Journal of

# Entomology

ISSN 1812-5670

Academic
Journals Inc.

www.academicjournals.com

Journal of Entomology 9 (6): 332-342, 2012
ISSN 1812-5670 / DOI: 10.3923/je.2012.332.342


# Bioefficacy of *Clerodendrum phlomidis* Linn. f. and *Flueggea leucopyrus* (Koen.) Willd. against *Earias vittella* Fab.

C. Muthu, K. Baskar, S. Kingsley and S. Ignacimuthu
Entomology Research Institute, Loyola College, Chennai-600 034, India

*Corresponding Author: C. Muthu, Entomology Research Institute, Loyola College, Chennai-600 034, India*

## ABSTRACT

Antifeedant and larvicidal activities of hexane, chloroform and ethyl acetate extracts of *Clerodendrum phlomidis* and *Flueggea leucopyrus* at 5, 2.5, 1.0 and 0.5% were studied against III instar larvae of *Earias vittella*. Hexane extract of *F. leucopyrus* and chloroform extract of *C. phlomidis* showed maximum antifeedant activity of 81.00 and 80.48%, respectively at 5% concentration. The least $LC_{50}$ and $LC_{90}$ values of 1.21 and 1.36% for hexane extract of *F. leucopyrus* and 4.96 and 5.11% for chloroform extract of *C. phlomidis*, respectively. Cent percent larvicidal activity was observed in chloroform extract of *C. phlomidis* at 5% concentration, while hexane extract of *F. leucopyrus* recorded at 87.52 and 5% concentration. The $LC_{50}$ and $LC_{90}$ values for larvicidal activity ware 0.51 and 1.74% for chloroform extract of *C. phlomidis* and 1.74 and 4.69% for hexane extract of *F. leucopyrus*, respectively. No adult emergence was observed at all concentrations of *C. phlomidis* chloroform extract and at 5 and 2.5% concentrations of *F. leucopyrus* hexane extract. The chi-square values for both antifeedant and larvicidal activities were significant. The results clearly indicated that chloroform extract of *C. phlomidis* and hexane extract of *F. leucopyrus* could be exploited to develop a new pesticidal formulation for eco-friendly pest management.

**Key words:** Antifeedant, larvicidal, adult emergence, *Clerodendrum phlomidis*, *Earias vittella*, *Flueggea leucopyrus*

## INTRODUCTION

Since the beginning of agriculture, insect control has been a challenging task for human race. With the advent of chemical pesticides, especially the chlorinated hydrocarbons, the pests problem was controlled to a certain extent and it was thought that the pest problem was solved. But soon it was realized that the pests had developed resistance to these chemicals; besides they increase the cost of application, leaving toxic residues and polluting the environment (Ahmed *et al*., 1981; Ali and Rizvi, 2008; Iyengar, 2010). Excessive application of these pesticides promotes speedier evolution of insect pests, destroys natural enemies, turns formerly harmless species into pests, affect other non-target species and contaminates food and feed (WCS, 1980). Bami (1997) estimated that hardly 0.1% of the agrochemicals used in crop protection reaches the target pests and the remaining 99.9% enter the environment and causes hazards to non-target organisms.

Fox *et al*. (2007) observed that most of the chemical insecticides containing pentachlorophenol (PCP) caused the strongest inhibition for symbiotic nitrogen fixation, resulting in the lowest plant yields and also affecting the seed germination. Pesticide residues are found in commercially grown fruits and vegetables causing Attention Deficit Hyper Activity Disorder (ADHD) in children when consumed (Bouchard *et al*., 2010). Hence, a search for alternate techniques for the management of insect pests is needed.

