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EFFECT OF COTTON VARIETIES ON THE GROWTH, MORPHOMETRICS AND LIFE LENGTH OF ARMY WORM

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ABSTRACT

The effects of CB1, CB3, CB5, CB8 and CB12 cotton varieties on the growth, morphometric parameters and life length of the armyworm *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) were studied under laboratory conditions. The growth of the larvae differed significantly and was the highest on CB8. The larvae that fed on CB1, CB3 and CB12 revealed statistically similar and lower growth rate. The morphometric parameters of *S. litura* as a result of feeding on five cotton varieties revealed that the larger egg masses were laid on CB5. The varieties showed statistically significant effects on length, width and weight of different larval instars. The larvae fed on CB8 molted to bigger-sized pupae, and emerged as heavier adults. The life lengths of the male and female insects were longest on CB8 however the female showed statistically similar result on CB5. The CB8 followed by CB5 revealed suitability as the host plant of *S. litura,* and such varieties are less suitable for cultivation in areas where army worm is a major pest.

Keywords: Cotton varieties, *Spodoptera litura*, morphometric, growth, life length.

INTRODUCTION

The army worm *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) is a polyphagous insect causing severe loss to many economically important crops and has been reported a major pest for 120 cultivated and uncultivated plant species distributed in 44 families in the world (Gao *et al.* 2004, Qin *et al.* 2004). In the recent years it has been appeared as a major pest of cotton in Bangladesh (Amin *et al.* 2011) and has showed resistance to many commonly used insecticides, particularly pyrethroids and carbamates, resulting in a failure of effective controls (Ahmad *et al.* 2007, Huang & Han 2007).

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Host plant resistance is the most important tool of the pest management tactics considering the economic and environmental effects. It reduces the costs of growers (Li *et al*. 2004). The availability of nutrients in the host plants and efficiency of food consumption are determining factors for the development of the insects (Browne and Raubenheimer 2003). The growth, morphometric development and life length of *S. litura* are related to host plant (Amin *et al.* 2011, Tithi *et al.* 2010 a, b). The identification of cotton varieties which are less susceptible to army worm is of paramount importance for cultivation in the areas where army worm is a major pest. Therefore, this study was undertaken with five cotton varieties to assess their effects on the growth, morphometric parameters and life lengths of *S. litura*.

MATERIALS AND METHODS

Cultivation of cotton varieties: Delinted seeds of the cotton varieties, namely CB1, CB3, CB5, CB8 and CB12 were collected from the Regional Cotton Research and Extension Centre, Dinajpur, Bangladesh. Seeds were sown in the Entomology Field Laboratory of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur on 2^{nd} July, 2013 in rows apart from 50 cm plant to plant and 1 m from row to row. The fertilizers were applied according to the recommendations of the Cotton Development Board of Bangladesh. The crops were kept free from insecticide application with a view to avoid its effects on the test insect.

Mass culture of the insect: Mass culture of the insect was done in the Entomology Laboratory of BSMRAU maintained at 28 ± 2 ^{o}C and 60 ± 5% RH. Adult males and females *S. litura* were collected from the Cotton Research Station, Sreepur, Gazipur. The collected moths were kept in paired in Petri dishes (9.0 cm × 1.5 cm) for mating. Every morning, fresh cotton flowers were supplied to the Petri dishes as food for the moths. The Petri dishes were continuously examined to observe mating. After completion of mating, the male moths were removed from the Petri dishes and the females were kept in jars (26.5 cm × 13.5 cm) for oviposition.

Observation of growth rate: Newly exuviated fifth instar larvae (approximately same size) were selected and individually placed in small Petri dishes, starved for 10 h, and then individually coded and weighed. Therefore, the larvae were equally divided into a control group and a treatment group. In the control group, the larvae and fresh leaves from host plants (one leaf for each larva) were individually dried in a drier at 70 ^{o}C and weighed. In the treatment group, leaves detached from the host plant were provided to the larvae. The larvae were fed host leaves for 48 h. Then the larvae were starved for 6 h to allow them to defecate. The larvae, leaf tissues in each dish were dried in a drier at 70 ^{o}C. The dried leaf tissues and larvae were weighed again and relative growth rate was calculated according to the following formula:

$$\text{Relative growth rate} = \frac{\text{Dry weight of larvae in treatment} - \text{Dry weight of larvae in control}}{(\text{Dry weight of larvae in treatment} + \text{Dry weight of larvae in control})/2}$$

Morphometric measurements:

Mated female moths were reared individually in jars (26.5 cm × 13.5 cm) containing leaves of the tested cotton varieties and the egg masses deposited by the females were collected and their diameters were measured. Therefore, eggs were reared for emergence of larvae and then adults. The body weights of the immature stages and adults were measured using a digital balance (AG204, Mettler Toledo, Switzerland). The lengths and breadths of the egg masses, larval instars, pupae and adult moths were done with the help of an ordinary millimeter scale. The measurements were replicated 5 times for each variety and each life stage of the insect.

Data analysis: Data were analyzed by one way analysis of variance (ANOVA) using IBM SPSS statistics 19. Statistical differences among the means were evaluated using DMRT.

RESULTS AND DISCUSSION

The growth rates of *S. litura* reared on five cotton varieties ranged from 0.04 ± 0.01 to 0.45 ± 0.04 (Fig. 1) and differed significantly ($F_{4, 20} = 3.1$, $p < 0.05$). The insects revealed the highest growth rate on CB8. Larval food consumption rate, amount of efficiency of conversion of ingested and digested food, and quality of the food may affect their relative growth rate. Zhu *et al.* (2005) found that *S. litura* larvae did not prefer feeding on banana leaves and had lower relative growth rate. Sandhyarani and Rani (2013) reported that host plants with the highest amount of carbohydrates may not be suitable for the growth of *S. litura* if the plants possess higher amount of phenols and a lower amount of proteins and amino acids.

Figure 2 showed that the diameter of the egg masses varied from 5.7 ± 0.5 to 6.9 ± 0.2 mm and the results differed significantly ($F_{4,20} = 5.4$, $p < 0.01$). The egg masses with the highest and the lowest diameter were produced by the moths developed from the larvae reared on CB5 and CB12, respectively.

Table 1 showed that the first, second, third, fourth and fifth instar larval, and pupal weights ranged from 8.7 ± 0.6 to 9.9 ± 0.6, 19.4 ± 1.9 to 21.8 ± 0.7, 127.0 ± 5.2 to 141.1 ± 5.7, 152.8 ± 5.7 to 169.8 ± 4.8, 911.1 ± 19.6 to 1015.4 ± 26.4 and 406.7 ± 13.2 to 425.8 ± 11.0 mg, respectively and the results differed significantly (first instar: $F_{4,20} = 3.4$, $p < 0.01$; second instar: $F_{4,20} = 3.4$, $p < 0.01$; third instar: $F_{4,20}$

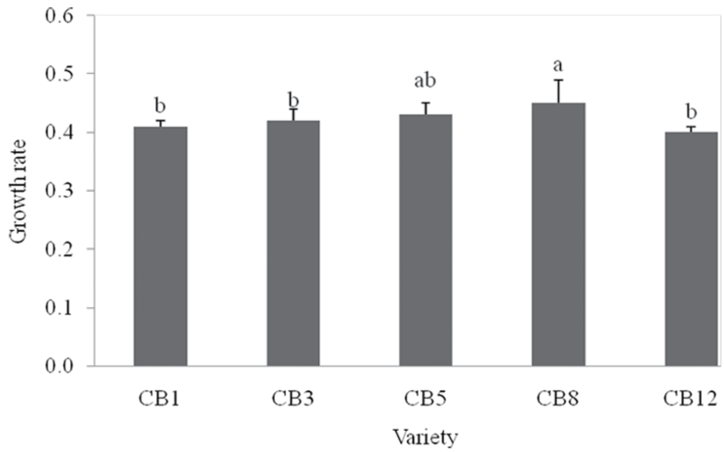

Fig. 1. Effect of five cotton varieties on the growth rate (mean ± SD) of the larvae of S. litura. Bars with same letter(s) are not significantly different by DMRT ($P \leq 0.05$)

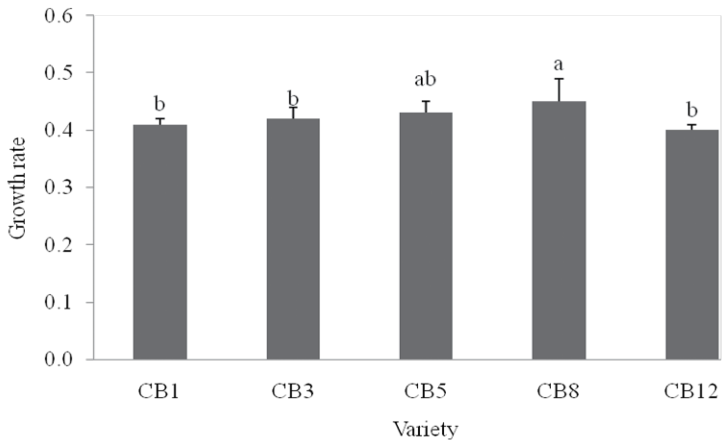

Fig. 2. Effect of five cotton varieties on the egg mass diameter (mean ± SD mm) of S. litura. Bars with same letter(s) are not significantly different by DMRT ($P \leq 0.05$)

Table 1. Effect of five cotton varieties on the weight (mean ± SD mg) of the immature life stages of *S. litura*

Life stages	Cotton varieties				
	CB1	CB3	CB5	CB8	CB12
1st instar larva	8.9 ± 0.5b	9.0 ± 0.7b	9.1 ± 0.6b	9.9 ± 0.6a	8.7 ± 0.6b
2nd instar larva	19.9 ± 1.3bc	20.3 ± 1.3ac	21.7 ± 0.9ab	21.8 ± 0.7a	19.4 ± 1.9c
3rd instar larva	129.1 ± 6.4bc	138.2 ± 6.8b	136.7 ± 5.5ab	141.1 ± 5.7a	127.0 ± 5.2c
4th instar larva	161.6 ± 5.0b	163.1 ± 6.1ab	162.5 ± 6.2ab	169.8 ± 4.8a	152.8 ± 5.7c
5th instar larva	935.9 ± 17.8bc	954.4 ± 18.4b	1004.9 ± 22.9a	1015.4 ± 26.4a	911.1 ± 19.6c
Pupa	406.3 ± 8.7 b	408.5 ± 9.3b	415.8 ± 11.2ab	425.8 ± 11.0a	406.7 ± 13.2b

Means within a row followed by same letter(s) are not significantly different by DMRT ($P \leq 0.05$)

= 3.4, $p < 0.01$; fourth instar: $F_{4,20} = 3.4$, $p < 0.01$; fifth instar: $F_{4,20} = 3.4$, $p < 0.01$; pupa: $F_{4,20} = 3.4$, $p < 0.01$) depending on the cotton varieties on which the larvae were fed. The larvae fed on CB5 revealed heavier weights in different instars and pupal stages.

Sakamoto *et al*. (2004) who found the last instar larval weight on soybean leaves, eddo leaves, an artificial diet and artificial diet supplemented with soybean oil as 788.7 ±41.5, 616.8 ±53.6, 868.3 ± 59.2 and 885.5 ± 68.5 mg, respectively. Sintim *et al*. (2009) reared *S. litura* on eight sesame cultivars and an artificial diet, and found the fifth instar larval body weight 197.9 ± 4.8 to 347.3 ± 88.5 mg on sesame cultivars and 706.1 ± 250.3 mg on the artificial diet. These weight variations might be due to the quality of the food. Greenberg *et al*. (2001) reared beet armyworm *S. exigua* on cabbage, cotton, bell pepper, pigweed and sunflower, and reported that food sources significantly affect the pupal weight. Sintim *et al*. (2009) found pupal weight 117.0 ± 82.6 to 189.6 ± 25.7 mg for *S. litura* fed on sesame cultivar and 367.2 ± 63.1 mg fed on an artificial diet.

Many authors documented the influence of host plants on the insect development and stated that host-plants significantly affected the body weight of pests (Tammaru 1998). Carbohydrates, proteins, lipids, nucleotides, vitamins, minerals and water are essential components for phytophagous insects, which take up large volumes of plant sap in order to extract enough starch and proteins to meet their metabolic needs.

Significantly differential lengths of the larvae and pupae of the *S. litura* were observed when reared on the five cotton varieties (Table 2). The length of 1st instar

Table 2. Effect of five cotton varieties on the length (mean ± SD mm) of the immature life stages of *S. litura*

Life stages	Cotton varieties				
	CB1	CB3	CB5	CB8	CB12
1st instar larva	8.9 ± 0.4a	9.2 ± 0.5a	9.2 ± 0.2a	9.4 ± 0.5a	8.4 ± 0.4a
2nd instar larva	12.9 ± 0.7cd	13.2 ± 0.5c	14.5 ± 0.3b	16.2 ± 0.3a	12.3 ± 0.3d
3rd instar larva	20.4 ± 0.6c	21.1 ± 1.0 bc	22.2 ± 1.3b	24.9 ± 0.8a	20.4 ± 1.1c
4th instar larva	29.2 ± 1.7c	31.0 ± 0.9b	32.0 ± 0.7ab	32.8 ± 1.0a	28.5 ± 1.2c
5th instar larva	47.2 ± 1.3b	46.4 ± 1.6b	48.0 ± 1.2ab	49.8 ± 1.2a	46.6 ± 2.3b
Pupa	19.4 ± 1.2bc	19.1 ± 1.3bc	20.6 ± 0.9b	22.2 ± 0.8a	18.6 ± 0.9c

Means within a row followed by same letter(s) are not significantly different by DMRT ($P \leq 0.05$)

Table 3. Effect of five cotton varieties on the width (mean ± SD mm) of the immature life stages of *S. litura*

Life stages	Cotton varieties				
	CB1	CB3	CB5	CB8	CB12
1st instar larva	1.1 ± 0.2bc	1.1 ± 0.2bc	1.3 ± 0.1ab	1.4 ± 0.2a	1.0 ± 0.1c
2nd instar larva	1.8 ± 0.1c	1.8 ± 0.2c	2.4 ± 0.2b	2.8 ± 0.2a	1.6 ± 0.2d
3rd instar larva	3.5 ± 0.2d	3.8 ± 0.2c	4.3 ± 0.3b	4.7 ± 0.3a	3..5 ± 0.2d
4th instar larva	5.4 ± 0.2cd	5.7 ± 0.2bc	6.0 ± 0.5b	6.8 ± 0.4a	5.0 ± 0.3d
5th instar larva	7.7 ± 0.3cd	8.2 ± 0.6bc	8.3 ± 0.3ab	8.8 ± 0.4a	7.4 ± 0.3d
Pupa	6.1 ± 0.6ab	6.1 ± 0.6ab	6.3 ± 0.6a	6.7 ± 0.7a	5.2 ± 0.8b

Means within a row followed by same letter(s) are not significantly different by DMRT (P ≤ 0.05)

larvae ranged from 8.4 ± 0.4 to 9.4 ± 0.5 mm and showed no statistical difference ($F_{4,20}$ = 0.89, p = 0.18) whereas the length of 2nd, 3rd, 4th and 5th instars larvae, and pupae varied from 12.3 ± 0.3 to 16.2 ± 0.3, 20.4 ± 1.1 to 24.9 ± 0.8, 28.5 ± 1.2 to 32.8 ± 1.0, 46.6 ± 2.3 to 49.8 ± 1.2 and 18.6 ± 0.9 to 22.2 ± 0.8 mm, respectively and differed significantly (second instar: $F_{4,20}$ = 3.9, p < 0.01; third instar: $F_{4,20}$ = 4.1, p < 0.01; fourth instar: $F_{4,20}$ = 4.7, p < 0.01; fifth instar: $F_{4,20}$ = 3.8, p < 0.01; pupa: $F_{4,20}$ = 4.7, p < 0.01). The 2nd, 3rd, 4th and 5th instars larvae, and pupae revealed significantly highest lengths when the larvae fed on CB8. Amin *et al.* (2011) observed that the first, second, third, fourth and fifth instar larval weights varied from 9.8 ± 2.3 to 10.3 ± 1.9, 20.3 ± 2.5 to 22.7±1.7, 126.5±6.2 to 133.8±7.3, 159.4±9.5 to 168.2 ± 8.7 and 1151.8 ±34.6 to 1190.2 ± 36.4 mm, on CB9, CB10 and SR05 cotton varieties, respectively.

