density and rate of disease also revealed the same result (r = 0.1029).

Relatively, it was found that the larval density was influenced by the age and availability of host plant. For example, on the 28 January 2004, the age of the host plant (i.e., long beans) was 1 month and 7 days, while on the 20 February 2004, it was 2 months and 3 days and on the 5 April 2004, the host plant was 3 months and 16 days and was about to be cleared out. Consequently, the average larva density was declining from 18.17 to 12.65 per m^2 to 2.0 per m^2 between those dates (Table 1). Whilst, on the 16 January 2004, the larva density was very low

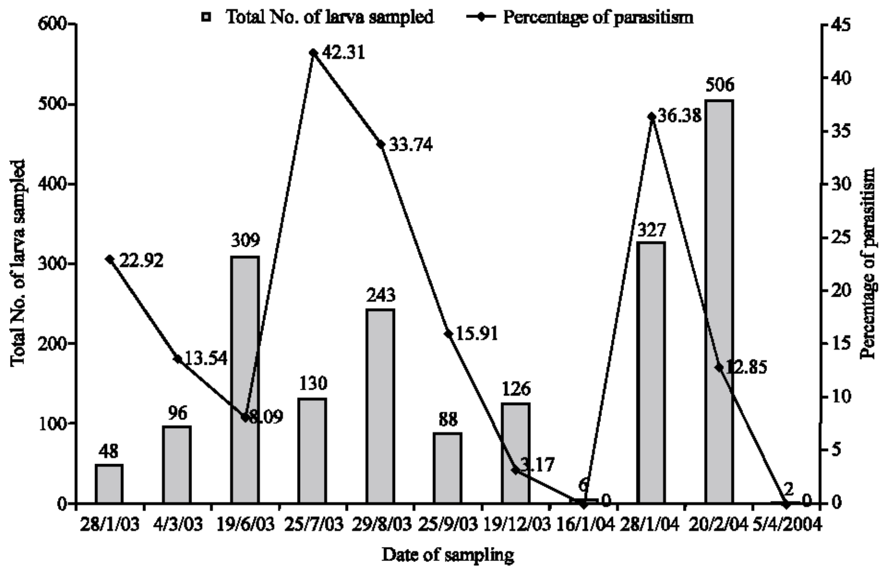

Fig. 1: Total number of larva sampled from the field and percentage of parasitism

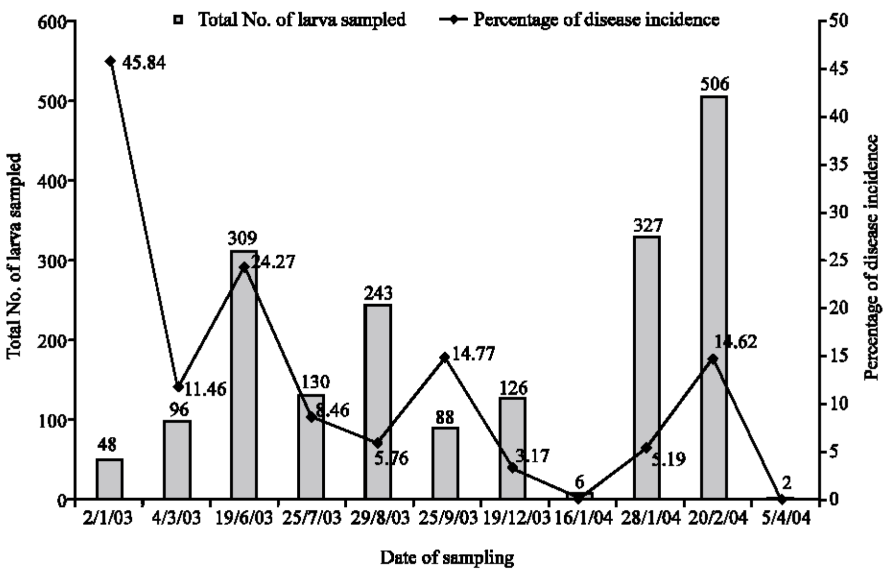

Fig. 2: Total number of larva sampled from the field and percentage of disease incidence

(1.5 per m^2) because the host plants i.e., long beans and brinjal were seedling and at old age, respectively. Another example is on the 19 June 2003, the age of the host plant (i.e., lady's finger) was 1 month and 24 days and on the 25 July 2003, the host plant age was 3 months and 7 days. During the earlier date, the average larva density was 16.26 per m^2, while on the later date it was 6.84 per m^2. The larva density also was found very low when the host plant was about to be cleared for new planting, for example, on the 16 January 2004, there was only 1.5 per m^2.