Natural derivatives exhibited biological activities of feeding deterrence, insecticidal and growth inhibitors against variety of agricultural pests (Muthu *et al*., 2010b; Baskar and Ignacimuthu, 2012a, b; Jeyasankar *et al*., 2012; Pavunraj *et al*., 2012). The use of locally available plants in the control of pests is an ancient technology in many parts of the world (Roy *et al*., 2005). The plant natural resource is not only documented in terms of the number of unique species and their medicinal use but also in terms of depth of the traditional knowledge base about the uses for human, veterinary health care and crop protection (Ved and Goraya, 2008). Prior to the discovery of organochlorine and organophosphate insecticides in the late 1930s and early 1940s, botanical insecticides were important products for pest management in industrialised countries (Isman, 1997). According to Isman (2008), botanical pesticides are useful for consumers and farmers not only due to economic considerations and potential health benefits but also for their naturalness. Plants are gifted with a potential to produce a range of secondary metabolites like alkaloids, terpenoids, flavonoids, phenols, glycosides, sitosterols and tannins. These phytochemicals are known to protect the plants from the attack of insect-pests (Ahmad, 2007).

The shoot and fruit borer, *Earias vittella* Fabricius (Lepidoptera: Noctuidae) is a notorious noctuid pest belonging to the order Lepidoptera causing more than 50% loss in cotton and okra crops (Mahapatro and Gupta, 1998) and 69% on okra alone (Rawat and Sahu, 1973) in various parts of India. With a view to control this pest, two medicinal plants namely, *Clerodendrum phlomidis* Linn. F. (Lamiaceae) and *Flueggea leucopyrus* (Koen.) Willd (Euphorbiaceae), were selected for this study. Traditionally, these plants have been used to treat many diseases. Juice of leaf and root from *C. phlomidis* are used for the treatment of rheumatism, asthma and other inflammatory diseases. It is used to treat diabetes, hypertension and as sedative (Mishra, 2003; Sankaranarayanan *et al*., 2010). Juice of leaves is alterative and given in neglected syphilitic complaints (Shafi *et al*., 2001). Previous studies showed that *C. phlomidis* (*Clerodendrum multiflorum)* was used as herbal pesticide particularly for insect pests like aphids and red hairy caterpillar (Upadhyay *et al*., 2002; Bharvad, 2005). Leaf extracts of this plant were used as grain protectant (Charpot, 1998) and to control *Heliothis* sp. (Gandhi, 1998).

Paste of *F. leucopyrus* leaves mixed with tobacco is used to destroy worms in sores (Solangaarachchi and Perera, 1993). It is used as fish poison. The leaves were boiled and taken orally twice a day for stomachache (Suresh *et al*., 2011). According to the available literature, no work has been reported against insect pests for these plants. Hence, this study was aimed to assess the bioefficacy of the extracts of *C. phlomidis* and *F. leucopyrus* against *E. vittella*.

## MATERIALS AND METHODS

**Collection and extraction of crude extracts:** The leaves of *Clerodendrum phlomidis* were collected from Coimbatore during the month of May, 2008 and the leaves of *Flueggea leucopyrus* were collected from foot hills of Tirisulam hills of Kancheepuram district of Tamil Nadu during May to July 2008. They were authenticated at the Department of Plant Biology and Biotechnology, Loyola College, Chennai and were deposited in the Herbarium of Entomology Research Institute, Loyola College, Chennai (*C. phlomidis*-ERICM-2 and *F. leucopyrus*-ERICM-3). They were shade dried at room temperature and powdered coarsely. The powders (1.0 kg) were soaked individually and sequentially with hexane, chloroform and ethyl acetate for a period of 48 h with intermittent shaking and the extracts were filtered through a Buchner funnel with Whatman No. 1 filter paper. The extracts were concentrated at reduced temperature using rotary evaporator and stored at 4°C in a refrigerator until use.

**Rearing of *Earias vittella*:** Larvae of *E. vittella* were collected from Thandalam village near Thirupporur, Kancheepuram district of Tamil Nadu and were reared on glass jars (21×15 cm) fed with bhendi fruits until pupation in the laboratory condition (27±2°C and 75±5% relative humidity). After pupation, the pupae (cocoon) were collected, kept in different glass jars covered with white muslin cloth. After the emergence of the adults (8-10 days), they were fed with 10% honey solution absorbed in cotton swabs inside glass jars. Muslin cloth was provided as an oviposition substrate. The eggs laid were kept in a glass jar covered with muslin cloth for hatching. After hatching the larvae were fed with tender leaves of bhendi in the neonate stage; after that they were fed with bhendi fruit.