Table 4. Effect of five cotton varieties on the growth parameters (mean ± SD) of the adult male *S. litura*

Growth parameters	Variety				
	CB1	CB3	CB5	CB8	CB12
Body weight (mg)	155.4 ± 3.2bc	158.9 ± 4.8b	161.8 ± 4.5 ab	166.5± 4.7a	153.6 ± 3.1c
Body length (mm)	17.2 ± 0.3b	17.5 ± 0.4ab	17.5 ± 0.4ab	17.8 ± 0.5a	17.0 ± 0.4b
Body width (mm)	5.9 ± 0.3ab	5.9 ± 0.2ab	6.1 ± 0.3a	6.1 ± 0.5a	5.5 ± 0.5b
Wing length (mm)	32.7 ± 0.7bc	32.9 ± 0.7ac	33.3 ± 0.5ab	33.7 ± 0.6a	32.1 ± 0.5c
Wing width (mm)	5.8 ± 0.2b	5.9 ± 0.3ab	5.9 ± 0.2ab	6.2 ± 0.3a	5.7 ± 0.2b

Means within a row followed by same letter(s) are not significantly different by DMRT (P ≤ 0.05)

Table 5. Effect of five cotton varieties on the growth parameters (mean ± SD) of the adult female *S. litura*

Growth parameters	Variety				
	CB1	CB3	CB5	CB8	CB12
Body weight (mg)	211.1 ± 9.9b	219.7 ± 8.2ab	224.4 ± 7.5a	228.3 ± 7.2a	210.1 ± 7.3b
Body length (mm)	19.8 ± 0.4b	20.2 ± 0.4ab	20.3 ± 0.4ab	20.5 ± 0.5a	19.7 ± 0.4b
Body width (mm)	7.3 ± 0.5bc	7.5 ± 0.4ac	7.9 ± 0.4a	7.8 ± 0.3ab	7.1 ± 0.4c
Wing length (mm)	33.0 ± 0.8b	33.0 ± 0.9b	33.3 ± 0.7ab	34.2 ± 0.3a	32.7 ± 0.6b
Wing width (mm)	5.9 ± 0.2b	6.0 ± 0.2ab	6.1 ± 0.3ab	6.3 ± 0.2a	5.9 ± 0.2b

Means within a row followed by same letter(s) are not significantly different by DMRT (P ≤ 0.05)

The width of larvae differed significantly depending on the cotton varieties (Table 3). The 1^{st}, 2^{nd} , 3^{rd}, 4^{th} and 5^{th} instar larval and pupal width ranged from 1.0 ± 0.1 to 1.4 ± 0.2, 1.6 ± 0.2 to 2.8 ± 0.2, 3..5 ± 0.2 to 4.7 ± 0.3, 5.0 ± 0.3 to 6.8 ± 0.4, 7.4 ± 0.3 to 8.8 ± 0.4 and 5.2 ± 0.8 to 6.7 ± 0.7 mm, respectively and showed significant difference (first instar: $F_{4,20} = 3.5$, $p < 0.01$; second instar: $F_{4,20} = 4.4$, $p < 0.01$; third instar: $F_{4,20} = 4.9$, $p < 0.01$; fourth instar: $F_{4,20} = 5.4$, $p < 0.01$; fifth instar: $F_{4,20} = 5.2$, $p < 0.01$; pupa: $F_{4,20} = 4.6$, $p < 0.01$). Larvae and pupae corresponding to CB8 exerted the highest widths.

Table 4 showed that the cotton varieties had significant effect on the adult males' weight, body length and width, and forewing length and width of *S. litura* (weight: $F_{4,20} = 3.3$, $p < 0.01$; body length: $F_{4,20} = 6.4$, $p < 0.01$; body width: $F_{4,20} = 5.5$, $p < 0.01$; wing length: $F_{4,20} = 3.9$, $p < 0.01$; wing width: $F_{4,20} = 4.4$, $p < 0.01$). The males revealed body weight from 153.6 ± 3.1 to 166.5± 4. mg, and body length

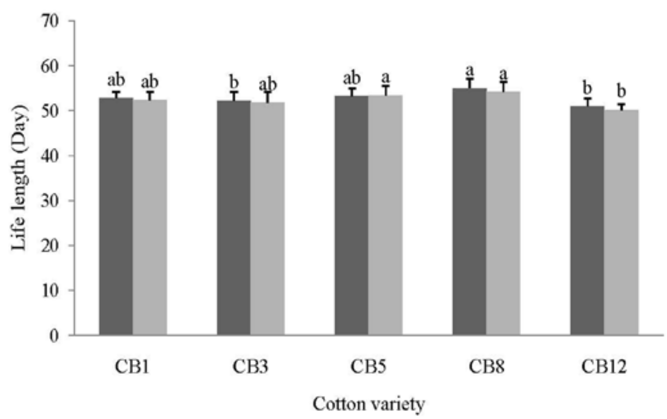

Fig. 3. Life length (mean ± SD day) of male (■) and female (□) S. litura reared on five cotton varieties. Bars with same letter(s) are not significantly different by DMRT (P ≤ 0.05)

and width from 17.0 ± 0.4 to 17.8 ± 0.5 and 5.5 ± 0.5 to 6.1 ± 0.5 mm, respectively. Their fore wing length and width varied from 32.1 ± 0.5 to 33.7 ± 0.6 and 5.7 ± 0.2 to 6.2 ± 0.3 mm, respectively.

Table 5 demonstrated that the body weight, body length and width, and forewing length and width of female *S. litura* were greatly affected by the cotton varieties on which the larval stages were fed (weight: $F_{4,20} = 3.7$, $p < 0.01$; body length: $F_{4,20} = 3.4$, $p < 0.01$; body width: $F_{4,20} = 6.1$, $p < 0.01$; wing length: $F_{4,20} = 4.5$, $p < 0.01$; wing width: $F_{4,20} = 4.8$, $p < 0.01$). The female moths possessed body weight from 210.1 ± 7.3 to 228.3 ± 7.2 mg, and body length and width from 19.7 ± 0.4 to 20.5 ± 0.5 and 7.1 ± 0.4 to 7.8 ± 0.3 mm, respectively. Their fore wing length and width varied from 32.7 ± 0.6 to 34.2 ± 0.3 and 5.9 ± 0.2 to 6.3 ± 0.2 mm, respectively.

The quality of larval food affected the pupal and adult phenotypic characteristics, thus the adults showed variation in their growth characteristics. Naseri *et al.* (2010) reported that the nutritional requirements of the herbivore insects over different developmental periods were positively correlated with growth, and growth was directly based on nutrient input.

The present study showed that the life lengths of male and female *S. litura* on cotton varieties varied from 51.0 ± 1.7 to 55.0 ± 2.1 and 50.2 ± 1.2 to 54.2 ± 2.2 days, respectively. There were found significant differences in the lengths of male ($F_{4, 20} = 3.3$, $p < 0.05$) and female ($F_{4, 20} = 3.2$, $p < 0.05$) and the durations varied from 51.0 ± 1.7 to 55.0 ± 2.1 days and 50.2 ± 1.3 to 54.2 ± 2.2 days, respectively (Fig. 3).

Both males and females showed longest and shortest life lengths on CB8 and CB12, respectively. Males and females originating from larvae fed on same variety did not show difference in their longevity (CB1: $t_4 = 0.74$, $p = 0.50$; CB3: $t_4 = 0.41$, $p = 0.70$; CB5: $t_4 = 0.27$, $p = 0.80$; CB8**:** $t_4 = 1.0$, $p = 0.37$; CB12: $t_4 = 1.1$, $p = 0.34$). Jawar *et al.* (2013) observed life length 31.87 ± 0.25 days. According to Wu *et al*. (2010), when the leaves of the high-gossypol cotton cultivar M9101 were fed, *Spodoptera exigua* had a longer larval life span.

The cotton varieties showed variations on the relative growth rate and morphometric parameters of *S. litura* that could be helpful for selection of cotton varieties in management program of this pest. But, further studies should be focused on the biochemical components in the cotton varieties for better understanding the mechanism of host suitability.

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BIO-RATIONAL MANAGEMENT OF POD BORER IN GREEN PEA FIELD

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ABSTRACT

This study evaluated the effect of Tracer 45 SC, Vertimec 18 EC, neem seed kernel extract, neem leaf extract with concentration of 1.2 ml l^{-1}, 0.4 g l^{-1}, 50 ml l^{-1} and 50 g l^{-1} water, respectively and hand picking along with an untreated control against pod borer *Maruca vitrata* infestation on green pea *Pisum sativum*. Application of the treatments was started from the advent of pod borer infestation and repeated three times with 15 days interval. The treatments revealed pod infestations from 4.2 to 6.0%, 1.3 to 2.7% and 4.9 to 8.3%, respectively at early, mid and late harvest which are statistically lower compared to untreated control. The treatments produced significantly longer (5.6 to 6.1 cm), wider (1.14 to 1.24 cm) and heavier (0.64 to 0.90 g pod^{-1}) pods as well as higher number of seed (3.0 to 3.4) per pod. The marketable yield (862.1 to 1033.7 kg ha^{-1}) and gross yield (884.3 to 1047.0 kg ha^{-1}) were statistically higher in the treatments and the infested yield (33.7 kg ha^{-1}) was highest in the untreated control. The treatments produced revealed 13.1 to 35.6% marketable yield over control. An economic analysis indicated that the highest gross return (837.6 US dollar ha^{-1}) was obtained from the Tracer 45 SC treated plot but net return (760.2 US dollar ha^{-1}), adjusted net return (123.4 US dollar ha^{-1}) and benefit cost ratio (1.7) were highest in the Vertimec 18 EC treated plot. The results indicated the insecticidal treatments were more potential compared to botanical and mechanical control against pod borer.

Keywords: *Maruca vitrata*, neem extracts, neem oil, *Pisum sativum,* Tracer, Vertimec.

INTRODUCTION

The green pea *Pisum sativum* is a leguminous winter crop in Bangladesh. It is one of the important vegetables which is a major source of protein and play a key role in human nutrition. Furthermore, it is an important source of protein in animal feed (Khan and Croser 2004). It also plays vital role in cropping system through nitrogen fixing in soil and thereby improves crop productivity (French 2004, Messiaen

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et al. 2006). But insect pests are the main biotic constraints for sustainable crop production.

Pod borer *Maruca vitrata* Fabricius (Lepidoptera: Pyralidae) is one of the major insect pests of green pea in Bangladesh. Its larvae damage stems, peduncles, flowers and pods of green pea (Sharma 1998). Insect pest management of green pea mainly depends on the use of chemical insecticides, however wide use of synthetic insecticides resulted in more pest problem due to disruption of balance between insect pests and natural enemies (Thomas and Waage 1996). Such adverse effects of dependence on chemical insecticides prompted an increased interest for the development of integrated pest management (IPM) program, which is sustainable and environment friendly pest management method. Now-a-days, there is growing interest in the application of botanical oils, powders and extracts as the components of IPM for crop protection (Pedigo 2002). This eco-friendly management tactics has a great chance to save the beneficial insects as well as microorganisms. Cultural and mechanical methods are integral part of IPM which conserve natural enemies, pollinators and keep the environment safe from pollution.

Therefore, in the present study, two chemical insecticides namely Tracer 45 SC (Spinosad) and Vertimec 18 EC (Abamectin) along with neem seed kernel extract, neem leaf extract and mechanical control (hand picking) were applied against pod borer *M. vitrata* in the green pea field to evaluate their effect on pod infestation and production of the crop with economic analysis.

MATERIALS AND METHODS

Study site and cultivation of green pea: The experiment was carried out in the research field of the Department of Entomology of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh from November 2014 to February 2015. Seeds of the green pea were collected from the Department of Horticulture of BSMRAU. The experiment was laid down in a randomized complete block design with a plot size of 3.0 × 2.0 m replicated three times. The number of plots per treatment was three, and spaces between blocks and between plots were 0.5 m and 1.0 m, respectively. Seeds were sown on 2nd November 2014 in rows. The manures and fertilizers were applied according to the recommended doses of Bangladesh Agricultural Research Institute.

Collection and preparation of bio-rational products: Insecticides were bought from Gazipur market, and the neem leaves were collected from BSMRAU campus. The leaves were washed with tap water and dried in sunlight. Afterwards, the materials were dried in an oven at 60 °C for 24 h to obtain a constant weight. Then the materials were powdered mechanically using an electric blender, passed through an 18-mesh screen and stored at 28°C in tightly closed dark glass bottles. The leaf powders of neem (50 g) were macerated separately in 2.5 l reagent bottles using 1 l of distilled water. The samples were shaken for 72 h on an electric shaker. Ten drops of 2% sodium dioctyl-sulfo-succinate were added to the bottle. The extract was decanted through a muslin cloth and the decanted material was used at 50 ml l^{-1} concentration. Pure neem oil was bought from a pesticide shop in Dhaka, Bangladesh, and 50 ml oil was dissolved in 1 l of water to obtain a 50 ml l^{-1} concentration. Tween 20 at a concentration of 0.1% was used in the oil treatment as an emulsifying agent.

Monitoring of pest and application of treatments: The experimental field was monitored weekly to observe the infestation of pod borer. The insecticides, oil and extract treatments were sprayed with a knapsack sprayer at the advent of infestation and repeated 3 times with 15 days interval. The Tracer 45 SC, Vertimec 18 EC, neem seed kernel extract and neem leaf extract were applied with concentration of 1.2 ml l^{-1}, 0.4 g l^{-1}, 50 ml l^{-1} and 50 g l^{-1} water, respectively. Hand picking was done three times with 15 days interval. Each treatment was applied in three plots and each plot was considered as a replication.

Data collection on pod infestation and pod size: The damaged and undamaged pods were harvested three times of which the first harvest was considered as early harvesting, second and last harvests were considered as mid and late harvest. Data were calculated as percent pod infestation at early, mid and late harvesting. At each harvest, damaged and undamaged pods were counted separately and their weight was taken. Percent pod infestation at each harvest was calculated. At the first harvest, 10 pods per treatment were randomly selected and their individual lengths and widths were measured using a millimeter scale, and the weights were taken using a digital balance ((AG204, Mettler Toledo, Switzerland).

Estimation of pod yield and economic analysis: At every harvest, the harvested pods of each treatment were separated into marketable and infested categories and their weights were taken. The yield of each plot was converted into kg ha^{-1}. The economic analysis and benefit-cost ratio (BCR) were calculated based on the total expenditure for each treatment and the total return ha^{-1}. The total expenditure for a treatment indicates the costs for labor and inputs. The gross return of a treatment is the total price obtained from the total yield of the treatment. The net return was calculated by subtracting the expenditure of a treatment from its gross return. The adjusted net return of each treatment was calculated by subtracting the net return of the untreated control from the net return of the treatments. The BCR is the result of the adjusted net return of a treatment divided by the total expenditure of the same treatment.

