Research article

Potential Use of Predatory Bug *Eocanthecona furcellata* for Biological Control of *Plutella xylostella* in Chinese Kale Production

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Abstract Predatory bug *Eocanthecona furcellata* was investigated for the potential of biological control agent to *Plutella xylostella* in the laboratory and greenhouse condition. Predation rate of 3rd to 4th instar nymphs *E. furcellata* on 2nd, 3rd and 4th instar larvae *P. xylostella* were studied in the laboratory. The results showed that predation rate of 4th and 5th nymphal instars of *E. furcellata* were higher than 3rd instar. Feeding rate were greater when they feed on 2nd and 3rd instar larvae than feed on 4th instar larvae of *P. xylostella*. The efficiency of *E. furcellata* in controlling *P. xylostella* under greenhouse conditions was conducted. When *P. xylostella* population reached to economic threshold (ET), 20 of *E. furcellata* were released to chinese kale greenhouse (18 m^3), Results showed that pest population was reduced 10.32% after 5 days of release when compared to control. Additionally, percentage of plant damage from released predatory bug greenhouse was lower than non-released greenhouse. Therefore, it is possible to release the predatory bug *E. furcellata* in vegetable production as a biological control agent.

Keywords predation, biological control, diamondback moth

INTRODUCTION

Plutella xylostella (L.) is an important pest to Brassicaceae including Chinese kale (*Brassica oleracea* var. *alboglabra*). The first instar larvae feed on mesophyll tissues inside the leaf, whereas, other instar larvae are surface feeders. They consume leaves, buds, flowers, siliques, and the green outer layer of stems (Sarfraz et al., 2005). The damage varies, depending on plant growth stage, plant varieties, larval densities and size. If larvae are numerous, they can consume the entire leaf except the veins. *P. xylostella* has been a serious pest of vegetable crops for many decades. The annual cost for its global control is estimated at US$ 4-5 billion per year (Zalucki et al., 2012). The short generation time, high fecundity and broad host usage within Brassicaceae host plant of *P.*

xylostella are the important factors for insecticide resistance for example chlorantraniliprole, Spinosad, chlorfenapyr and lufenuron, an insect growth regulator (IGR) (Arruda et al., 2020).

A method to delay the evolution of insecticide resistance is to integrate the use of control methods such as chemical and biological controls (Mccord and Yu, 1987). *Eocanthecona furcellata* Wolff (Hemiptera: Pentatomidae) is a common predatory stink bug in Southeast Asia (Tuan et al., 2016). It has been mass-reared and used as a biological control agent in Thailand (Suasa-ard, 2010). It has been reported for controlling many caterpillars worm such as *Mythimna separata*, *Helicoverpa armigera*, and *Heliothis assulta* etc. Predation of *E. furcellata* gradually increased from the 2nd instar to 5th instar nymph when fed on *Maruca vitrata* (Pillai and Agnihotri, 2013) and *Spodoptera litura* (Tuan et al., 2016). Even though, there are some studies of feeding efficiency and utilization of *E. furcellata* for many insect pests, there are not many studies of *E. furcellata* fed on *P. xylostella*. Tuan et al. (2016) revealed predation rate of each stage and life table of *E. furcellata* when fed on 4th larval instar but not all stage. Therefore, this study revealed the predation rate for 3rd -5th nymphal stages of *E. furcellata* when fed on 2nd-4th larval stages of *P. xylostella* for finding suitable stages for biological control. Additionally, *E. furcellata* was evaluated for its efficiency as a biological control agent in the greenhouse.

OBJECTIVE

The objectives of this study were to examine predation rate of the *E. furcellata* in predation life stages and to evaluate its efficiency as a biological control agent in the chinese kale greenhouse.

METHODOLOGY

Insect Rearing

Plutella xylostella was collected from chinese kale production area in Khon Kaen Province, Thailand. Thirty larvae were transferred in an aluminum cage (90x 60x 60 cm) with 15 days old chinese kale in a pot inside the cage. The larvae were maintained in the cage until they became to pupae. Pupae were transferred to the mating cage (10 cm in diameter and 10 cm in height). Newly emerged adults were provided with cotton balls soaked with 20% honey water as food source. Shredded of chinese kale leaves was used as the substrate for oviposition by the diamondback moth and the F3 was then used in the experiment. *E. furcellata* were taken from a colony (10th generation) maintained at NBCRC, Upper Northeastern Regional Center. The experimental insect was maintained in the laboratory at room temperature, 28 ± 5°C, relative humidity of 60 ± 10%.