**Antifeedant activity:** Antifeedant activity of the crude extracts of *C. phlomidis* and *F. leucopyrus* was studied using fruit disc no choice method (Isman *et al*., 1990). Fresh bhendi fruit discs of 10 mm thickness were used for this study. The bhendi fruit discs were dipped individually in 0.5, 1.0, 2.5 and 5.0% concentrations of crude extracts. The fruit discs dipped in acetone+Tween 80 were used as negative control since it was used to dissolve the crude extracts. In each plastic petri dish (1.5×9 cm) wet filter paper was placed to avoid early drying of the test materials and three third instar larvae were introduced into each petri dish containing five discs of bhendi fruit. Five replicates were maintained for each treatment with 15 larvae per replicate (total n = 75).

Progressive consumption of the fruit discs consumed by *E. vittella* larvae was observed. After 24 h, the fruit discs were weighed using Mettler digital balance and the difference between initial and final weights was calculated. Real consumption was calculated as follows:

$$\text{Weight loss due to desiccation (D)} = \text{Initial weight-Final weight}$$

$$\text{Real consumption} = \text{Initial weight-(Final weight+D)}$$

The experiment was conducted at laboratory condition (27±2°C) with 14:10 light and dark photoperiod and 75±5% relative humidity. Antifeedant activity was calculated according to the formula of Bentley *et al*. (1984):

$$\text{Antifeedant activity} = \frac{\text{Consumption in control} - \text{Consumtion in treated}}{\text{Consumtion in control}} \times 100$$

**Larvicidal bioassay:** Larvicidal activity was studied using fruit disc no choice method (Isman *et al*., 1990). Bhendi fruit discs (*Abelmoschus esculentus*) were dipped in different concentrations of crude extracts, placed in petri dishes and the larvae were introduced as in the antifeedant experiment. After 24 h treatment the larvae were continuously maintained on the untreated fresh bhendi fruits. Diet was changed every 24 h. Larval mortality was recorded up to

96 h of treatment. The number of larvae, replicates used and the laboratory conditions were the same as in antifeedant experiment. Percent mortality was calculated using Abbott's formula (Abbott, 1925):

$$\text{Abbott corrected mortality} = \frac{\text{Mortality in treatment (\%)-Mortality in control (\%)}}{\text{100-Mortality in control (\%)}} \times 100$$

**Adult emergence:** The treated larvae were maintained for adult emergence. Adult emergence was calculated by subtracting the number of emerging adults from the total number of pupae.

**Statistical analysis:** The data for antifeedant and larvicidal activities and adult emergence were analysed using one way ANOVA. Significant differences between treatments were determined using Tukey's multiple range test ($p \leq 0.05$). $LC_{50}$ and $LC_{90}$ values were calculated using probit analysis (Finney, 1971). Statistical package SPSS version 11.5 was used for statistical analysis.

## RESULTS

**Antifeedant activity:** Antifeedant activities of hexane, chloroform and ethyl acetate extracts of *Clerodendrum phlomidis* and *Flueggea leucopyrus* against *Earias vittella* are presented in Table 1. The results revealed that maximum antifeedant activities of 81.00 and 80.48% were recorded in hexane extract of *F. leucopyrus* and chloroform extract of *C. phlomidis* at 5% concentration, respectively. Antifeedant activity of *C. phlomidis* chloroform extract was on par with the hexane extract of *F. leucopyrus*. More than 60% of antifeedant activity was observed in chloroform extracts of *F. leucopyrus* and hexane and ethyl acetate extracts of *C. phlomidis*. In the case of *F. leucopyrus* hexane extract showed moderate to high activity in all the concentrations tested. Similar trend was also observed in chloroform extract of *C. phlomidis*.