Statistical analysis: Data were analyzed by one-way analysis of variance (ANOVA) and the mean values were separated by Duncan multiple range test (DMRT). All the analyses were performed using SPSS (IBM Statistics 21.0).

RESULTS AND DISCUSSION

Table 1 shows the pod infestation at early, middle and late harvesting. The pod infestation at early harvest ranged from 4.2 ± 1.7 to 11.4 ± 1.6% and the results differed significantly ($F_{5,12} = 3.8$, $p < 0.05$). All the treatments had significantly lower percentage of infestation than that of untreated control. There was a significant difference in pod infestation at mid-harvest ($F_{5,12} = 12.7$, $p < 0.001$), and the results varied from 1.3 ± 0.3 to 10.7 ± 1.2%. All the treatments revealed significantly lower infestation level compared to untreated control. The pod infestation levels at late harvest differed significantly ($F_{5, 12} = 4.0$, $p < 0.05$), and the results ranged from 4.9 ± 1.5 to 15.3 ± 4.1%. The results obtained from this study clearly indicated that the treatments significantly reduced green pea pod infestation by pod borer. The insecticides and hand picking kill pod borer larvae and moths, and reduced their population and resulted lower level of infestation. The neem oil and neem leaf extract possess anthraquinones, monoterpenoids, naphthoquinones, phenols, and related substances that have insecticidal properties and affected the pod borer population and reduced infestation (Bakkali *et al.* 2008 & Kim *et al.* 2010). Alam *et al.* (2005) found that crashed neem seed kernel reduced infestation level of pod borer in bean field. Sarkar (2005) reported that neem oil at a concentration of 10 ml l^{-1} water reduced 50.7% infestation of *Helicoverpa armigera* in chickpea. Romesh and Pandey (2005) found that 5% neem seed kernel extract killed early stage larvae of *M. vitrata* in the bean field.

Table 1. Effect of different bio-rational management approaches on % pod infestation by pod borer (*M. vitrata*) at early, mid and late harvest of green pea

Treatment	% Infestation		
	early harvest	mid harvest	late harvest
Tracer 45 SC	4.2 ± 1.7 b	1.4 ± 0.6 b	4.9 ± 1.5 b
Vertimec 18 EC	4.6 ± 2.2 b	1.3 ± 0.3 b	6.7 ± 1.5 b
Neem seed kernel extract	5.5 ± 1.2 b	2.7 ± 1.3 b	6.9 ± 4.8 b
Neem leaf extract	6.0 ± 1.8 b	2.6 ± 1.3 b	8.1 ± 3.6 b
Handpicking	5.3 ± 3.0 b	1.4 ± 1.0 b	8.3 ± 0.6 b
Control	11.4 ± 1.6 a	10.7 ± 1.2 a	15.3 ± 4.1 a

Data expressed as mean ±SE. Means within a column followed by same letter(s) are not significantly different by DMRT at $p \leq 0.05$

Table 2 showed that the lengths, widths and weights of the pods, and number of seed per pod in the treated plots varied from 4.3 ± 0.4 to 6.1 ± 0.1 cm, 1.10 ± 0.03 to 1.24 ± 0.04 cm, 0.56 ± 0.07 to 0.90 ± 0.12 g pod^{-1} and 2.2 ± 0.37 to 3.4 ± 0.24 seed pod^{-1}, respectively. The treatments had significant effects on the length ($F_{5, 24} = 9.2$, $p < 0.001$), width ($F_{5, 24} = 2.7$, $p < 0.05$) and weight ($F_{5, 24} = 2.7$, $p < 0.05$) of the pods, and number of seed per pod ($F_{5, 24} = 2.9$, $p < 0.05$). All the treatments had significantly longer, wider and heavier pods and higher number of seed per pod than the untreated control. Due to severe feeding of borer larvae, infested pods were twisted and stunted in untreated control plot and subsequently shorter, narrower and lighter pods were produced with lower number of seed per pod. In addition, larvae fed inside the developing pods of the control plots without any hindrance, thereby affecting pod growth. These findings are in agreement with Thejaswi *et al.* (2008) who reported that *A. craccivora* infested bean plants produced stunted and twisted pods.

There were significant differences in the marketable yield ($F_{5, 12} = 3.4$, $p < 0.05$), infested yield ($F_{5, 12} = 29.2$, $p < 0.001$) and gross yield ($F_{5, 12} = 3.1$, $p < 0.05$) of the green pea pods compared to that of untreated control plot (Table 3). The marketable yield, infested yield and gross yield of the pods ranged from 762.3 ± 25.0 to 1033.7 ± 95.4, 13.3 ± 1.3 to 33.7 ± 1.0 and 796.0 ± 25.9 to 1047.0 ± 94.9 kg ha^{-1}, respectively. These findings corroborate with those of Randhawa and Saini (2015) who reported that spinosad provided effective control of pod borer, reduced pod damage and increased the grain yield as compared to control. Similar results were also recorded by Ankali *et al* (2009) and Ameta *et al* (2011) who concluded that insecticides resulted significantly high reduction in *Helicoverpa armigera* and *Maruca testulatis*, respectively and thereby reduced pod damage in pigeon pea and also increased the grain yield of the crop.

Table 2. Effect of different bio-rational management approaches used against pod borer (*M. vitrata*) on the yield contributing characters of green pea

Treatment	yield contributing characters (Pod size)			Number of seed per pod
	Length (cm)	Width (cm)	Weight (g)	
Tracer 45 SC	5.7 ± 0.2 a	1.24 ± 0.04 a	0.90 ± 0.12 a	3.4 ± 0.24 a
Vertimec 18 EC	6.1 ± 0.1 a	1.22 ± 0.03 a	0.84 ± 0.06 ab	3.4 ± 0.24 a
Neem seed kernel extract	5.7 ± 0.2 a	1.15 ± 0.01 ab	0.78 ± 0.05 ac	3.2 ± 0.20 a
Neem leaf extract	5.6 ± 0.1 a	1.20 ± 0.04 ab	0.82 ± 0.07 ab	3.4 ± 0.24 a
Handpicking	5.8 ± 0.1 a	1.14 ± 0.02 ab	0.64 ± 0.07 bc	3.0 ± 0.31 ab
Control	4.3 ± 0.4 b	1.10 ± 0.03 b	0.56 ± 0.07 c	2.2 ± 0.37 b

Data expressed as mean ±SE. Means within a column followed by same letter(s) are not significantly different by DMRT at $p \leq 0.05$

Table 3. Effect of different bio-rational management approaches used against pod borer (*M. vitrata*) on the yield of green pea

Treatment	Yield (kg ha^{-1})			% Marketable yield increaser over control
	Marketable	Infested	Gross	
Tracer 45 SC	1033.7 ± 95.4 a	13.3 ± 1.3 c	1047.0 ± 94.9 a	35.6
Vertimec 18 EC	1022.2 ± 69.6 a	18.8 ± 1.2 b	1041.1 ± 68.6 a	34.1
Neem seed kernel extract	983.4 ± 44.1 a	20.6 ± 0.8 b	1004.0 ± 44.8 a	29.0
Neem leaf extract	877.8 ± 45.5 ab	21.3 ± 2.0 b	899.1 ± 45.6 ab	15.2
Handpicking	862.1 ± 42.4 ab	22.3 ± 0.6 b	884.3 ± 42.8 ab	13.1
Control	762.3 ± 25.0 b	33.7 ± 1.0 a	796.0 ± 25.9 b	

Data expressed as mean ±SE. Means within a column followed by same letter(s) are not significantly different by DMRT at $p \leq 0.05$

The costs of the treatments for pod borer management and the returns obtained from the green pea yields are presented in Table 4. The management cost was highest for Tracer 45 SC (US$78.8 ha^{-1}). The highest gross return (US$837.6 ha^{-1}) and BCR (1.54) were obtained from Tracer 45 SC but net return (US$760.2 ha^{-1}) and adjusted net return (US$123.4 ha^{-1}) were obtained from the Vermitec 18 EC.

This study showed that higher yield was obtained from the treatments because of higher number of healthy pods with larger size having more number of seeds pod^{-1}. The yield reduction in the untreated control plot was due to the feeding activities of the borer larvae. Annan *et al.* (1995) observed reduced plant growth and yield in the cowpea *Vigna unguiculata* due to the infestation of *A. craccivora*.

The insecticides are expensive compared to plant materials. These are cheaper and easily available. Therefore, attention should be given to incorporate botanicals in integrated pest management program to combat pod borer in green pea fields.

Table 4. Benefit-cost ratio analysis of different bio-rational management approaches used against pod borer (*M. vitrata*) infesting green pea

Treatment	Management cost (US dollar ha^{-1})	Gross return (US dollar ha^{-1})	Net return (US dollar ha^{-1})	Adjusted net return (US dollar ha^{-1})	BCR
Tracer 45 SC	78.8	837.6	758.8	122.0	1.54
Vertimec 18 EC	72.6	832.8	760.2	123.4	1.7
Neem seed kernel extract	70.3	803.2	732.9	96.1	1.4
Neem leaf extract	68.1	719.3	651.2	14.4	0.2
Handpicking	67.3	707.4	639.2	2.4	0.03
Control	68.2	636.8	636.8		

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EFFECTIVE SPRAY SCHEDULE OF CYPERMETHRIN FOR MANAGING POD BORER ATTACKING SUMMER COUNTRY BEAN

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ABSTRACT

The study was conducted in order to find out an effective spray schedule of cypermethrin insecticide against pod borer, *Maruca vitrata* F. attacking summer country bean. Including an untreated control there were six treatments were used to measure the effectiveness of cypermethrin based on inflorescence and pod infestation, yield and also benefit cost ratio (BCR). Among the different spray schedules of cypermethrin, the lowest rate of pod infestation (4.59% by number and 6.10% by weight) and the highest BCR (6.98) were obtained with Ripcord (cypermethrin) 10 EC @ 1 ml l^{-1} of water sprayed after observing 5% level of pod infestation and repetition of the same at 15 days interval up to last harvest. On the other hand, highest marketable yield (11.64 t ha^{-1}) was obtained Ripcord (cypermethrin) 10 EC @ 2 ml l^{-1} of water sprayed after observing 5% level of pod infestation and repetition of the same at 15 days interval up to last harvest but the BCR was lower (4.21) compare to the application rate 1 ml l^{-1} of water. So, Ripcord (cypermethrin) 10 EC @ 1 ml l^{-1} of water sprayed after observing 5% level of pod infestation and repetition of the same at 15 days interval up to the last harvest performed the best.

Keywords: Spray schedule, Cypermethrin, *Maruca vitrata*, Summer country bean.

INTRODUCTION

Country bean, *Lablab purpureus* (Linn.) is a popular protein rich leguminous vegetable widely grown in Bangladesh (Chowdhury *et al.* 1989). Hossain and Awrangzeb (1992) reported that more than 80% bean production in Bangladesh is occurred in the Rabi season while less than 20% in Kharif season. Farmers are cultivating country bean in summer due to its high price, but high incidence of insect pests resulted its significant yield loss compared to the Rabi season (Alam

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et al. 2005). Although no regular statistical records are available, the yield loss in country bean due to insect pests is reported to be about 12-30% (Hossain 1990).

Bakar *et al.* (1980) reported that among the insect pests, *Maruca vitrata* is a serious one infesting leguminous vegetables. Butani and Jotwani (1984) reported that the lepidopteran insect pod borer, *Maruca vitrata* was a major insect pests of bean causing damage by boring tender or mature pods. Bean pod borer is able to establish itself on legumes from vegetative to reproductive stage and cause substantial damage to flowers and fruit setting (Kennedy 1976). The borer is voracious, widely distributed and has a wide host range. Pod borers make hole in flowers and tunnel in the pods. The newly hatched larvae preferably feed on the contents of flower and buds. The damaged buds and flowers normally fall off. The mature larvae feed on the tender grains inside the pods preferably near the base by clinging half portion of its body downwards (Ali 2006, Karim 1995).

Current management practices of insect pests are mostly based on chemical insecticides as they give quick result. Barman (2012) reported that the Cypermethrin provided effective result against the country bean pod borer which showed lower level of inflorescence infestation, lowest rate of pest incidence (4.59%), thus resulted the highest yield (11.64 t ha^{-1}). Hossain *et al.* (2013) found cypermethrin as the most effective against pod borer of yard long bean. Rahman *et al.* 2014 obtained cypermethrin to be effective against brinjal shoot and fruit borer. Among the insecticides used in Bangladesh, Cypermethrin have some important properties such as greater photo-stability, effectiveness at low concentrations, low environmental persistence and easy breakdown compared to other group of insecticides (Rahman *et al.* 2014). But, the dose and spray schedule of this insecticide is not yet studied for summer country bean. So, the present study was undertaken to find out an effective spray schedule of cypermethrin for suppressing pod borer of summer country bean field.

MATERIALS AND METHOD

The study was carried out in the field laboratory of the Department of Entomology, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during March to August 2014. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The experimental field was divided into 3 blocks and each block was again divided into 6 unit plots (4m x 3m). The seeds of IPSA Seem 2 were collected from the Department of Horticulture, BSMRAU, Gazipur-1706. Before sowing seeds for raising seedling, the germination test was done to ensure 90% germination. Pits were prepared 10 days before sowing of seeds. After sowing, a light irrigation was given. After 15 days of germination, a single healthy seedling per pit was allowed to grow discarding the others and gap filling was performed with poly bag seedling from the stock when necessary. Manure and fertilizer application, irrigation, trailing, mulching and weeding were done according to Rashid (1999). All plants in the plot were closely monitored every day for the purpose of observing the incidence of insect pests for starting application of insecticide. Effectiveness of five spray schedule (treatments) were evaluated with an untreated control against pod borer infestation as follows:

T_1 = Ripcord (cypermethrin) 10 EC @ 1 ml l^{-1} of water sprayed at 45 DAT and repetition of the same at 7 days interval up to last harvest.

T_2 = Ripcord (cypermethrin) 10 EC @ 1 ml l^{-1} of water sprayed after initiation of 2% level of pod infestation and repetition of the same at 15 days interval up to last harvest.

T_3 = Ripcord (cypermethrin) 10 EC @ 2 ml l^{-1} of water sprayed after initiation of 2% level of pod infestation and repetition of the same at 15 days interval up to last harvest.

T_4 = Ripcord (cypermethrin) 10 EC @ 1 ml l^{-1} of water sprayed after observing 5% level of pod infestation and repetition of the same at 15 days interval up to last harvest.

T_5 = Ripcord (cypermethrin) 10 EC @ 2 ml l^{-1} of water sprayed after observing 5% level of pod infestation and repetition of the same at 15 days interval up to last harvest and an untreated control was maintained.

Ripcord (cypermethrin) 10 EC was procured from Gazipur market was started to apply as per treatment by mixing with tap water. Data on pest infestation, yield attributes and pod yield were recorded. Rate of inflorescence infestation were recorded from 5 randomly selected inflorescence in each plot after 3 days and 7 days of insecticide application. The number of healthy and infested pods and their weight per plot were recorded at each harvest. The infestation of the pest was expressed in percentage based on number (n/n) and weight (w/w) of pod. The final yield was expressed in ton per hectare. For economic analysis, benefit cost ratio (BCR) was calculated on the basis of total expenditure of the respective spray schedule along with the total return from that particular spray schedule according to Ali *et al.* (1996). All the data collected and computed were analyzed statistically. Data were analyzed by ANOVA of using MSTAT-C software and the means were separated by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Rate of inflorescence infestation: Significant variation was observed in rate of inflorescence infestation at 3 and 7 days after spraying (DAS) for different spray schedule of cypermethrin is presented in Table 1. Rate of inflorescence infestation ranged 15.08-29.33% at 3 DAS and 16.69-33.09% at 7 DAS under different treatments. At 3 DAS, the highest inflorescence infestation was observed in untreated control plot and the lowest infestation was obtained in T_2 treated plot (15.08%) which was statistically similar to that of T_3 (15.19%) and T_1 (15.51%) treated plots followed by T_4 (18.57%) and T_5 (19.43%) treated plots and these were statistically similar with each other. The highest inflorescence infestation reduction over untreated control was 48.59% in T_2 treated plot followed by T_3 (48.21%) and T_1 (47.12%) treated plots. The least inflorescence infestation reduction over untreated control was found in T_5 (33.75%) followed by T_4 (36.69%) treated plot (Table 1).