Bioassay

Laboratory: The experiment was examined in the laboratory using Completely Randomized Design (CRD) with 10 replications. A newly hatched of 3rd, 4th and 5th nymphs of *E. furcellata* were test for predation rate. One of each nymph was transferred into a container (7x 9x 4 cm) with cotton balls soaked with water, and a chinese kale leaf. Second larval instar of *P. xylostella* (n = 20) were provided daily as a food until predator change to a new nymphal stage. Then, the experiments were repeated, 3rd and 4th instar larvae of *P. xylostella* were provided instead as a pray. Predation rate were recorded every day until *E. furcellata* change to new nymphal stage. The data were statistically analyzed using Statistix 10 (Analytical software, 2013) and treatments were compared using Tukey's HSD test ($P < 0.05$).

Greenhouse: The experiment was examined in the 8 chinese kale greenhouses (18 m^3) at NBCRC. Forty pots of chinese kale were use as the experimental units for each greenhouse. The population of *P. xylostella* was artificial infestation by releasing a cluster of eggs/pot when plants were 30 days old. After eggs hatched to the larvae, the population were recorded. When the population reached to the economic threshold level (ET) (1 larva/plant), Twenty of *E. furcellata* were released into the

greenhouse. While, control greenhouse was not released. The experiment was studied with 4 replications. The data were statistically analyzed using Paired sample t-test using Statistix 10 (Analytical software, 2013). Percentage of leaf area damage was recorded in level of injury (0=no damage, 1 = < 25% damage, 2 = 25-50% damage, 3 = 50-75% damage, 4 = >75% damage). The percent reduction of *P. xylostella* was statistically calculated according to the equation of Henderson and Tilton (1955).

$$\%\ reduction = 100 \times (1 - (Ta \times Cb)/(Tb \times Ca)) \quad (1)$$

Where, Ta = population of insect counts after treatment, Cb = population of untreated insect count before treatment, Tb = population of insect counts before treatment, and Ca = population of untreated insect count after treatment.

RESULTS AND DISCUSSION

Prey consumption of *E. furcellata* fed on larvae of *P. xylostella* was significantly different. The third nymphal instar of *E. furcellata* fed on 3rd and 4th instar larvae more than 2nd instar larvae, whereas, 4th and 5th nymphal instar of *E. furcellata* fed on younger more than the older prey (Table 1). Predation rate of *E. furcellata* may involve with a prey species. Tiwari et al. (2017) revealed that when *E. furcellata* fed on *S. litura*, and *M. vitrata*, predation rate of prey consumed slightly increased with increasing prey stage. However, when *E. furcellata* fed on *Spilarctia obliqua* and *S. frugiperda* predation rate of prey consume decreased with increasing prey size (Kumar et al., 2001; Keerthi et al., 2020). Rani and Wakamura 1993 suggested that physical stimuli such as host shape or movement had no influence on acceptability of the prey to *E. furcellata*.

Table 1 Prey consumption of different stages of *Eocanthecona furcellata* fed on larvae of *Plutella xylostella*

Treatment	*P. xylostella* [1/]		
E. furcellata	2nd instar	3rd instar	4th instar
3rd nymph	28±0.50 B	65±4.50 A	50±1.91 A
4th nymph	71±5.91 A	79±4.72 A	24±0.82 B
5th nymph	71±2.65 A	60±5.35 AB	38±2.08 B
F-test	**	**	*
CV (%)	24.33	30.28	26.08

[1/]*Within each column, mean±SD followed by the same capital letter indicate no significantly different (P>0.05)*

However, Kumar et al. (2001) revealed that visualization of the predator and movement of prey increases the predation rate. In this case, the active movement of 2nd and 3rd instar larvae of *P. xylostella* may be a factor of high predation rate of 4th and 5th nymphal stage of predator. Contrast to 4th and 5th nymphal stage, 3rd nymphal stage may difficult to handle the active prey movement.

The results of laboratory experiment for predation of *E. furcellata* lead to a decision to release 3rd nymphal stage of *E. furcellata* as a biological control in chinese kale greenhouse. Twenty of 3rd nymphal stage in a bio-product were released into the greenhouse after diamond back moth reach to 1 larva/plant. The results revealed that the number of *P. xylostella* was not significant different between treatment and control (Table 2). However, population of *P. xylostella* was reduced at 3 days after *E. furcellata* released. The percent reduction of *P. xylostella* at 3-5 day after predator released were 10.32, 21.79 and 18.06%, respectively. During 1-2 days after predator released the population in treatment was not reduced. At that period, most of *P. xylostella* was 2nd instar which was not suitable for the predator stage. Two day later, most of pest population was 3rd instar, and predator was changing nymphal stage from 3rd to 4th nymph. Then the population was reduced (Percent reduction was higher). Therefore, in case of a serious outbreak, 4th nymphal stage may use

instead. Level of chinese kale leaf damage in control greenhouse increased from level 1 to level 3, whereas, level of chinese kale leaf damage in control greenhouse was level 1 and level 2.