Effective concentrations for antifeedant activity of the selected plants against *E. vittella* are presented in Table 2. Hexane extract of *F. leucopyrus* showed the least $LC_{50}$ value of 1.21% and the $LC_{90}$ value of 4.96%, while the chloroform extract of *C. phlomidis* recorded the $LC_{50}$ and $LC_{90}$ values of 1.36 and 5.11%, respectively. Hexane extract of *C. phlomidis* had also recorded notable amount of $LC_{50}$ and $LC_{90}$ values of 1.92 and 6.16%, respectively. In the case of intercept values hexane extract of *F. leucopyrus* recorded least intercept value of 0.42 followed by chloroform and hexane extracts of *C. phlomidis* which showed 0.47 and 0.58, respectively. In the case of regression

Table 1: Antifeedant activity (%) of selected plants' extract against *Earias vittella*

| | Concentrations (%) | | | |
|---|---|---|---|---|
| Crude extracts | 0.5 | 1.0 | 2.5 | 5 |
| *Clerodendrum phlomidis* | | | | |
| Hexane | $45.93\pm2.21^{d}$ | $55.60\pm2.17^{f}$ | $64.85\pm3.90^{e}$ | $74.37\pm2.83^{de}$ |
| Chloroform | $48.92\pm3.88^{de}$ | $70.02\pm2.42^{g}$ | $73.19\pm2.55^{fg}$ | $80.48\pm3.41^{ef}$ |
| Ethyl acetate | $35.32\pm3.92^{c}$ | $46.59\pm3.09^{e}$ | $54.22\pm2.93^{d}$ | $65.88\pm2.23^{c}$ |
| *Flueggea leucopyrus* | | | | |
| Hexane | $54.90\pm4.32^{e}$ | $68.40\pm3.81^{g}$ | $76.97\pm2.22^{g}$ | $81.00\pm2.98^{ef}$ |
| Chloroform | $24.16\pm5.49^{b}$ | $32.88\pm3.63^{cd}$ | $49.19\pm3.55^{cd}$ | $63.86\pm3.47^{c}$ |
| Ethyl acetate | $6.73\pm3.59^{a}$ | $12.60\pm2.11^{b}$ | $30.65\pm2.17^{b}$ | $35.49\pm3.83^{b}$ |
| Control | | $4.68\pm1.72^{a}$ | | |

Values are Mean±SD of five replicates, Values followed by similar alphabets in a column do not differ significantly using Tukey's test at $p \leq 0.05$

Table 2: Effective concentrations (%) for antifeedant activity of *E. vittella*

| | | 95% fiducial limit | | | 95% fiducial limit | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Crude extracts | $LC_{50}$ | Lower | Upper | $LC_{90}$ | Lower | Upper | $\chi^{2}$* | Intercept | Regression coefficient |
| *Clerodendrum phlomidis* | | | | | | | | | |
| Hexane | 1.92 | 1.31 | 2.57 | 6.16 | 4.92 | 8.63 | 243.00 | 0.58±0.04 | 0.30±0.016 |
| Chloroform | 1.36 | 0.611 | 2.00 | 5.11 | 4.00 | 7.47 | 346.00 | 0.47±0.38 | 0.34±0.16 |
| Ethyl acetate | 2.74 | 2.19 | 3.46 | 7.44 | 6.04 | 10.06 | 170.00 | 0.75±0.39 | 0.27±0.15 |
| *Flueggea leucopyrus* | | | | | | | | | |
| Hexane | 1.21 | 0.38 | 1.87 | 4.96 | 3.85 | 7.42 | 396.00 | 0.42±0.038 | 0.34±0.016 |
| Chloroform | 3.28 | 2.86 | 3.82 | 7.45 | 6.43 | 9.01 | 99.44 | 1.01±0.04 | 0.31±0.015 |
| Ethyl acetate | 5.91 | 5.14 | 7.09 | 11.08 | 9.39 | 13.77 | 64.95 | 1.46±0.05 | 0.24±0.017* |