At 7 DAS, the highest rate of inflorescence infestation (33.09%) was recorded in untreated control plot, which was statistically different from all other treatments followed by T_5 (27.57) and T_2 (27.32) treated plots. On the other hand, the lowest rate of inflorescence infestation (16.69%) was recorded in T_3 treated plots which was statistically similar with T_1 (20.53%) and T_4 (20.10%) treated plots (Table 1). Among the treatments, the highest reduction of inflorescence infestation over untreated control (51.80%) was calculated in T_3 treated plots and the lowest reduction over untreated control (18.93%) was calculated in the T_5 treated plots. The reduction percentage of inflorescence infestation over control of T_1, T_4, T_5 treated plots were 43.96%, 42.39% and 22.52%, respectively (Table 1).

Table 1. Effect of spray schedule for Cypermethrin application in suppressing pod borer in summer country bean in terms of rate of inflorescence infestation

Spray schedules (Treatments)	3 DAS		7 DAS	
	% infestation	% inflorescence infestation reduction over control	% infestation	% inflorescence infestation reduction over control
T_1	15.51c	47.12	20.53c	43.96
T_2	15.08c	48.59	27.32b	22.52
T_3	15.19c	48.21	16.69c	51.80
T_4	18.57b	36.69	20.10c	42.39
T_5	19.43b	33.75	27.57b	18.93
Untreated control	29.33a	-	33.09a	-
CV (%)	10.16	-	11.06	-

Means within a column followed by same letter(s) do not differ significantly (P=0.05) according to Duncan's Multiple Range Test (DMRT)

On the other hand, Hossain (2011) found the lowest rate of inflorescence infestation (7.25 %) and the lowest number of flower shedding (16.00) in yard long bean by using mechanical control (hand picking) & 2 sprays with Ripcord 10 EC @ 1.0 ml l^{-1} of water at 15 days interval after 3 days of spraying.

Rate of pod infestation (n/n and w/w): Effect of different spray schedule of cypermethrin application in terms of the rate of pod infestation (n/n and w/w) was presented in Figure 1. The highest rate of pod infestation by number (13.21%) was found in untreated control plot and the lowest rate of pod infestation (4.59%) was found in the T_4 treated plots. The rate of pod infestation by number of T_1, T_2, T_3 and T_5 treated plots were 5.38%, 7.57%, 9.59% and 5.28%, respectively.

The highest rate of pod infestation by weight (22.12%) was found in the untreated control plot and the lowest rate of pod infestation (6.10%) was found in the T_4 treated plot followed by 6.36%, 6.55%, 6.83% and 6.89% in T_1, $T_{3,}$ T_2 and T_5 treated plot, respectively (Fig. 1).

The present results may be discussed with the finding of Hossain *et al.* (2013). They studied the relationship between pod borer infestation and yield (healthy pods) of yard long bean. They found that pod borer infestation is negatively correlated with yield of yard long bean. The relationship was significant and about 15% yield was affected due to pod borer infestation. Barman (2012) also found the pod borer infestation is negatively correlated with yield in country bean which is similar to the present study. Ahmed *et al.* (2003) stated that Furadan 5G @ 1.5 kg/ha + Ripcord 10 EC @ 1 ml l^{-1} of water ensured the highest (68.48%) reduction of infested pod (by weight) per plant over control. The results obtained in the present study are comparable to the findings of Rahman *et al.* (2014) who found that the use of Ripcord (cypermethrin) 10 EC @ 1 ml l^{-1} of water sprayed after observing 5% level of fruit infestation of brinjal and repetition of the same at 15 days interval achieved the highest reduction of infestation (42.16% by weight and 40.15% by number) over control. Findings of the present study are comparable with the findings of Alam *et al.* (2005).

Effect of different spray schedule of cypermethrin on yield (t ha^{-1}): Significant variation was observed in marketable, infested and total yield (t ha^{-1}) in suppressing pod borer of country bean using different spray schedule of Cypermethrin application (Table 2). The highest marketable yield (11.64 t ha^{-1}) was obtained from T_5 treated plot which was statistically identical to that of T_4 (10.74 t ha^{-1}) treated plot. On the other hand, significantly the lowest marketable yield (6.57 t ha^{-1}) was recorded in untreated control plot. However, T_1 (9.01 t ha^{-1}), T_3 (8.65 t ha^{-1}) and T_4 (9.25 t ha^{-1})

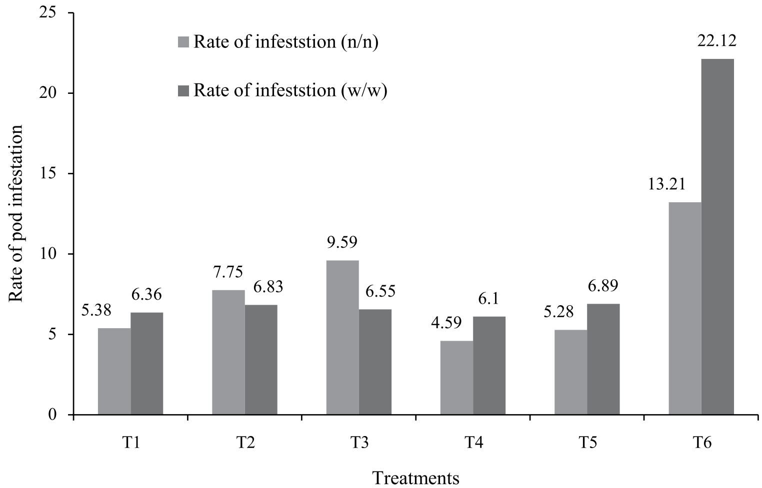

Fig. 1. Effect of spray schedule for Cypermethrin application in suppressing pod borer in summer country bean in terms rate of pod infestation (n/n and w/w)

treated plots showed intermediate level of yield and they were statistically identical to each other.

The highest infested yield (1.86 t ha^{-1}) was harvested from untreated control plot which was statistically different from all other treatments. On the other hand, the lowest infested yield (0.61 t ha^{-1}) was recorded in T_1 treated plots which was statistically identical to that of T_2 (0.69 t ha^{-1}), T_3 (0.78 t ha^{-1}), T_4 (0.75 t ha^{-1}) and T_5 (0.85 t ha^{-1}) treated plots.

The highest total yield (12.50 t ha^{-1}) was recorded in T_5 treated plots which was statistically similar to that of T_4 (11.49 t ha^{-1}) treated plots. On the other hand, the lowest total yield (8.43 t ha^{-1}) was recorded in untreated control plot which was statistically similar to that of T_1 (9.62 t ha^{-1}), T_2 (8.94 t ha^{-1}) and T_3 (9.43 t ha^{-1}) treated plots.

The highest marketable yield increase over untreated control (77.09%) was found in the T_5 treated plot and the lowest (25.62%) was in the T_2 treated plots. The pod infestation increase over control in T_1, T_3 and T_4 treated plots were 37.18%, 31.60%, and 63.40%, respectively (Table 2).

The use of cypermethrin might significantly increase the yield by reducing the rate of infestation. Reduced rate of infestation ultimately contributed to the increased number of pod set, higher number and quality of healthy pod, higher marketable yield and gross return and ultimately resulted in the higher BCR (Figure 1, Table 2

Table 2. Effect of spray schedule using cypermethrin on the yield (t ha^{-1}) of summer country bean

(Spray schedule) Treatments	Marketable yield (t ha^{-1})	Infested yield (t ha^{-1})	Total yield (t ha^{-1})	% increase over untreated control
T_1	9.01c	0.61b	9.62c	37.18
T_2	8.25c	0.69b	8.94c	25.62
T_3	8.65c	0.78b	9.43b	31.60
T_4	10.74ab	0.75b	11.49ab	63.40
T_5	11.64a	0.85b	12.50a	77.09
Untreated control	6.57d	1.86a	8.43c	-
CV (%)	8.31	11.47	8.54	-

Means within a column followed by same letter(s) do not differ significantly (P=0.05) according to Duncan's Multiple Range Test (DMRT)

& 3). Hossain *et al.* (2013) found the highest marketable yield (12.62 t ha^{-1}) in yard long bean by using mechanical control (hand picking) & 2 sprays with Ripcord 10 EC (Cypermethrin) @ 1.0 ml/l of water at 15 days interval which was 82.62% yield increase over untreated control.

Economic analysis of different spray schedule of cypermethrin: The highest management cost (45240.00 tk ha^{-1}) was obtained from T_1 followed by T_3 and T_5 (38880.00 tk/ha). On the other hand, the lowest management cost (20880.00 tk/ha) was obtained from the T_2 and T_3. Untreated control plot T_6 has no cost (Table 3).

The highest gross return (Tk. 465600.00) was obtained from T_5 followed by Tk. 429600.00 from T_4. On the other hand, the lowest gross return (Tk. 262920.00) was obtained from the T_6 followed by Tk. 330280.00 from T_2, Tk. 346000.00 from T_3 and Tk. 360680.00 from T_1 treated plot. On the other hand, the highest net return (Tk. 426720.00) was obtained from T_5 followed by Tk. 408720.00 from T_4. On the other hand, the lowest net return (Tk. 262920.00) was obtained from the T_6 followed by Tk. 307120.00 from T_3, Tk. 309400.00 from T_2 and Tk. 315440.00 from T_1 treated plot. The highest adjusted net return (Tk. 163800.00) was obtained from T_5 followed by Tk. 145800.00 from T_3. On the other hand, the lowest adjusted net return (Tk. 44200.00) was obtained from the T_3 followed by Tk. 46480.00 from T_2 and Tk. 52520.00 from T_1 treated plot (Table 3).

Considering the management approach of pod borer of summer country bean by different spray schedule of cypermethrin, the highest benefit cost ratio (6.98) was obtained from T_4 followed by T_5 (4.21). On the other hand, the lowest benefit cost ratio (1.14) was obtained from the T_3 followed by T_1 (1.16) and T_2 (2.23) (Table 3).

Table 3. Benefit cost ratio analysis of different spray schedule of cypermethrin for the management of summer country bean

Treatment	Management cost (Tk ha^{-1})	Gross return (Tk ha^{-1})	Net return (Tk ha^{-1})	Adjusted net return (Tk ha^{-1})	BCR
T_1	45240.00	360680.00	315440.00	52520.00	1.16
T_2	20880.00	330280.00	309400.00	46480.00	2.23
T_3	38880.00	346000.00	307120.00	44200.00	1.14
T_4	20880.00	429600.00	408720.00	145800.00	6.98
T_5	38880.00	465600.00	426720.00	163800.00	4.21
Untreated control	0.00	262920.00	262920.00	0.00	-

T_1 consisted 13 sprays, T_2 and T_3 consisted 6 sprays and T_4 and T_5 consisted 5 sprays. Market value of summer country bean was 40 taka/kg, Ripcord (cypermethrin) 10 EC @ Tk. 120/100 ml bottle, Insecticide preparation and application @ 3 labor/ha, Labor wage @ Tk. 150/3 hr, Sprayer rent @ Tk. 30/day

Barman (2012) also found the highest BCR (7.39) by using 3 spray of Ripcord 10 EC (Cypermethrin) @ 1 ml l^{-1} of water with mechanical control at 10 days interval in country bean which is almost similar to this study. Hossain *et al.* (2013) found the highest BCR (4.65) in yard long bean by using mechanical control (hand picking) & 2 sprays with Ripcord 10 EC (Cypermethrin) @ 1.0 ml l^{-1} of water at 15 days interval. However, the BCR (6.98) of the present study at 5% level of pod infestation may be acceptable though BCR varies with the season, market value of the product and cost of management.

In this study, it was found that, Ripcord (cypermethrin) 10 EC @ 1 ml l^{-1} of water sprayed after observing 5% level of pod infestation and repetition of the same at 15 days interval up to the last harvest performed best. This spay schedule may be selected for commercial application in summer country bean after multilocational trial.

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EFFECT OF ADULT DIETS ON THE LONGEVITY OF STERILE ORIENTAL FRUIT FLY, *BACTROCERA DORSALIS* (HENDEL) (DIPTERA: TEPHRITIDAE)

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ABSTRACT

In the present study the effect of different adult diets on the longevity of sterile oriental fruit fly, *Bactrocera dorsalis* (Hendel) was compared under controlled laboratory condition. Adult flies were provided with protein diet + water and sugar diet as pre-release supplements for five days after adult emergence and then transferred to four post-release diet treatments *viz.*, (i) protein diet + water, (ii) sugar diet (20% sugar solution), (iii) only water and, (iv) nill (without food and water) and their longevity was recorded until death. Experimental results revealed that flies had comparatively longer lifespan on sugar diet than protein diet when either protein or sugar used as pre-release diets. Flies died within two days while provided only water and one to two days without food irrespective of any pre-release supplements. The experimental findings were discussed in the light of possible use in Sterile Insect Technique (SIT) of *B. dorsalis*.

Keywords: *Bactrocera dorsalis*, Sterile Insect Technique, adult diet, longevity.

INTRODUCTION

The oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera:Tephritidae) is a serious pest of a wide variety of fruit crops and regarded as one of the most significant pests of agriculture in South-East Asia (Waterhouse 1993). Different fruits viz., mango, litchis, apples, oranges, guava, papaya, star- fruit, etc were observed to infest by this pestiferous species. In Bangladesh, the control measure adopted for this species includes contact poisons or bait and cover spraying. Initiatives have also been taken through extensive monitoring using synthetic-lures (methyl-eugenol). Recently the Sterile Insect Technique (SIT) has proven effective as part of Area-Wide Integrated Pest Management (AW-IPM) to suppress and eradicate different *Bactrocera* fruit

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flies particularly, *B. dorsalis* in different countries. The implementation of area-wide integrated pest management using SIT mainly depends on mass rearing of the insect species using artificial diets and inundative release of sterile flies. Diet is probably the single most important component of mass rearing, sexual development and longevity in adults of many tephritid flies. Sterile male longevity after release and competitiveness with wild males are two factors that can impact the effectiveness of a SIT program (Barry *et al*. 2007).

Protein and carbohydrates are essential dietary components for optimum fruit fly development and fecundity and could impact the effectiveness of sterile males (Barry *et al*. 2007). Sucrose is needed to fuel daily foraging, flight and courtship activities and is necessary for survival, but alone it does not assure the nutritional requirements of the flies, and proteins are crucial for sexual development in both sexes and egg production in females (Cangussu & Zucoloto 1995; Teal *et al*. 2004). Thus, to achieve maximum productivity in fruit fly mass rearing, the most commonly used adult diet contains a mixture of sugar and hydrolyzed yeast (3:1), although the pre-release diet of sterile males consists normally only of sucrose. However, in SIT sterile adult fruit flies were usually provided with sucrose diet for two to five days (depends on species) before release. Improving the pre-release adult diet is considered as one of the possible way of increasing sterile fly longevity for field application of SIT.