The number of larva per plant which was evaluated from the lady's finger also followed the same pattern as the larva density. An averaged of 5.42 larvae per plant were collected on the 19 June 2003 (Table 2) and 2.28 larvae per plant were collected on the 25 July 2003. This is also due to the age of the host plant, where on the 19 June 2003, the host plant was 1 month and 24 days while, on the 25 July 2003, the host plant was 3 months and 7 days.

A total of 1881 larvae were collected during this study, where 18.29 and 20.31% were successfully becoming female and male moths respectively. While a total of 20.63% was being parasitized, where, respectively 7.07, 11.43, 0.11 and 2.02% were being parasitized by *M. manilae* (a braconid), *Chelonus* sp. (a braconid), *Temelucha* sp. (an ichneumonid) and *P. orbata* (a tachinid) (Fig. 3). During the laboratory observation, majority of parasitism and resultant larval mortality occurred in the early instars.

During this study, it was found that *M. manilae* occurred most of the time (about 82%) in the field (Fig. 4), although its' total parasitism rate was not as high as *Chelonus* sp. The *Chelonus* sp. occurred about 55%, whilst *Temelucha* sp. and *P. orbata* about 9% of the time (Fig. 4). The parasitism rate of *M. manilae* varies between 0 and 22.92%, whilst *Chelonus* sp., *Temelucha* sp. and *P. orbata* was between 0-27.16, 0-1.54 and 0-11.62%, respectively (Fig. 4).

Besides that, other biotic factor such as infected by fungus or bacteria also cause death to the *S. exigua* larva, where a total of 1.91 and 10.89% from the 1881 field collected larvae were infected by them, respectively (Fig. 3). The fungal infection varies between 0 and 10.42%, while the bacterial infection was between 0 and 35.42% (Fig. 5). Larva which was infected by fungus was recognized by a whitish or greenish envelope on the body. These envelopes are the mycelia of the fungus. Whereas, larva that died with its body soft and blotting, yellowish brown in colour and secretes a yellowish fluid was diagnosed as bacterial infection. Whilst 16.64% of the collected larvae were dead due to pesticide and 7.44% were not known cause of the death. Larva that died due to pesticides, the body turned to black and dried. Besides died during the larva stages, there was also some *S. exigua* died in pupal stage or during emergence (3.89%). Overall, parasitoid and pathogen related mortality was 33.43%.

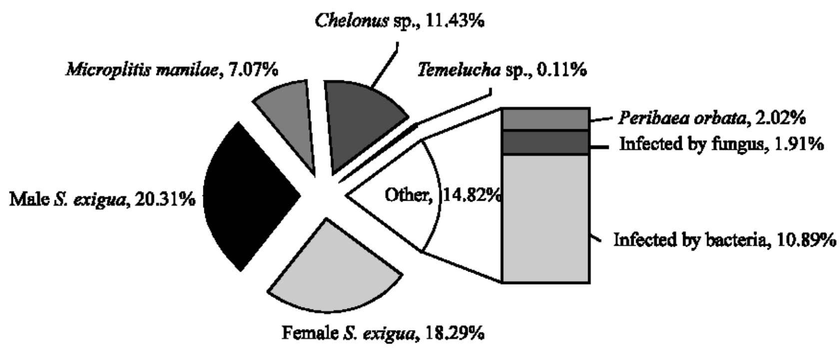

Fig. 3: Percentage of emerged moths, parasitoids and pathogenic infected from the field collected larvae