*Chi-square values are significant at $p \le 0.05$

Table 3: Larvicidal activity (%) of selected plants' crude extracts against *Earias vittella*

| | Larvicidal activity (%) | | | |
|---|---|---|---|---|
| | Conc. (%) | | | |
| Crude extracts | 0.5 | 1.0 | 2.5 | 5 |
| *Clerodendrum phlomidis* | | | | |
| Hexane | $8.38\pm2.76^{bc}$ | $21.04\pm4.40^{c}$ | $32.38\pm3.61^{c}$ | $43.71\pm3.72^{c}$ |
| Chloroform | $52.09\pm3.16^{g}$ | $81.71\pm3.69^{f}$ | $97.14\pm3.91^{g}$ | $100.00\pm0.00^{h}$ |
| Ethyl acetate | $0.00\pm0.00^{a}$ | $7.04\pm0.21^{ab}$ | $12.66\pm3.11^{ab}$ | $23.90\pm3.45^{ab}$ |
| *Flueggea leucopyrus* | | | | |
| Hexane | $20.76\pm4.42^{def}$ | $45.80\pm3.01^{e}$ | $74.95\pm4.06^{f}$ | $87.52\pm3.01^{g}$ |
| Chloroform | $23.52\pm2.86^{ef}$ | $49.90\pm4.27^{e}$ | $58.28\pm5.28^{de}$ | $66.57\pm3.91^{d}$ |
| Ethyl acetate | $19.42\pm2.96^{def}$ | $44.38\pm2.08^{de}$ | $76.38\pm3.75^{f}$ | $80.57\pm2.96^{ef}$ |

Values are Mean±SD of five replicates, Values with similar alphabets in a column do not differ significantly using Tukey's test at $p \le 0.05$

coefficient, chloroform extract of *C. phlomidis* and hexane extract of *F. leucopyrus* recorded maximum regression coefficient values. The regression coefficient values were more in the case of active crude extracts but the coefficient values were less in the case inactive crude extracts.

**Larvicidal activity:** Larvicidal activities of different solvent extracts of the selected plants against *E. vittella* are presented in Table 3. Chloroform extract of *C. phlomidis* exhibited 100% larval mortality at 5% concentration followed by the same extract at 2.5% concentration which recorded 97.14%. The concentration at 1.0% had also shown promising larvicidal activity of 81.71%. Hexane extracts of *F. leucopyrus* exhibited statistically significant larvicidal activity of 87.52% at 5% concentration. Ethyl acetate extract of *F. leucopyrus* had also recorded notable amount of larvicidal activity of 80.57 and 76.38% at 5 and 2.5% concentration, respectively.

Lethal concentrations for different crude extracts, their chi-square, intercept and regression co-efficient values are presented in Table 4. Chloroform extract of *C. phlomidis* recorded minimum $LC_{50}$ value of 0.51% against the larvae of *E. vittella* with $LC_{90}$ value of 1.74% followed by hexane extract of *F. leucopyrus* which recorded $LC_{50}$ value of 1.74% with $LC_{90}$ value of 4.69%. Significant chi-square values were observed. In the case of intercept values, chloroform extract of *C. phlomidis* and hexane extract of *F. leucopyrus* recorded 0.53 and 0.50, respectively. The regression co-efficient was maximum in the case of chloroform extract of *C. phlomidis* (1.03) followed by hexane extract of *F. leucopyrus* (0.44).