MATERIALS AND METHODS

The present study was conducted at Insect Biotechnology Division (IBD), Institute of Food and Radiation Biology (IFRB), Atomic Energy Research Establishment (AERE), Savar, Dhaka. Adult *B. dorsalis* were collected from stock culture of IBD originated in 1995 from infested mangoes collected from Rajshahi district, North-western part of Bangladesh. Later rearing of *B. dorsalis* was maintained more than 300 generations using artificial liquid larval diet according to Khan *et al.* (2011). About 5,000 adult flies were maintained in steel framed cages (76.2 x 66 x 76.2 cm) covered with wired net. The flies were supplied with protein based diets both in the liquid and dry form *viz*., (i) baking yeast: sugar: water at 1:3:4 ratio, and (ii) casein: yeast extract: sugar at 1:1:2 ratio. Water was supplied in a conical flask socked with cotton ball. The temperature and the relative humidity of the rearing room maintained at 27±1^{0}C and 65-75%, RH and 14L:10D cycle.

Adult Sterile *B. dorsalis* were obtained from irradiating pupae before 24-48 hours of adult emergence with a dose of 50 Gy from ^{60}Co Gamma cell irradiator of IFRB. After emergence male & female flies were sorted. Newly emerged sterile adult male *B. dorsalis* were then offered two pre-release diet treatments for 5 days: (i) protein diet (casin: yeast extract: sugar, 1:1:2) + water (ii) sugar diet (20% sugar solution). After 5 days following four post-release diet as treatments were offered to flies as: (i) protein diet + water, (ii) sugar diet (20% sugar solution) (iii) only water and (iv) nill (i.e., without food and water). Water was provided in a 20-ml container with a cotton wick and was changed every after 4-5 days. Protein diet was provided in small watch glass. A total of ten cages containing twenty adult male *B. dorsalis* per cage were used for each diet (treatment) (2 pre-release × 4 post-release treatments). Cages were checked every day for adult mortality and after all flies died, the average longevity of flies was counted and recorded.

Data analysis: Longevity data collected per diet treatments was analyzed using one and two-way Analysis of Variance (ANOVA). Percentage data were transformed into arcsine. Tukey's pair-wise comparison test was performed by statistical software (Minitab-version 16).

RESULTS AND DISCUSSION

Adult sterile *B. dorsalis* longevity was significantly affected by post-release diet, but was not affected by pre-release diet or the interaction of pre- and post-release diet (Table 1; pre-release diet F = 3.42; df = 1; P = 0.077; post-release diet F = 223.91; df = 3; P= 0.000; interactions F = 1.79; df = 3; P = 0.177). The mean longevity of sterile adult *B. dorsalis* exposed to protein diet + water and sugar diet as pre-release supplement and then transferred to four post-release diet treatments *viz*., protein diet + water, sugar diet, only water and nill shown in Table 1**.** The present experimental results revealed that protein diet + water and sugar diet as pre-release supplement did not showed significant difference on adult longevity when transferred to either protein diet + water or sugar diet. The present observations have some similarities with findings of Barry *et al*. (2007) who reported that a diet of dry hydrolyzed yeast + sucrose supplied during the pre-release interval did not significantly affect field survivorship of med fly *Ceratitis capitata* (Widemann) adult males relative to the standard sucrose diet. The findings of Yuval *et al.* (2002) also partially similar to the present observations where no differences was documented in survival of sugar fed or sugar and protein fed sterile med fly males when they have access to natural sources of food (apple slice) from the fifth days of life onwards. In both the cases when protein diet + water and sugar diet was used as pre-release diet the adult *B. dorsalis* observed to die within two days on only water, and one to two days on nill as post-release diets (Table 1).

Table 1. Mean (±SE) longevity of adult sterile male *B. dorsalis* exposed to different pre- and post-release adult diets

Pre-release diets (0- 120 hours)	Post-release diets (>120 hours)	Longevity after 120 hours (mean days ± SE)
Protein diet + water	Protein diet + water	16 ± 0.88a
	Sugar diet	21.08 ± 1.21b
	Only water	2.74 ± 0.11c
	Nill	2.26 ± 0.18c
Sugar diet	Protein diet + water	18.73 ± 1.82a
	Sugar diet	24.15 ± 1.45b
	Only water	2.5 ± 0.09c
	Nill	1.86 ± 0.08c

Means for longevity among four post-release diet treatments against two pre-release diet treatments with different letters differ significantly (P>0.05).

The adult male *B. dorsalis* that were offered to the post-release sugar diet lived significantly longer than those offered three other post-release diet and males provided protein diet + water lived significantly longer than flies offered only water and nill (Fig. 1 & 2). Study also revealed that males fed on protein diet + water as pre release diet died rapidly compared to sugar diet. Similarly, Kaspi & Yuval (2000) reported that males who had previously fed on protein died significantly faster than sugar-fed males. The higher mortality rates in *C. capitata* males provided with protein in the adult diet when deprived of protein also reported by Carey *et al*. (1999). Protein-fed wild flies and laboratory males were more likely to release pheromones in leks than protein-starved flies (Papadopoulos *et al.* 1998, Kaspi *et al*. 2000, Kaspi & Yuval 2000). Field-collected lekking wild males contained higher amounts of protein and sugar compared to resting males also reported by Yuval *et al*. (1998). From these studies it is apparent that there are some benefits of protein in the adult diet, however the impact would often depend on field conditions (e.g., likelihood of 24 h starvation). Niyazi *et al.* (2004) found that laboratory flies provided with a pro-biotic, yeast-enhanced, sugar diet had a significant mating advantage over protein-starved flies fed either a pro-biotic or non-probiotic diet in the laboratory, but there was no significant effect of diet between these 2 treatments in field cage studies. In one study with wild flies, the addition of protein in the adult diet increased mating success over protein-starved counterparts (Shelly & Kennelly 2002).

Sterile males may not find needed nutrients after field release to allow for longevity, reproductive development and to mate with wild females. However, in a study with field enclosures, Maor *et al.* (2004) found that both protein-starved and protein-fed flies were able to successfully forage for protein and sugar when it was available. Although inclusion of protein (hydrolysate yeast) as pre-release diets for SIT reported to be beneficial for mating success but it reduces the longevity while

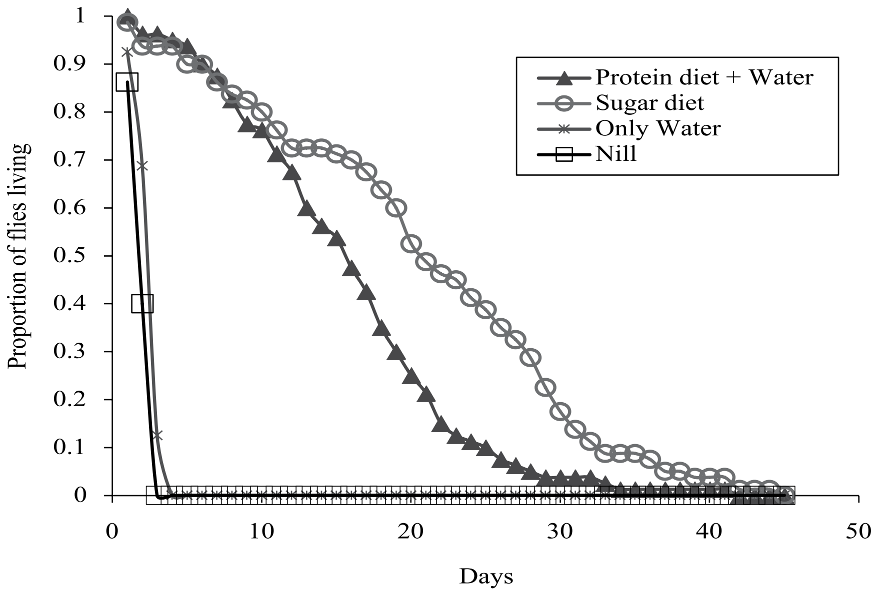

Fig. 1. Proportion of survival of adult sterile *B. dorsalis* exposed to protein diet + water as pre-release supplement and then transferred to four post-release diet treatments viz., protein diet + water, sugar diet, only water, and nill, respectively

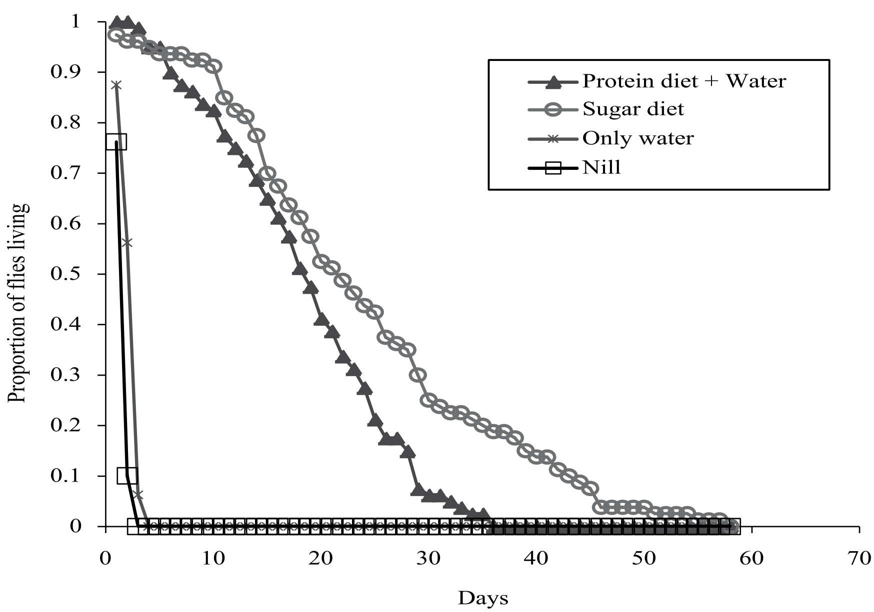

Fig. 2. Proportion of survival of adult sterile *B. dorsalis* exposed to sugar diet as pre-release supplement and then transferred to four post-release diet treatments viz., protein diet + water, sugar diet, only water, and nill, respectively

starved (Taylor *et al.* 2013). This leads us to suggest that incorporation of mixture of hydrolyzed yeast and sucrose into the pre-release diet of sterile *B. dorsalis* would not be beneficial unless there were other advantages (mating success) that would not convey to those sterile flies if they foraged for protein in the field. So it is concluded that the post-release food foraging ability of *B. dorsalis* sterile males will have a larger effect on sterile male longevity than the pre-release diet.

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STATUS AND SPATIAL DISTRIBUTION OF MAJOR INSECT AND MITE PESTS ATTACKING CITRUS AT SYLHET REGION IN BANGLADESH

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ABSTRACT

The study was conducted to determine the pest status and spatial distribution of major insect and mite pests of citrus in Jaintapur, Sylhet, Bangladesh during May to October 2014. In this study, twelve insect and one mite species were found to attack mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and jara lemon (*Citrus pennivesiculata*) plants. Among them four insect species viz., lemon butterfly (*Papilio demoleus* L.), citrus leafminer (*Phyllocnistis citrella* St.), asian citrus psyllid (*Diaphorina citri* Kuwayana), spined citrus bug (*Biprorulus bibax* Breddin) and one mite species, citrus red mite (*Panonychus citri* McGregor) have been found as major pests. Citrus leafminer was found as the most devastating pest (24.29%) followed by lemon butterfly (21.40%) and spined citrus bug (14.29%). As per *in-situ* count of leaf infestation, the highest infestation (60.40%) was caused by citrus red mite while it was the lowest (37.23%) by lemon butterfly. Intermediate level of leaf infestation was recorded in case of citrus leafminer (55.44%) and asian citrus psyllid (52.62%) with no significant difference over the locations. Similar to leaf infestation, no significant difference was found in fruit infestation over the locations.

Keywords: Mandarin, sweet orange, jara lemon, citrus.

INTRODUCTION

The genus *Citrus* (Rutaceae) comprises a wide range of economically and nutritionally rich fruit varieties such as mandarin, sweet orange, pummelo, citron, lime and lemon etc. The citrus plants are grown-well in the Sylhet region besides other districts (DAE 2010). The common citrus fruits like, jara lemon, elachi lemon, ada lemon, satkara, pummel etc. are exported from Bangladesh (Hortex Foundation 2010). Although the climate of Bangladesh is very favorable for the

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year-round production of citrus (Razzaque *et al.* 1984), Bangladesh cannot play any significant role in the world trade. The citrus industry of the country has not yet been well developed due to many problems like pest infestation, postharvest losses, peak season glut and lack of proper information about both domestic and export markets (Hortex Foundation 2010). Among these limiting factors insect and mite pests are of major concern. Sixty one organisms and pathogens have been identified so far as potential problems of citrus fruits in different citrus growing countries of the world, of which 36 species are insects and mites. In Bangladesh 21 insect and mite pests have been recorded on citrus (DAE 2010).

Rod (2006) reported old world swallow tail butterfly, *Papilio demoleus* L. as a potential citrus pest in the Dominican Republic. More than five decades ago, Ebling (1959) had listed as many as 823 species of insects and mites on citrus trees around the world and found that lemon butterflies, citrus leaf miner, Asian citrus psyllid, spined citrus bug, orange fruit fly, mealy bugs and citrus red mite are economically important pests which regularly cause economic damage to citrus crops. Besides leaf roller, bark eating caterpillars, bark and stem borer, fruit sucking pest such as whiteflies, scale insects, juice sucker also occasionally cause serious damage. Aphids, citrus thrips, fire ants, termites etc. are considered minor pests. Recently DAE (2010) has shown that 18 insect pests attacking the citrus fruits all over Bangladesh of which, lemon butterfly, citrus leafminer, Asian citrus psyllid, orange spined bug, citrus red mites have been regarded as important factors responsible for low production and inferior fruit quality. However, adequate scientific data about the status of citrus insect and mite pests and their spatial distribution on citrus host plants are still limited especially in the Sylhet region. It is very important to determine the pest status and their distribution on host plants develop successful integrated pest management strategies. Considering the importance of citrus plants and their associated insect and mite pests in the Sylhet region, the present study was conducted to determine the status of various citrus pests and to explore their spatial distribution on citrus host plants.

MATERIALS AND METHODS

The experiments were conducted during May to October 2014 on three citrus plant species namely mandarin (*Citrus reticulata*), sweet orange (*Citrus sinensis*) and jara lemon (*Citrus pennivesiculata*) at five locations viz., Citrus Research Station, Dowdic, Bagerkhal, Lamashampur and Utlarparunder at Jaintapur in Sylhet. Yellow tape was used to tag the selected host plants for experimentation.

Collection of leaf and fruit infestation data: A total of fifteen (15) citrus stands from five different locations were surveyed. Random sampling techniques were used to collect leaf and fruit infestation data. The number of infested leaves was counted from 50 leaves of each selected twig and then calculated percent leaf infestation. The number of infested fruits was counted from 25 fruits of each canopy direction and then calculated percent fruit infestation. Distribution of major insect pests was also studied based on leaf and fruit infestation (%). All the collected species of citrus insect pests were sorted and identified up to species level. Then identified samples were categorized as major and minor pests based on their level of infestation to leaf and fruit.

Determination of insect and mite pest status: In order to obtain primary infestation data, from each citrus stand of mandarin, sweet orange and jara lemon, four plants (60 plants from 15 citrus stands in total) were randomly selected and tagged for data collection on insect infested leaves and fruits. Farmers' opinion on insect pest status of citrus were documented by using pre-designed objective oriented questionnaire in a Focus Group Discussion (FGD) program in Citrus Research Station (CRS) through interviewing the local citrus farmers from each location. The secondary data on insect pests of citrus were collected from the published reports and electronic facilities of Department of Agriculture Extension (DAE), Citrus Research Station (CRS) and Bangladesh Agricultural Research Institute (BARI). These data were compared with the primary data and then finalized the list of major and minor insect and mite pests of citrus.