However, applying in open field condition may have some factors such as temperature, various pests, other natural enemies and chemical insecticide which involving the efficiency of predator.

Table 2 Number of *Plutella xylostella* in chinese kale greenhouse and level of leave damage with released and non-released *Eocanthecona furcellata* as a biological control agent, and percentage reduction.

Plant age (day)	non-released		released		Reduction (%)
	Insect/plant	Level of leave damage	Insect/plant	Level of leave damage	
36[2/]	2.32±1.15a[1/]	1	1.44±0.15a	1	na
37	2.21±1.12a	1	1.42±0.14a	1	-3.52
38	2.17±1.09a	1	1.40±0.15a	1	-3.94
39	2.12±1.04a	2	1.18±0.18a	1	10.32
40	2.06±1.00a	2	1.00±0.26a	1	21.79
41	1.75±1.00a	3	0.89±0.24a	2	18.06

[1/]Within each row, mean±SD followed by the same small letter indicate no significantly different (P>0.05)
[2/] Eocanthecona furcellata was released into the greenhouse.

CONCLUSION

E. furcellata is an effective predator of *P. xylostella*, the third nymphal stage consumed 3rd and 4th larval instar than 2nd instar. In contrast, 4th and 5th nymphal stage consumed 2nd and 3rd instar more than 4th instar. *E. furcellata* is an alternative biological control agent in chinese kale green house. It can reduce pest population and level of leaf damage.

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REFERENCES

Arruda, S.L., Rodrigues, R.S.A., Bermudez, C.B.N., Ribeiro, M.S.L., Neto, L.E.J. and Siqueira, A.A.H. 2020. Field resistance of *Plutella xylostella* (Lepidoptera: Plutellidae) to lufenuron: Inheritance and lack of cross-resistance to methoxyfenozide. Crop Protection, 136, 105237, Retrieved from DOI https://doi.org/10.1016/j.cropro.2020.105237

Kumar, V., Morrison, N.M., Rajadurai, S., Babu, M.A., Thiagarajan, V. and Datta, K.R. 2001. Studies on the biology and predatory behaviour of Eocanthecona furcellata (Wolff.) predating on Spilarctia obliqua (Walk.) in mulberry plantation. International Journal of Industrial Entomology, 2 (2), 173-180.

Maccord, E. 1987. The mechanisms of carbaryl resistance in the fall armyworm, Spodoptera frugiperda (J. E. Smith). Pesticide Biochemistry and Physiology, 27 (1), 114-122.

Pillai, A.K. and Agnihotri, M. 2013. Biology and predatory potential of *Eocanthecona furcellata* (Wolff.) on *Maruca vitrata* geyer. Madras Agricultural Journal, 100, 193-195.

Rani, U.S. and Wakamura, S. 1993. Host acceptance behaviour of a predatory pentatomid, *Eocanthecona Furcellata* (Wolff) (Heteroptera: Pentatomidae) towards larvae of *Spodoptera Litura* (Lepidoptera: Noctuidae). International Journal of Tropical Insect Science, 14 (2), 141-147, Retrieved from DOI https://doi.org/10.1017/S1742758400014521

Sarfraz, M., Keddie, B.A. and Dosdall, M.L. 2005. Biological control of the diamondback moth, *Plutella xylostella*: A review. Biocontrol Science and Technology, 15 (8), 763-789, Retrieved from DOI https://doi.org/10.1080/09583150500136956

Suasa-ard and National Biological Control Research Center (NBCRC), 2010. Natural enemies of important insectpests of field crops and utilization as biological control agents in Thailand. Retrieved from https://www.naro.affrc.go.jp/archive/niaes/sinfo/sympo/h22/1109/paper_12.pdf

Tiwari, S., Maurya, R. and Pandey, K.A. 2017. Effect of different insect hosts on biology and predation efficiency of Eocanthecona furcellata Wolff (Hemiptera: Pentatomidae). The Bioscan, 12 (1), 193-197.

Tuan, S., Yeh, C., Atlihan, R. and Chi, H. 2016. Linking life table and predation rate for biological control: A comparative study of *Eocanthecona furcellata* (Hemiptera: Pentatomidae) fed on *Spodoptera litura* (Lepidoptera: Noctuidae) and *Plutella xylostella* (Lepidoptera: Plutellidae). Journal of Economic Entomology, 109 (1), 13-24, Retrieved from DOI https://doi.org/10.1093/jee/tov265

Zalucki, P.M., Shabbir, A., Silva, R., Adamson, D., Liu, S. and Furlong, J.M. 2012. Estimating the economic costof one of the world's major insect pests, *Plutella xylostella* (Lepidoptera: Plutellidae), Just how long is a pieceof string? Journal of Economic Entomology, 105 (4), 1115-1129, Retrieved from DOI http://dx.doi.org/10.1603/EC12107