Table 4: Lethal concentrations (%) of selected plants' extracts for larvicidal activity of *Earias vittella*

| Extract | $LC_{50}$ | 95% fiducial limit Lower | 95% fiducial limit Upper | $LC_{90}$ | 95% fiducial limit Lower | 95% fiducial limit Upper | $\chi^{2}$* | Intercept | Regression coefficient |
|---|---|---|---|---|---|---|---|---|---|
| *Clerodendrum phlomidis* | | | | | | | | | |
| Hexane | 5.32 | 4.63 | 6.41 | 10.98 | 9.20 | 13.99 | 43.40 | 1.21±0.057 | 0.22±0.180 |
| Chloroform | 0.51 | 0.29 | 0.66 | 1.74 | 1.57 | 1.99 | 44.77 | 0.53±0.850 | 1.03±0.070 |
| Ethyl acetate | 7.38 | 6.42 | 8.95 | 12.13 | 10.24 | 15.30 | 37.42 | 1.99±0.081 | 0.27±0.020 |
| *Flueggea leucopyrus* | | | | | | | | | |
| Hexane | 1.74 | 1.38 | 2.08 | 4.69 | 4.11 | 5.56 | 89.26 | 0.50±0.05 | 0.44±0.021 |
| Chloroform | 2.38 | 1.76 | 3.03 | 8.47 | 6.77 | 12.02 | 77.05 | 0.76±0.05 | 0.21±0.017 |
| Ethyl acetate | 1.88 | 1.36 | 2.35 | 5.37 | 4.52 | 6.85 | 131.00 | 0.69±0.05 | 0.36±0.019* |

*Chi-square values are significant at $p \le 0.05$

Table 5: Effect of different crude extracts of the selected plants on adult emergence (%) of *Earias vittella*

| | Emergence (%) | | | |
|---|---|---|---|---|
| | Conc. (%) | | | |
| Crude extract | 0.5 | 1 | 2.5 | 5 |
| *Clerodendrum phlomidis* | | | | |
| Hexane | $100.00\pm0.00^{d}$ | $89.80\pm4.02^{cd}$ | $81.9\pm4.69^{de}$ | $78.80\pm1.78^{cd}$ |
| Chloroform | $0.00\pm0.00^{a}$ | $0.00\pm0.00^{a}$ | $0.0\pm0.00^{a}$ | $0.00\pm0.00^{a}$ |
| Ethyl acetate | $100.00\pm0.00^{d}$ | $100.00\pm0.00^{e}$ | $100.0\pm0.00^{f}$ | $95.00\pm5.00^{e}$ |
| *Flueggea leucopyrus* | | | | |
| Hexane | $70.30\pm3.31^{b}$ | $61.42\pm2.39^{b}$ | $0.0\pm0.00^{a}$ | $0.00\pm0.00^{a}$ |
| Chloroform | $100.00\pm0.00^{d}$ | $100.00\pm0.00^{e}$ | $100.0\pm0.00^{f}$ | $100.00\pm0.00^{e}$ |
| Ethyl acetate | $69.09\pm3.31^{b}$ | $52.50\pm5.59^{b}$ | $40.0\pm9.12^{bc}$ | $36.66\pm7.45^{b}$ |

Values are Mean±SD of five replicates, Values with similar alphabets in a column do not differ significantly using Tukey's test at $p \le 0.05$

**Adult emergence:** Adult emergence of different solvent crude extracts of the selected plants against *E. vittella* is presented in Table 5. Chloroform extract of *C. phlomidis* at all the concentrations and hexane extract of *F. leucopyrus* at 5 and 2.5% concentrations did not show any adult emergence.

## DISCUSSION

Different plant extracts using various organic solvents yield secondary plant metabolites in varied proportions which may have various types of biological activity alone or in combination to protect plants from insects (Sharma and Bisht, 2008). Fraenkel (1959) stated that food preference by insects is based solely on the presence or absence of secondary plant metabolites.