In-situ determination of insect and mite pest: A list of insect and mite pests was prepared based on field survey data and then ranked as major and minor pests according to the rates of leaf and fruit infestation. Insects and mites were considered major pests when leaf infestation reached up to 30% or >30% and when fruit infestation reached up to 25% or >25 % (DAE 2010).

Farmers' opinion on insect and mite pest: In each location five farmers (25 farmers in total) were selected as members of the Focus Group Discussion (FGD) program. All the selected members were then interviewed with the help of structured questionnaire. In Citrus Research Station (CRS) 25 farmers were interviewed during the study to record their opinions and comments on the status of various citrus pests. The infestation levels were determined based on the farmers' opinion and comments on the pest status of citrus insects and mite.

Analysis of data: All statistical analyses were done using R (v3.0.2, R Development Core Team 2013).

RESULTS AND DISCUSSION

In this study, citrus leafminer, asian citrus psyllid, lemon butterfly and spined citrus bug were found as major insect pests and citrus red mite as major mite pest (Table 1). Their infestation ranged from 34.65% to 60.40%. Similar results were reported by Mannan (2014) who found that citrus leafminer, psyllid bug and lemon butterfly were the major citrus pests at Jamalpur. Besides, DAE (2010) reported that infestation of major pests ranged from 30% to 58%. Narayanamma *et al.* (2001) also reported that lemon butterfly caused 83% defoliation of sweet orange plants in Aandra Pradesh, India. DAE (2010) reported that citrus leafminer is a major pest which is linked with citrus canker disease at Jaintapur, Goinghat and Bianibazar sub-districts in Sylhet. DAE (2010) also mentioned that citrus greening as a major disease in Jaintapur, Sylhet in jara lemon which was transmitted by asian citrus psyllid. James (1990) stated that orange spined bug emerged as a major citrus pest in the late 1980s in Australia. Beattie (2003) observed that citrus red mite economically injured both the leaves and fruits and thus it is considered the world's serious pests of citrus. Besides major pests, eight insect's namely citrus aphid, bark and stem borer, citrus mealy bug, citrus stem borer, citrus leaf roller, thrips, termite and red fire ant were found as minor pests (Table 2). The infestation of these pests ranged from 6.76% to 15.59%. The present findings were in consistent with the reports of DAE (2010) which showed 8% infestation by thrips, 5% by citrus red scale, 12% by citrus leaf roller, 10% by red fire ant, 8% by citrus mealy bug, 10% by citrus stem borer, 12% by citrus aphid and 15% by bark and stem borer.

It was found from the farmers' interview that citrus leafminer was the most devastating pest (24.29%) followed by lemon butterfly (21.40%), spined citrus bug (14.29%), citrus red mite (12.86%), leaf roller (8.57%), termite (4.29%), bark and stem borer (4.29%), mealy bug (4.29%) and aphid (2.86%) (Table 3). However, they did not mention Asian citrus psyllid as a pest of citrus. In contrast, the present results showed Asian citrus psyllid a threat to the cultivation of citrus especially jara lemon. This was because it had been reported to be a vector of serious citrus

Table 1. Major insect and mite pests of mandarin, sweet orange and jara lemon

Common name	Scientific name	Infestation (%)
Citrus leafminer	*Phyllocnistis citrella* Stainton	56.33
Asian citrus psyllid	*Diaphorina citri* Kuwayana	52.60
Lemon butterfly	*Papilio demoleus* Linnaeus	37.51
Spined citrus bug	*Biprorulus bibax* Breddin	34.65
Citrus red mite	*Panonychus citri* McGregor	60.40

Major pests indicate 30% or >30% leaf infestation and 25% or >25% fruit infestation (DAE 2010)

Table 2. Minor insect pests of mandarin, sweet orange and jara lemon

Common name	Scientific name	Infestation (%)
Thrips	*Scirtothrips citri* Moulton	15.59
Citrus red scale	*Aonidiella aurantii* Maskell	15.52
Citrus leaf roller	*Platynota stultana*	15.05
Red fire ant	*Solenopsis invicta*	14.70
Citrus mealy bug	*Pseudococcus filamentosus* Cockrell	13.73
Citrus stem borer	*Chelidonium cinctum* Guerin-Meneville	13.72
Citrus aphid	*Toxoptera aurantii* Boyer de Fonscolambe	12.91
Bark and stem borer	*Indarbela quadrinotata* Walker	6.76

Minor pests indicate<30% leaf infestation and <25% fruit infestation (DAE, 2010)

Table 3. Farmers' opinion on citrus insect and mite pest infestation in mandarin, sweet orange and jara lemon stands

Insect and mite found	Farmers' opinion	
	Frequency	Percent
Citrus leafminer	17	24.29
Lemon butterfly	15	21.40
Spined citrus bug	10	14.29
Citrus red mite	9	12.86
Leaf roller	6	8.57
Termite	3	4.29
Bark and stem borer	3	4.29
Mealy bug	3	4.29
Aphid	2	2.86
No response	2	2.86
Total	70	100.0

greening disease and this was a major disease (75% incidence) of jara lemon at Jaintapur in Sylhet which were transmitted by Asian citrus psyllid (DAE 2010).

In the present study, leaf infestation was found the highest when citrus plants were infested by citrus red mite and the lowest when citrus plants were infested by lemon butterfly. Moreover citrus red mite was found as the most prominent in Lamashampur among other locations (Table 4). Apart from citrus red mite, among different locations, the highest infestation of citrus leafminer was appeared in Dowdic, lemon butterfly was found in Bagerkhal and asian citrus psyllid was observed in CRS. But statistical analysis showed no significant difference between citrus red mite and citrus leafminer in case of percent leaf infestation.

Citrus red mite was a serious pest of citrus infesting both leaves and fruits of citrus crop. At different study sites the two important pest, spined citrus bug and citrus

Table 4. Leaf infestation due to major insect and mite pests

Name of insect and mite pests	Leaf infestation (%)	*F*- value	LSD value	CV (%)
Citrus leafminer	55.44 ab			
Lemon butterfly	37.23c	15.96	7.16	18.83
Asian citrus psyllid	52.62 b			
Citrus red mite	60.40 a			

Table 5. Distribution of citrus red mite and spined citrus bug on citrus fruits

Study sites	Fruit infestation (%) over the locations	
	Spined citrus bug	Citrus red mite
CRS	29.96	28.28
Utlarpar	31.44	28.16
Dowdic	41.92	31.80
Bagerkhal	34.04	27.76
Lamashampur	35.80	33.76
LS	NS	NS

LS = Level of significance

red mite were mainly responsible for fruit infestation. The highest fruit infestation was occurred in Dowdic by spined citrus bug and the lowest by citrus red mite in Bagerkhal (Table 5). There was no significant difference between the fruit infestation caused by the two pests. Besides, there was no significant difference among the infestation level over the locations (Table 6). The present results clearly indicated that different locations had not supported variable levels of fruit infestation. This might happened as those locations were adjacent each other and thus weather parameters were similar. Citrus red mite and spined citrus bug were distributed among the locations. The association between citrus leafminer and citrus canker disease was not investigated in the present study. It may be noted that most of the citrus orchards were being infected with these diseases on a regular fashion. It is thus essential to explore

Table 6. Distribution of major insect and mite pests on the leaf of citrus plant

Study sites	Citrus leafminer	Lemon butterfly	Asian citrus psyllid	Citrus red mite
CRS	55.34	35.60	55.94	57.56
Utlarpar	52.88	36.50	50.62	59.44
Dowdic	59.40	35.90	51.58	59.34
Bagerkhal	55.06	42.70	52.16	60.66
Lamashampur	54.16	36.50	52.78	64.96
LS	NS	NS	NS	NS

LS= Level of significance

possible associations between citrus leafminer and citrus canker disease through future research activities. Effective technologies for the management of Asian citrus psyllid and citrus red mite also need to be developed to solve the increasing pest problems in the Sylhet region.

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REPELLENCY EFFECT OF *ADENANTHERA PAVONINA* (L.) EXTRACTS AGAINST PULSE BEETLE, *CALLOSOBRUCHUS CHINENSIS* L. (BRUCHIDAE)

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ABSTRACT

The leaves, seed and stem bark of *Adenanthera pavonina* (L.) were extracted in different organic solvents namely Petroleum ether, acetone, chloroform and methanol to investigate the repellent activities of *Callosobruchus chinensis* L. (Bruchidae). The extracts from the above solvents showed repellent activities against adult *C. chinensis* at 471.50, 235.75, 117.88, 58.94, and 29.47 $\mu g/cm^2$ on filter paper. All the test extracts offered repellency at 0.01% level of significance except the stem (acetone) extract which was found 0.1% level of significance ($P<0.01$). According to the intensity of repellency the result could be arranged in a descending order: leaf (petroleum ether extract) >leaf (chloroform extract) >seed (methanol extract > stem wood (acetone) extract and in all the cases significant differences were noticed.

Keywords: Extracts, *Adenanthera pavonina*, repellent, *Callosobruchus chinensis.*

INTRODUCTION

Callosobruchus chinensis L. is one of the most damaging pests to the stored grains due to their generalized legume diets and wide distribution (Yanagi *et al*. 2013). It displayd a cosmopolitan distribution pattern and has been spotted in most countries due to the commercial export of beans (Varma & Anadi 2010). The beetle females lay their eggs directly on the surface of the legume singly and hatch after 3-5 days and the new larvae burrow into the bean for the rest of development. The larvae chew tunnels through the bean until it is ready to pupate. Mature adults emerge from the bean, biting a neat circular exit from the pod as soon as 25 days after hatching. The beetles are oligophages and exhibit a high degree of specificity for its growth and development (Mishra *et al*. 2015). They cause both qualitative and quantitative losses. Gujar & Yadav (1978) reported 55-60% loss in seed weight and 45.5-66.3% loss in protein content due to its damage and pulse seeds became unfit for human consumption as well as for planting.

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At present, pest control measures in storage rely on the use of synthetic insecticides and fumigants, which is the quickest and surest method of pest control but it is also not advised to mix the insecticides with food grains. Their indiscriminate use in the storage, however, has led to a number of problems including insect resistance, toxic residues in food grains (Fishwick 1988). In view of these problems together with the up-coming WTO regulations, there is a need to restrict their use globally and implement safe alternatives of conventional insecticides and fumigants to protect stored grains from insect infestations (Subramanyam & Hagstrum 1995). Plant based insecticides were found to be potent candidates for insect control in stored legumes (Rajapakse & Ratnasekera 2008).

Several plant extracts have been reported as effective fumigants and repellent against many stored product pests (Suthisut *et al*. 2011 & Nattudurai *et al*. 1012). *Adenanthera pavonina* (L.) is a medicinal plant. It is commonly called 'Red Lucky Seed' or 'mutual love bean', Rata-chandan.

The plant has medicinal properties. Its uses include food drink, traditional medicine and timber (Bisby 1994). The young leaves can be cooked and eaten. The raw seeds are toxic, but may be eaten when cooked.

In the present study the repellency activity of petroleum ether, acetone, chloroform and methanol extracts of *A. pavonina* seed, leaf and stem were determined against *Callosobruchus chinensis* L.

MATERIALS AND METHODS

The plant *Adenanthera pavonina* were collected from the Rajshahi University campus, Bangladesh. The adult *Callosobruchus chinensis* were collected from the stock culture of infested lentil seeds, (*Lens culinaris*). They were reared at 30 ± 0.5^0C and 70-75% RH) with photoperiod of 12h L: 12h D in the Entomology and Insect Biotechnology Laboratory, Institute of Biological Sciences, University of Rajshahi.

Preparation of extracts: The fresh leaves, seeds and stem woods were individually powdered in a grinder machine. The powdered materials were weighed and placed in separate conical flasks to add sufficient amount of chloroform (500g × 1500ml × 3 times) followed by filtration through What man filter no. 1 paper at 24 h interval. The filtrate was then allowed to vaporize in rotary evaporator until completely dried up. The yield of the extracts of laves, seeds and stem were collected separately. The extracts were poured in to glass vials and preserved in a refrigerator at 4ºC with proper labeling. For each of the samples four solvents have been used separately and successively.

Preparation of doses for the repellency test: All the test extracts of leaves, seed and stem of *A. pavonina* collected in petroleum ether, acetone, chloroform and methanol at dose levels 471.50, 235.75, 117.88, 58.94, and 29.47 µg/cm^2 on filter paper for conduct the repellent activity against adult beetles of *C. chinensis* .

Application of doses for repellency of insects: The repellency test was adopted from the method of Talukder & Howse (1993, 1994). Half filter paper discs (What man No. 40, 9 cm diam.) were prepared and selected doses of all the petroleum ether, acetone, chloroform and methanol extracts separately applied onto each of the half-disc and allowed to dry out as exposed in the air for 10-15 minutes. Each treated half-disc was then attached lengthwise, edge-to-edge, to a control half-disc with adhesive tape and placed in a Petri dish (9 cm diam.), the inner surface of which was smeared with flu on to prevent insects escaping. The orientation of the same was changed in the replica to avoid the effects of any external directional stimulus affecting the distribution of the test insects. Ten adult insects were released in the middle of each filter-paper circle. Each concentration was tested five times. Insects that settled on each half of the filter paper discs were counted after 1 h and then at hourly intervals for 5 h. No significant difference was detected between the repellency of only solvent impregnated and untreated filter papers in tests designed to check for any possible influence of solvents. The average of the counts was converted to percentage repellency (*PR*) using the formula of Talukder & Howse (1993, 1995):

$$PR = 2(C - 50),$$

Where, C is the percentage of insects on the untreated half of the disc. Positive values expressed repellency and negative values for attractant activity.

Reading and analysis of data for repellency test: Repellency was observed for one-hour interval and up to five successive hours of exposure, just by counting the number if insects in the treated and non-treated part of the filter paper spread on the floor of the 90 mm Petri dish. The values in the recorded data were then calculated for percent repellency and then ANOVA.

RESULTS AND DISCUSSION

All the test extracts of seed, leaves and stem of *A. pavonina* collected in petroleum ether, acetone, chloroform and methanol showed repellent activity against adult beetles of *C. chinensis* at dose levels 472.00, 236.0, 118, 59.0, and 30.0 µg/cm^2 on filter paper (Tables, 1, 2, 3 & 4).

Among the tested chloroform extracts all the rest offered repellency at 0.01% level of significance (P<0.001) except the stem (acetone) extract which was found active at 0.1% level of significance (P<0.01). According to the intensity of repellency the result could be arranged in a descending order: leaf (petroleum ether extract) >leaf (chloroform extract) >seed (methanol extract) > stem wood (acetone) extract and in all the cases significant differences.

The petroleum ether extracts of *A. pavonina* leaves were found repellent at 0.1% level of highly significance (P<0.001) against *C. chinensis*. In addition, the stem and seed extracts of the same plant against the same beetles showed repellency at 1% level of significance (P<0.1).