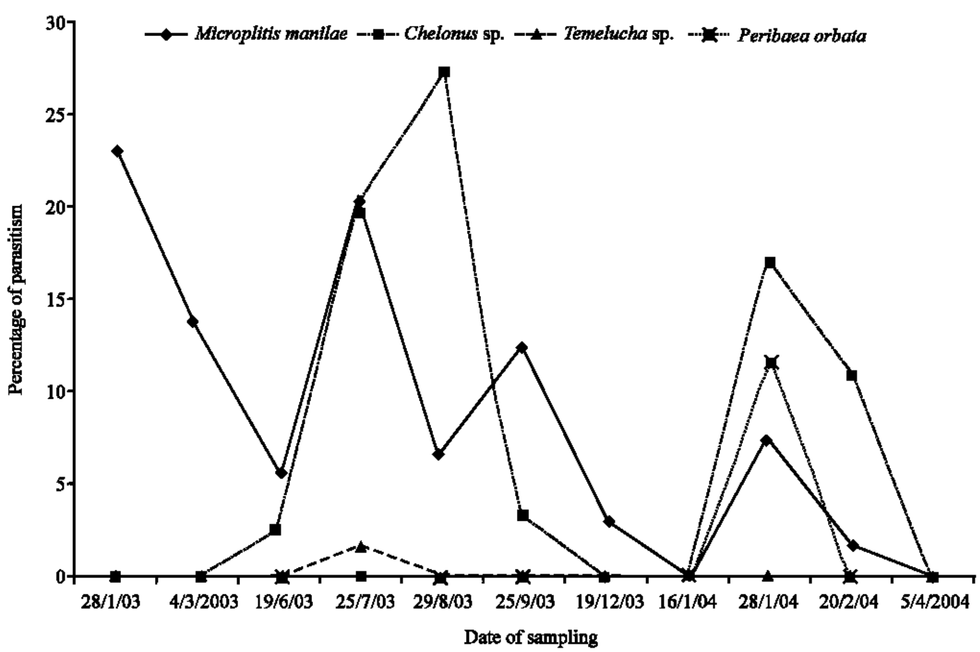

Fig. 4: Percentage of parasitism by the parasitoids

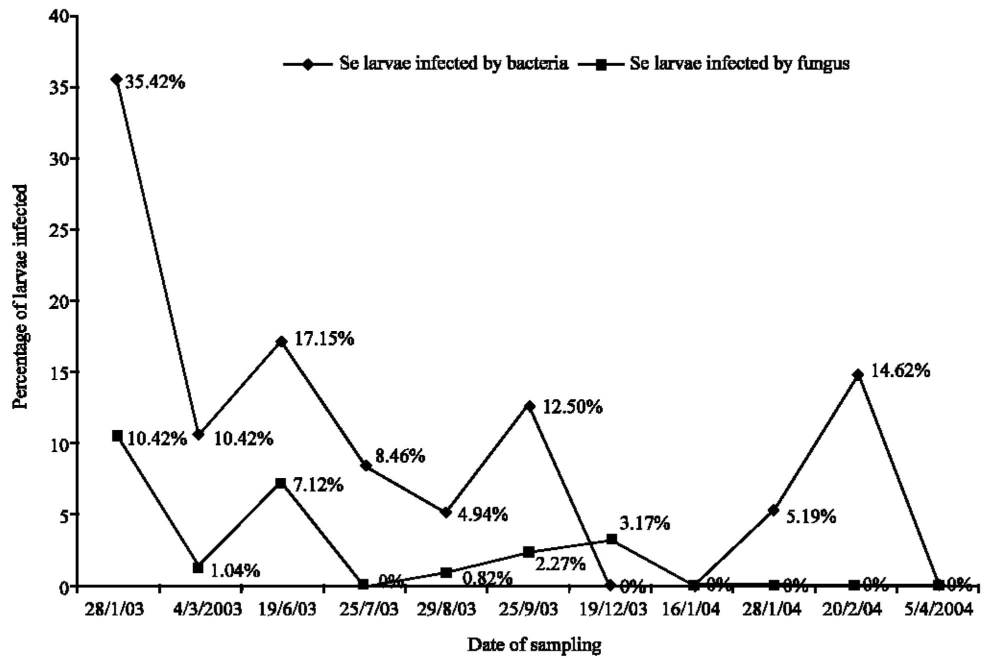

Fig. 5: Percentage of larvae infected by pathogens

The averaged temperature ranges from 24.5 to 28.9°C, relative humidity 74.0 to 96.0% and rainfall 0.00 to 20.8 mm. Based on the data, climatic factors did not influence the larva populations. This suggested that there were no correlation between the number of larva collected with the means of temperature (r = 0.0678), relative humidity (r = 0.2648) and rainfall (r = 0.3740).

DISCUSSION

This study shows that *S. exigua* occurred all year round with several outbreaks. Thus, it is considered as a common pest in the vegetables farm in Sekinchan, Selangor. Palasubramaniam *et al.* (2000) reported that the incidence of *S. exigua* was low during the period of January to August 2000. Whilst, Rauf (2001) stated that the *S. exigua* outbreak usually occurred on the third planting (i.e., August-October) of shallot in Brebes, Indonesia. This is as a result of population multiplication from previous two planting seasons and short distance migration of moths among shallot field.

In this study, the *S. exigua* larva population density fluctuates from an averaged of 1.5 larvae per m^2 to 18.17 larvae per m^2, or an averaged of 1.83 larvae per plant to 5.42 larvae per plant. While, Takai and Wakamura (1996) reported that the maximum density was more than 400 individuals per 100 hills during their study in Japan and Rauf (2001) stated that in Indonesia, the number of larvae collected were as high as 2619 per 10 beds (each bed measured 1.5×6 m). Further, in Thailand, Jaipet (1998) found 8.3 larvae per plant. However, the larva population study was not performed continuously by monthly due to clearance of the plantation area for new planting.