Table 1. Repellency effect of *A. pavonia* seed extracts using different solvents against *C. chinensis* adults (N=50)

Solvents	Conc. (µg/cm^2)	Distribution of adult in treated area/ hour					Percent repulsion % PR=(N_c-5) x 20				
		1	2	3	4	5	1	2	3	4	5
Petroleum ether	472	9.00	8.00	8.00	8.00	7.67	80.00	60.00	60.00	60.00	53.32
	236	8.00	7.67	7.67	8.00	7.33	60.00	53.32	53.32	60.00	46.66
	118	7.33	7.00	6.67	7.00	7.00	46.66	40.00	33.32	40.00	40.00
	59	6.33	6.00	7.33	7.33	7.33	26.66	20.00	46.66	46.66	46.66
	30	6.00	6.67	6.67	6.00	6.33	20.00	33.32	33.32	20.00	26.66
Acetone	472	9.67	9.33	9.00	8.33	9.00	93.32	86.66	80.00	66.66	80.00
	236	9.67	8.33	9.00	8.00	8.67	93.32	66.66	80.00	60.00	73.32
	118	8.33	9.00	9.00	8.67	8.33	66.66	80.00	80.00	73.32	66.66
	59	8.67	7.67	8.00	8.00	8.00	73.32	53.32	60.00	60.00	60.00
	30	8.00	7.67	8.00	7.00	7.33	60.00	53.32	60.00	40.00	46.66
Chloroform	472	7.00	7.67	8.00	8.00	7.33	40.00	53.32	60.00	60.00	46.66
	236	6.67	6.67	7.33	6.33	7.33	33.32	33.32	46.66	26.66	40.00
	118	6.00	6.67	6.67	6.33	6.67	20.00	33.32	33.32	26.66	33.32
	59	6.67	6.67	6.67	6.33	6.67	33.32	33.32	33.32	26.56	33.32
	30	6.67	6.33	6.00	6.33	6.33	33.32	26.66	20.00	26.6	26.66
Methanol	472	9.33	9.00	9.33	9.00	9.00	86.66	80.00	86.66	80.00	80.0
	236	9.00	8.0	8.67	8.33	8.67	80.00	60.0	73.32	66.66	73.32
	118	8.00	7.67	7.0	8.00	8.00	60.00	53.32	40.0	60.00	60.00
	59	7.33	7.67	7.00	7.67	7.00	46.66	53.32	40.00	53.32	40.00
	30	7.00	7.33	6.67	7.00	6.67	40.00	46.66	33.32	40.00	33.32

Table 2. Repellency effect of A. *pavonina* leaf extracts using different solvents against *C. chinensis* adults (N=50)

Solvents	Conc. (µg/cm^2)	Distribution of adult in treated area/hour					Percent repulsion % PR=(N_c-5) x 20				
		1	2	3	4	5	1	2	3	4	5
	472	9.67	10.0	9.67	9.33	9.67	93.32	100.0	93.32	86.66	93.32
Petroleum	236	9.00	9.33	9.33	9.00	9.00	80.00	86.66	86.66	80.00	80.00
ether	118	8.00	8.33	9.00	7.67	7.67	60.00	66.66	80.00	53.32	53.32
	59	7.33	7.00	7.67	7.67	7.00	46.66	40.00	53.32	53.32	40.00
	30	7.33	7.33	7.00	7.67	7.33	46.66	46.66	40.00	53.32	46.66
	472	9.00	9.00	9.00	8.67	9.00	80.00	80.00	80.66	73.32	80.00
	236	8.67	7.33	8.00	8.00	8.33	73.32	46.66	60.00	60.00	66.66
Acetone	118	7.00	7.67	7.67	6.00	6.66	40.00	53.32	53.32	20.00	33.32
	59	7.0	6.00	6.33	6.67	5.67	40.0	20.00	26.66	33.32	13.32
	30	6.0	6.33	6.33	5.67	6.00	20.0	26.66	26.66	13.32	20.00
	472	8.00	7.33	7.67	8.0	7.33	60.00	46.66	53.32	60.0	46.66
	236	6.67	6.67	6.67	6.33	6.67	33.32	33.32	33.32	26.66	33.32
Chloroform	118	6.00	5.67	5.67	6.00	5.67	20.00	13.32	13.32	20.00	13.32
	59	5.33	6.00	5.33	5.33	6.00	6.66	20.00	6.66	6.66	20.00
	30	5.33	5.67	5.67	5.33	5.33	6.66	13.32	13.32	6.66	6.66
	472	7.00	6.67	7.0	6.0	6.00	40.00	33.32	40.0	20.0	20.00
	236	5.33	5.67	6.0	7.00	6.0	6.66	13.32	20.0	40.00	20.0
Methanol	118	6.00	6.00	5.67	6.00	5.67	20.00	20.0	13.32	20.00	13.32
	59	5.33	5.67	5.33	5.33	5.67	6.66	13.32	6.66	6.66	13.32
	30	5.67	5.33	5.33	5.67	5.33	13.32	6.66	6.66	13.32	6.66

Table 3. Repellency effect of *A. pavonina* stem extracts using different solvents against *C. chinensis* adults (N=50)

Solvents	Conc. (µg/cm^2)	Distribution of adult in treated area/hour					Percent repulsion % PR=(N_c-5) x 20				
		1	2	3	4	5	1	2	3	4	5
	472	5.67	6.0	6.0	6.33	6.67	13.32	20.0	20.00	26.66	33.32
Petroleum	236	5.00	6.00	6.0	6.33	6.0	00.0	20.00	20.0	26.66	20.0
ether	118	5.33	5.67	4.33	5.33	6.0	6.66	13.32	-13.34	6.66	20.00
	59	5.0	4.67	5.67	5.33	4.00	0.0	-6.66	13.32	6.66	-20.0
	30	4.33	5.33	5.00	5.33	4.33	-13.34	6.6	0.0	6.6	-13.34
	472	6.0	5.33	5.33	6.0	5.33	20.0	6.66	6.66	20.00	6.66
	236	5.33	5.67	6.67	5.33	5.67	6.66	13.32	33.32	6.66	13.32
Acetone	118	5.67	5.33	4.67	5.67	6.00	13.32	6.66	-6.68	13.32	20.0
	59	5.33	5.67	5.33	6.00	5.33	6.66	13.32	6.66	20.00	6.66
	30	5.67	5.00	5.33	5.67	5.67	13.32	0.0	6.6	13.32	13.32
	472	8.00	6.0	7.00	7.0	6.33	60.00	20.0	40.00	40.0	26.66
	236	6.33	6.0	6.33	5.33	6.00	26.66	20.0	26.66	6.6	20.00
Chloroform	118	5.33	6.00	5.67	5.33	5.00	6.66	20.00	13.32	6.66	0.0
	59	6.00	5.67	5.33	6.00	5.67	20.00	13.32	6.66	20.00	13.32
	30	5.33	6.0	5.33	5.67	6.0	6.66	20.0	6.66	13.32	20.0
	472	6.67	6.00	5.33	6.33	5.67	33.32	20.00	6.66	26.66	13.32
	236	5.67	6.00	5.33	5.67	5.33	13.32	20.0	6.66	13.32	6.66
Methanol	118	5.33	6.33	5.67	5.33	5.67	6.66	26.66	13.32	6.66	13.32
	59	5.67	5.33	5.67	5.33	5.00	13.32	6.66	13.32	6.66	0.0
	30	5.33	5.67	4.67	4.33	5.33	6.66	13.32	-6.68	-13.34	6.66

Table 4. ANOVA results of repellent action of *A. pavonina* extracts against *Collosobrachus chinensis* by contact

Plant parts	Extracts	Factors	F-value	P-value (df=4)
	Petroleum ether	Concentrations	11.155**	0.00016
		Exposure Time	0.26	0.898
	Acetone	Concentrations	10.77**	0.00019
Seed		Exposure Time	3.867	0.022
	Chloroform	Concentrations	11.481**	0.00013
		Exposure Time	0.771	0.559
	Methanol	Concentrations	36.69**	7.16
		Exposure Time	0.969	0.451
	Petroleum ether	Concentrations	39.861***	3.96
		Exposure Time	1.1756	0.3585
Leaf	Acetone	Concentrations	32.042***	1.87
		Exposure Time	1.241	0.333
	Chloroform	Concentrations	38.786***	4.81
		Exposure Time	0.1344	0.967
	Methanol	Concentrations	5.993**	0.0038
		Exposure Time	0.229	0.917
	Petroleum ether	Concentrations	3.621**	0.0276
		Exposure Time	0.939	0.0466
Stem bark	Acetone	Concentrations	0.438*	0.778
		Exposure Time	0.72	0.591
	Chloroform	Concentrations	5.191**	0.007
		Exposure Time	0.458	0.765
	Methanol	Concentrations	3.5139**	0.031
		Exposure Time	1.514	0.245

Note: *** = Highly significant, ** =Significant

Discussion

Repellency by the petroleum ether, acetone, chloroform, and methanol extracts of *A. pavonina* against *C. chinensis* adults was very much promising, while all the extracts found to repel at 0.01% level of significance (P<0.001) except the stem (acetone) extract which was found active at 0.1% level of significance (P<0.01). The repellency record triggers a hope for the use of *A. pavonina* extracts as repellents since most of the extracts repelled the beetles significantly. These results are in agreement with similar works of Talukder & Howse (1995) and Nattudurai *et al*. (2012). Janlaor & Auamcharcen (2015) investigated laboratory bioassys of crude extracts of *A. pavonina* seeds against *Sitophilus zeamais* Motschulsky adults extracted with different organic solvents (hexane, dichloromethane, methanol) at room temperature and found that hexane crude extract at 7% (v/v) concentration and dichloromethane crude extract at 3% (w/v) concentration indicated the highest efficiency to repel *S. zeamais* adult with maximum repellency of 80% at hour 4 and hour 3 and 5 after treatment. Fumigant toxicity and repellent activity of *Toddalia asiatica* (L.) Lam.

(Rutaceae) leaf and fruit extracts were screened against *Callosobruchus maculatus* (F.), *Sitophilus oryzae* (L.) and *Tribolium castaneum* (Herbst) adults by Nattidurai *et al* (2012). All the solvent extracts of leaf and fruits recorded mortality and repellency against the tested insects in a concentration dependent manner. *Callosobruchus maculatus* was the most susceptible pest to the treatments. Lethal concentrations for 50% mortality (LC_{50}) of *Callosobruchus maculatus*, *S. oryzae* and *T. castaneum* were recorded as 39.19, 44.13 and 61.10 µl 1^{-1} respectively. Diethyl ether fruit extract exhibiting 100% repellent activity against *Callosobruchus maculatus* and *S. oryzae* and 92% against *T. castaneum* adults at 20 µl concentration. These results suggested that Diethyl ether fruit extract of *T. asiatica* can be used as an ecofriendly fumigant and repellent against *Callosobruchus maculatus*, *S. oryzae* and *T. castaneum*. Abdullah *et al*. (2011) assessed the mortality and repellency of the chloroform extracts of different parts of *Urena sinuate* on *T. castaneum* adults and found that the root and stem extracts showed significant repellent effect on the beetles but the fruit and leaf extracts produced no repellency at all. Mondal *et al*. (2011) assessed the repellent activity of *Derris indica* extracts against *T. castaneum* adults. They found that fruit shell, leaves, seed and stem bark extracts showed repellent activity.

The antioxidant activity of herbal extract is due to various biochemicals, which act as inhibitors of the process of oxidation, and thus have diverse physiological role in the body. Antioxidant activities of crude extracts were determined using DPPH radical Spectrophotometer assay using α-tocopherol (Roberta *et al*. 2006). The free radicals are in those molecules/atoms that possess an unpaired electron in their outermost orbit, which is capable of inducing chain reaction and thereby damaging different types of cells, resulting into accelerated aging, various diseases, stress, and also hampering the defense mechanisms of the body.

The present study indicated that the repellent effects of *A. pavonina* extracts on the adult beetles, *C. chinensis* and the plant indicated the potentiality for the management of the pest.

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Scientific Note

FIRST RECORD OF THE TARO HORN WORM, *THERETRA OLDENLANDIAE* ON PANIKACHU (*COLOCASIA ESCULENTA*) IN BANGLADESH

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Panikachu (*Colocasia esculenta*) is one of the most important tuber crops commercially grown in all parts of the country. The crop has good potential for production in the wet season and can survive a certain period in flood water. It is a good source of carbohydrate and other nutrients, supplementing a diet that tends to be deficient during this particular period. The whole plant of panikachu including leaves, petioles, stolon and rhizomes are edible (Saha and Hussain 1983). Among the insect pests infesting Panikachu, leaf hopper, *Amrasca biguttula biguttula* Ishida; aphid, *Aphis gossypii* Glover; leaf roller, *Tetranychus* spp. and common cutworm, *Spodoptera litura* are reported earlier.

In the study of integrated management of common cutworm in aroid during 2014-15, a new insect, Taro horn worm (*Theretra oldenlandiae*) appeared on leaves in Panikachu at Patabuka, Panchbibi, Joypurhat (N $25^0$10.095 E $89^0$01.001). The population was observed in the last week of March, 2015.The full grown caterpillars were then brought to the laboratory; reared and observed their feeding, pupal period and adult morphology.

The caterpillars are voracious feeder, chew the edges of the leaves (Fig. 1). The mature larvae are black in colour with yellow bands down its body, with seven pairs round eye spots from metathorax to the 6^{th} abdominal segment (Fig. 2). The caterpillars have a thin black spine at the end of the abdomen that has a white tip (Fig. 3). The thin horn is movable in a vertical plane in all instars. There are five larval instars (He Jiaqing and Shi Zhonghui 1995). Before pupation the caterpillar will reach a length of 7.5 cm, width 0.7 cm. In the laboratory the caterpillars made a chamber by two leaves and pupate within it (Fig. 4). Pre-pupal and pupal period was 2 and 13 days, respectively. The pupa has a length of 4.2 cm, width 0.9 cm. Colour pale yellowish-brown, abdomen dotted with black (Fig. 5, 6). The adult

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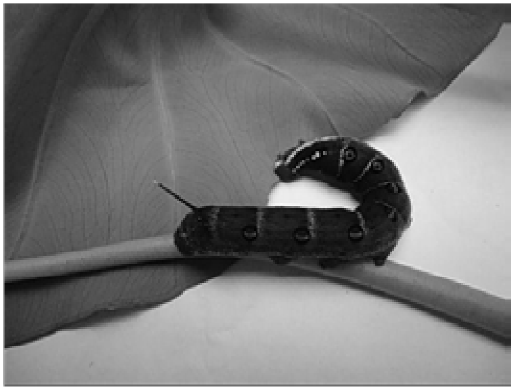

Fig. 1. Voracious caterpillar of *Theretra oldenlandiae* chew the edge of the leaf

Fig. 2. Showing 7 pairs of eye spots on larvae of *Theretra oldenlandiae* from metathorax to 6th abdominal segment

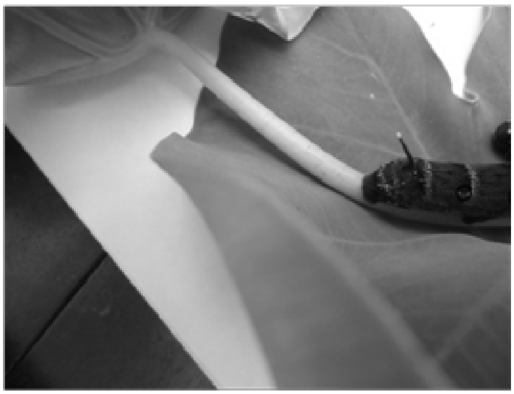

Fig. 3. *Theretra oldenlandiae* caterpillar with thin black spine at abdominal end having white tip

Fig. 4. *Theretra oldenlandiae* caterpillar making chamber with 2 leaves and pupate within

Fig. 5 & 6. *Theretra oldenlandiae* pupa color yellowish brown, abdomen dotted with black

Fig. 7 & 8. Greyish brown *Theretra oldenlandiae* adult with broad white stripe on fore wings, abdomen greyish brown with a double-silvery-white dorsal stripe

is greyish brown except a broad white stripe on fore wings, abdomen greyish-brown with a double silvery-white dorsal stripe (Fig. 7,8). They are night flyers, but sometimes can also be found in the daytime. The species has a good adaptive and migratory ability, and inhabits at the edge of forests, open shrubs, fruit yards and flower gardens (Holloway 1987). The species is median sized hawk-moth, has a wingspan of 60-74 mm. The moth is often found to feed on flowers at dusk (Bell & Scott 1937).

Theretra oldenlandiae is found on a wide range of hosts like *Alocasia, Amorphophallus, Arisaema, Caladium, Colocasia, Cryptocoryne, Pinellia, Typhonia, Zantedeschia* (Araceae); *Impatiens* (Balsaminaceae); *Careya, Planchonia* (Barringtoniaceae); *Clystostoma* (Bignoniaceae); *Ipomoea* (Convolvulaceae); *Hibbertia* (Dilleniaceae); *Clarkia, Epilobium, Fuchsia, Ludwigia* (Onagraceae); *Coelospermum, Oldenlandia, Pentas, Richardia* (Rubiaceae); *Ampelocissus, Ampelopsis, Cayratia, Cissus, Vitis* (Vitidaceae) (Bell & Scott 1937, Pholboon 1965, Miyata 1983, Moulds 1981, 1984). Occasionally the larvae are considered as minor pest to agricultural or horticultural plants such as taros and impatiens. But extensive defoliation of vineyards leads to the total loss of the crop.The adults have an important role as pollinators of many plant species.

Surveying fields weekly and handpicking caterpillars is usually an effective means of control. Adult moths are night flying, and is also attracted by light (Bell & Scott 1937). Carbaryl or chlorpyrifos used to control the pest. Dichlorvos or Dipterex is also very effective in controlling small larvae (He Jiaqing and Shi Zhonghui 1995). *Charopshersei* Gupta & aheshwary was observed parasitizing larvae of *Theretra oldenlandiae* (*Hippotion oldenlandiae*) at Trivandrum, Kerala, India. The life cycle of the ichneumonid lasted 22-27 days, with field parasitization rates of 6-10% (Palaniswami and Pillai 1983).

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Scientific Note

A NEWLY RECORDED SPIDER OF THE GENUS *CROSSOPRIZA* SIMON FROM BANGLADESH (ARANEAE : PHOLCIDAE)

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A newly recorded spider of the genus *Crossopriza* Simon namely – *C. lyoni* (Blackwall) is described. The species is cosmopolitan and recorded for the first time from Khulna, Bangladesh. Generic diagnosis, description together with the distribution of the species are provided herewith.

Keywords : New record, *Crossopriza,* Araneae, Pholcidae, Bangladesh.

The pholcids (family Pholcidae) are commonly known as 'dady long-legged spiders'. It is one of the most fascinating group of orb-weaving spiders in the houses and gardens of the tropics. Spiders of the genus *Crossopriza* Simon are common members of the Indian sub-continent and received serious attention since Pocock (1900) as one of the important predators of mosquitoes and flies of the houses and gardens. The genus *Crossopriza* was first irrected by Simon in 1890 with the type-species *Artema pristina* Simon and till date are represented by only 7 (seven) species worldwide (World spider catalog 2016, Kim 1988, Huber *et al.* 1999, Irie 2001, Bauer *et al.* 2016, Yao & Li 2013, Yao *et al.* 2012, 2016). In Indian sub-continent the genus contains only 1 (one) species but there is no distributional record of its in Bangladesh (Silwal*et al.*2005, Keswani*et al.* 2012, Sen *et al.* 2015, Chowdhury & Nagari 1981, Chowdhury & Pal 1984, Biswas *et al.* 1993, Okuma *et al.* 1993, Begum & Biswas 1997). The present paper contains descriptiuon of the species *C. lyoni* (Blackwall) together with the generic diagnosis and distribution.

Collection and preservation: Specimens of pholcid spiders were collected from the webs by hand in vials by jarking the branches of shrubs and small plants on the clothes and inverted umbrella as described by Kaston (1972) and Tikader (1987). The collected specimens were anesthesized in a killing jar and then transferred to a Petridish filled with 70% alcohol for sorting and were then transferred to a petridish filled with 70% alcohol for relaxation of body muscles (Chowdhury & Nagari 1981). The specimens were then preserved in 70% alcohol (single specimen in

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single vial) temporarily for further study. After study, the specimens were preserved permanently in ' Audmans preservatives' (90 parts 70% alcohol + 5 parts glycerine + 5 parts glacial acetic acid). Preservation and other necessary techniches were followed by Lincoln and Sheals (1985) and Tikader (1987).

Identificationand Illustration: A detailed taxonomic study including identification was done based on various relevant literatures of home and abroad. Finallly, identity of the species were confirmed from 'the Zoological Survey of India', Kolkata. Drawings, measurements and other necessary works were done by Cameralucida fitted with Stereo Binocular Microscope. Measurements of different body parts were taken in millimeters (mm) by stage micrometer.

Type-preservation: The types are at present in the collection of the Department of Zoology, Khulna Government College, Khulna and will be preserved in the Museum of the Department of Zoology, University of Dhaka, Dhaka-1000, Bangladesh in due course.

Taxonomic account

Family : PHOLCIDAE C.L. Koch, 1851
Genus : *Crossopriza* Simon, 1890
Type-species : *Artema pristina* Simon

1893. *Crossopriza*	:	Simon, *Hist. Nat. Araign*., **1** : 476.
1900. *Crossopriza*	:	Pocock, *The Fauna Brit. India, Arachn*. : 240.
1942. *Crossopriza*	:	Roewer, *Catalogue der Araneae*, **1** : 334.
1981. *Crossopriza*	:	Tikader & Biswas, *Rec. zool. Surv. India*, Occ. pap.**30** : 18.
1986. *Crossopriza*	:	Yaginuma, *Spiders of Japan in colour* : 31.
1991. *Crossopriza*	:	Chen & Zhang, Fauna of Zhejiang, Araneida : 72.
1997. *Crossopriza*	:	Platnick, Advances in Spider Taxonomy : 189.
1999. *Crossopriza*	:	Song et al. The spiders of China : 52.
2005. *Crossopriza*	:	Majumder, *Mem. Zool. Surv. India*, **20**(1): 32.
2009. *Crossopriza*	:	Biswas : In Ahmed (ed.) *Flora & Fauna of Bangladesh, Arachn*. **18** (1): 257.
2016. *Crossopriza*	:	Platnick*, World spider catalog*, version 16.0, online at http ://research. amnh.org./entology/spiders/catalog /index. html.

Diagnosis : Spiders of this genus are small to medium in size. Chelicerae short, fused basally, depressed at the inner margin and each provided with an apical tooth. Eyes

8 (eight) in number, variably arranged; anterior row recurved, narrowly spaced. Maxillae and labium short and small. Sternum broadly truncated posteriorly. Legs extremely long and thin with long tarsi. Abdomen slightly ovate, abruptly declined, posteriorly raised, much above spinnerets.

Biological note: These spiders are commonly observed in the houses and dark places of garden, forests etc. They found to build irregular webs in hollow trees beneath the over hanging rocks and in the houses on which they hang directing upward. The females were seen to carry the cocoons in her mandibles. They found to predate on mosquitoes and flies in the houses and gardens.

Distribution : ASIA; EGYPT; EUROPE; NEW GUINEA.

***Crossopriza lyoni* (Blackwall)** (Figs. 1, a-g)

1867. Crossopriza lyoni	*:*	Blackwall, *Ann. Mag. Nat. Hist.,* **19** (3) : 302.
1900. *Crossopriza lyoni*	:	Pocock, *Fauna of Brit. India, Arach*., : 240.
1942. *Crossopriza lyoni*	:	Roewer, *Catalogue der Araneae*, **1** : 334.
1981. *Crossopriza lyoni*	:	Tikader & Biswas, *Rec. zool. Surv. India*, occ.pap. **30** : 18.
1986. *Crossopriza lyoni*	:	Yaginuma, *Spiders of Japan in colour* : 31.
1991. *Crossopriza lyoni*	:	Chen & Zhang, *Fauna of Zhejiang, Araneida*: 72.
1997. *Crossopriza lyoni*	:	Platnick, *Advances in Spider Taxonomy* : 189.
1999. *Crossopriza lyoni*	:	Song *et al.The Spiders of China* : 52.
2005. *Crossopriza lyoni*	:	Majumder, *Mem. Zool. Surv. India,* **20** (3): 41.
2009. *Crossopriza lyoni*	:	Biswas : In Ahmed (ed.) *Flora & Fauna of Bangladesh, Arach*. **18**(1):257.
2016. *Crossopriza lyoni*	:	Platnick, *World Spider Catalog,* version 16.0, online at http://amnh. org./iz/spiders/ catalog/INTRO/html.

Material examined: Two females, Jhenidah, 25.III.1990 , Coll. V. Biswas; One female, Magura, 12.IV.1992, Coll. V. Biswas ; One female, Noakhali, 5.IV.1993, Coll. V. Biswas; Two females, Potuakhali, 14.X.199, Coll. V. Biswas ; Two females, Rajshahi, 2.III. 1992, Coll. V. Biswas ; One female, Tangail, 1.IV.1993, Coll. V. Biswas.

General: Cephalothorax and legs dark brown or black ; abdomen brown without any distinct marking or decoration. Total body length (female) 4.70 mm. Carapace 1.60 mm long, 2.10 mm wide ; abdomen 3.10 mm long and 2.55 mm wide.

Cephalothorax: Nearly rounded, wide medially, anteriorly narrowed and with pointed tip; cephalic region raised (Fig. 1a). Eyes brownish, dissimilar, anteromedians smaller, otherwise all the eyes larger and ringed with black basal band; both anteriorland posterior row of eyes recurved; abdomen rounded (Fig. 1b); thoracic region broad and flat. Chelicerae brown, robust, outer margin with 1 tooth (Fig. 1c). Maxillae brown, longer than wide, medially constricted, scopulate anteriorly (Fig. 1d). Labium brown, anteriorly scopulate (Fig. 1d). Sternum brown, rounded, both anterior and posterior margins concave (Fig. 1e). epigynum present (Fig. f). Legs very long and slender, with sharp spines; leg formula 1423 and the measurements (in mm) of different segments are shown in Table-1.

Abdomen: Broad, nearly pear-like, medially wide, posteriorly narrowed ; dorsum without any decoration ; epigynum tongue like and internal genitalia is bean shaped sac (figs. 1f-g). Spinnerets blunt, spoon-shaped (Fig. 1b).

Distribution : BANGLADESH : Jhenidah, Magura, Noakhali, Potuakhali, Rajshahi, Tangail; MYANMAR ; INDIA (Tikader & Biswas 1981).

So far consulted, the taxonomic records on pholcid spiders of Bangladesh (Pocock 1900, Chowdhury & Nagari 1981, Chowdhury & Pal 1984, Okuma *et al.* 1993, Biswas *et al.* 1993, Begum & Biswas 1997), it is found that the studied species *Crossopriza lyoni* (Blackwall) is a new record for the area of present study although it is described earlier in different countries (Majumder 2005, Yaginuma 1986, Chen & Zhang 1991, Song *et al.* 1999, Huber 2000, Yao & Li 2013) of the world and variable in different characters viz. colour, shape, size and decoration with the present one.

Table 1. Measurements (mm) of leg segments of *Crossopriza lyoni* (Blackwall)

Leg	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
I	12.00/12.00	0.80/0.80	9.00/9.00	7.00/7.00	2.00/2.00	30.80/30.80
II	12.00/12.00	0.70/0.70	9.00/9.00	6.00/6.00	1.30/1.30	29.00/29.00
III	10.00/10.00	0.50/0.50	8.00/8.00	5.00/5.00	1.00/1.00	24.50/24.50
IV	12.00/12.00	0.60/0.60	9.00/9.00	6.00/6.00	1.90/1.90	29.50/29.50

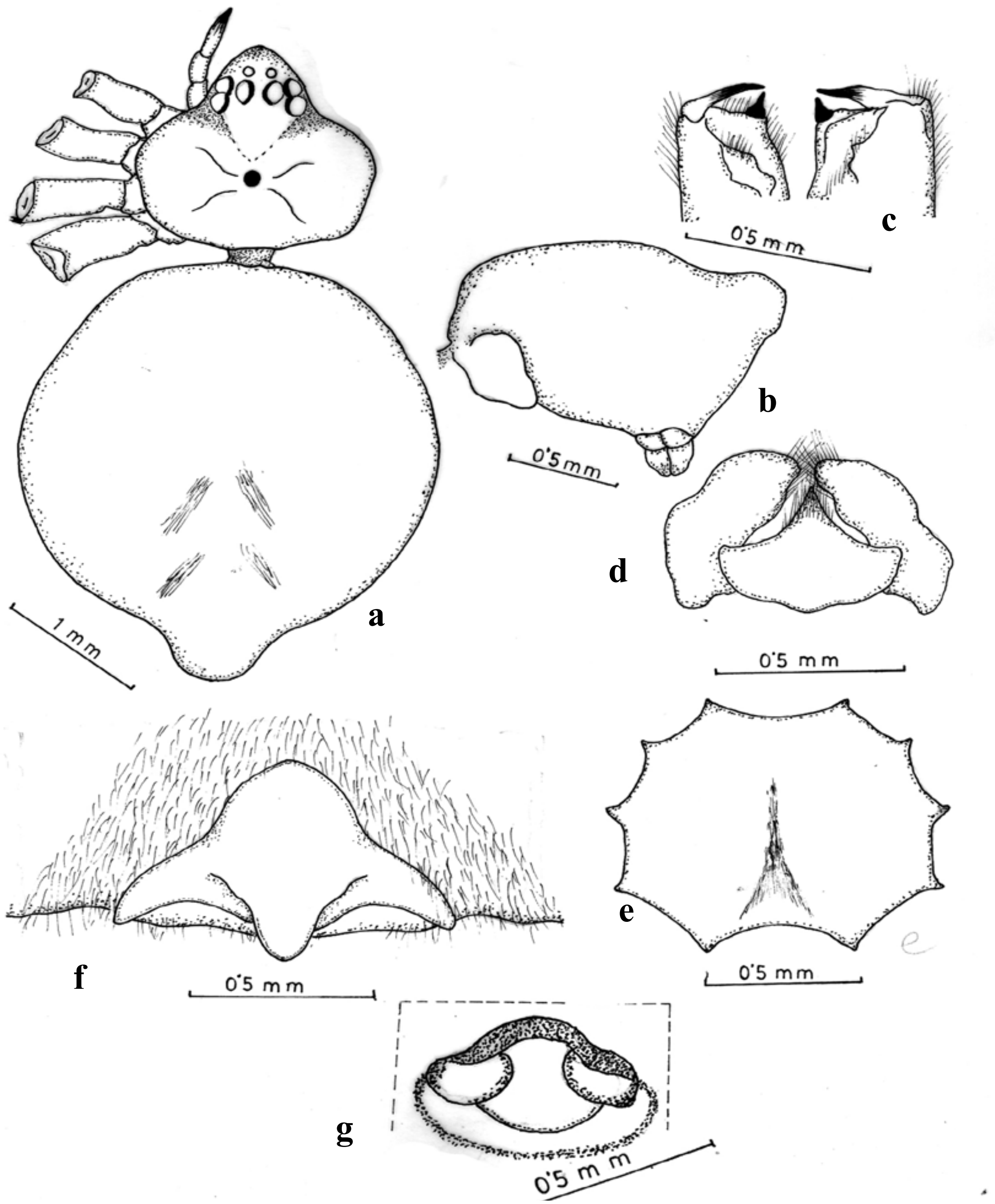

Fig. 1. *Crossopriza lyoni* (Blackwall) a. Whole body (dorsal view); b. Abdomen (lateral view); c. Chelicerae; d. Maxillae & labium; e. Sternum; f. Epigynum; g. Internal genitalia

Present species is found to spin typical geometric webs in the dark places of the houses, garden and forests. Small kinds of pest insects (like – mosquitoes, flies etc.) entangle on the webs and they catch the preys from there and thus they help in the biological control of insect pests in nature.

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