This study also shows that the larva population was high when the host plant is younger, i.e., approximately between one to two months old. This is because at young age the host plant leaves are still soft and the nutritional quality is high (Beckwith, 1976; Hough and Pimentel, 1978). During scouting the larva in the field, the larvae were found feeding on the exposed, sunny, upper parts of the plant. This phenomenon is usual for several aposematic species (Bernays and Chapman, 1994). Furthermore, larva is known to be thermoregulate behaviourally and also their choice of food is often limited within the selected plant. Moreover, the upper parts usually consisted of younger leaves. In fact, most of the time, they were found in the center or along the midvein. Presumably, this is due to micro climatic factor of a plant, where the center of a leaf is warmer than the edge as reported by Bernays and Chapman (1994) and also the larva thermoregulate behaviour.

Although over 100 species of parasitoids have been recorded from *S. exigua* worldwide (Polaszek, 2001), only four species of parasitoids attacking the *S. exigua* were discovered in this study. They are *M. manilae*, *P. orbata*, *Chelonus* sp. and *Temelucha* sp. The first two species also were reported by Sivapragasam and Syed (2001) and Sivapragasam *et al.* (2001). Thus, they can be considered as the major larval parasitoids of *S. exigua* in Malaysia. Both *M. manilae* and *P. orbata* also have been recorded in Thailand and Vietnam (Polaszek, 2001). Whilst, the other two species i.e., *Chelonus* sp. (an egg larval parasitoid) and *Temelucha* sp. (a larval parasitoid) have not been reported before in Malaysia. However, *Chelonus farmosanus* has been found in the neighbouring country i.e., Thailand (Polaszek, 2001). Whereas, *Temelucha* sp. has never been reported in the Southeast Asia vicinity (Polaszek, 2001). Thus, it is useful to explore more on the occurrence of this two species in Malaysia, as they could be used as the biological control agent for *S. exigua*.

This study has shown that the parasitism rates were varies. The maximum parasitism rate in Sekinchan was about 42%. Whereas, Sivapragasam *et al.* (2001) reported that 45, 10 and 33% of the larvae which were collected from Sungai Pelek (Selangor), Kampung Felda (Melaka) and Serdang (Selangor) were being parasitized. Further, Sivapragasam and Syed (2001) demonstrated that the parasitism level by *P. orbata* can reached as high as 45% in the field. This is higher than the result of this study, which is about 12%. Besides that, Ruberson *et al.* (1994) reported that the parasitism rates of *S. exigua* larvae in Georgia, USA for both 1992 and 1993 were 46.8 and 40.2%, respectively. Whereas, studies by Gumbek (2001) and Rauf (2001) recorded a much lower larva parasitism rate i.e., between 1.6 to 2.6% and less than 7%, respectively.

Ruberson *et al.* (1994) also discovered that pathogens did not appear to be a substantial mortality factor. *Erynia* sp. nr. *pieris* (a fungus) and a nuclear polyhidrosis virus were the pathogen which killed 6.2, 0.3, 1.8 and 0.1% of the collected larvae, respectively in 1992 and 1993. However, bacterial infection in this study was relatively higher compared to their findings. Hence, this is another aspect that needs further investigation.

Besides that, pesticides also could be considered as one of the mortality factors for the *S. exigua* larvae in the field. Although, the percentage of mortality caused by the pesticides in this study was moderate, it was found that the pesticides coverage is often inadequate to control the pest. This is because the females usually oviposit on the underside of the leaves and the first and second instars larvae usually feed in groups in a relatively small area underside of the leaves during the larvae are most susceptible to the pesticides.

Rauf (2001) demonstrated that beet armyworm larval population density during dry season was about 78 times higher than those during rainy season. While, Jaipet (1998) found there was a positively correlation between *S. exigua* larvae with minimum and average humidity. Nevertheless, the abiotic factors did not give any impact on the larval populations in this study.

Generally, Beckwith (1976) stated that site, tree species, climate, parasitoids, predators, pathogens and the availability of suitable food play an important role in population dynamics. This study somehow has demonstrated that the host plant aspect is responsible for the larval population fluctuations compared to the other factors. Thus, further investigation has to be performed, in order to get more concrete conclusion on this matter.

ACKNOWLEDGMENTS

I would like to thank Dr. Lim Guan Soon for his suggestion and initiative of this project. I am very grateful to the Institute's support staffs who have been kindly helping me in this project. I also would like to thank Dr. Andy Polaszek from the Natural History Museum, London for the identification of the parasitoids, the Meteorological Department for the Weather Records and the owner of the vegetables plantation for letting me using his farm. This study is supported by the Malaysian Government Research Grant, IRPA No. 01-02-03-0695.

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