**Antifeedant activity:** In the present investigation, maximum antifeedant activity of more than 81.00% was observed in low polar hexane extract of *Flueggea leucopyrus* against *Earias vittella* at 5% concentration. This result corroborates with the reports of Zapata *et al.* (2009) who evaluated hexane, acetone and methanol-water (80:20%) extracts of *Drimys winteri* against *S. littoralis* and observed that hexane extract exhibited antifeedant activity of 76.51%. Muthu *et al.* (2010a) reported that hexane extract of *Atalantia monophylla* at 5% concentration exhibited antifeedant activity of 70.89% against *E. vittella*. Baskar *et al.* (2010) reported that hexane extract of *Couroupita guianensis* showed more than 80% antifeedant activity against *H. armigera*. Tewary *et al.* (2005) reported that low polar solvent extract had higher activity than the high polar solvent extracts. Similarly, Baskar *et al.* (2008) studied the hexane extract of *A. monophylla* against *S. litura* and observed higher antifeedant activity. The activity may be due to the presence of active principles present in the plant extracts. This was in agreement with the findings of (Kumar and Thakur, 1988) who reported that the antifeedant activity was related to the amount of active substances present in the crude extracts. The present investigation coincides with the earlier findings of Kulkarni *et al.* (2003) who studied hexane, benzene, chloroform, acetone and methanol extracts of *Annona squamosa* against *Crypsiptya coclesalis*. They observed that hexane extract revealed maximum feeding deterrent activity of 95.43% compared to other extracts.

In the present study chloroform extract of *C. phlomidis* exhibited 80.48 and 73.19% antifeedant activity at 5 and 2.5% concentrations, respectively with the $LC_{50}$ values of 1.36 and 0.96% against *E. vittella*. This finding corroborates with the earlier findings of Lingathurai *et al.* (2011) who reported phagodeterrent activity of chloroform extract of *Acalypha fruticosa* against *Plutella xylostella*; they observed maximum antifeedant activity of 92.8 and 78.35% at 5 and 2.5% concentration, respectively with the $LC_{50}$ value of 1.86. Similarly, Gogoi *et al.* (2003) reported that chloroform extract of *Pogostemon parviflorus, Pongamia glabra* and *Annona squamosa* exhibited higher feeding deterrent activity against *Helopeltis theivora* than petroleum ether and methanol extracts. Chloroform extract of *Clausena anisata* root showed maximum antifeedant activity compared to petroleum ether, hexane, ethyl acetate and methanol extracts against *H. armigera* (Pitan *et al.*, 2009).

**Larvicidal activity:** In the present study, 100% larvicidal activity was observed in chloroform extract of *C. phlomidis* against *E. vittella*. Earlier, Reena and Singh (2007) reported 100% larval mortality at 10% methanolic extract of *P. pinnata* seeds against the III instar larvae of *E. vittella*. Sankari and Narayanasamy (2007) reported that fly ash waste and neem seed kernel caused 77.33% mortality on *E. vittella* larvae after 72 h of treatment. Larvicidal activity of the extracts may be due to the synergistic action of different toxic secondary substances present in the plants that influence different sites of action physiologically and biochemically resulting in quicker mortality. Earlier, quite a few researchers reported that plant extracts controlled a variety of insects (Baskar *et al.*, 2011a, b; Jeyasankar *et al.*, 2012).

In the present findings, hexane extract of *F. leucopyrus* and chloroform extract of *C. phlomidis* showed maximum larvicidal activity against *E. vittella* since its consumption was very low. This finding corroborates with the findings of Muthu *et al.* (2010a) who reported that hexane extract of *Atalantia monophylla* showed 85.33% larvicidal activity against *E. vittella* where its consumption was low. Similarly, Rao *et al.* (2003) reported that reduced feeding by *E. vittella* increased the mortality. Baskar *et al.* (2010) stated that hexane extract of *Couroupita guianensis* showed larvicidal activity, while antifeedant activity was high against *H. armigera*. Sundararajan (2002) evaluated the methanol extracts of 8 medicinal plants for their larvicidal activity against *H. armigera* and observed that *Vitex negundo* showed higher larval mortality at 82.5% at 2% concentration. Berenbaum (1986) observed that the postingestive effect of plant extracts could be acute or chronic in phytophagous insects. The larval mortality was increased significantly with the increase in the concentration of the active crude extracts. The findings of the present research work corroborate with the earlier findings of Muthu *et al.* (2010a) on *E. vitella* and Baskar *et al.* (2012a) on *S. litura* and *H. armigera*.

**Adult emergence:** In the present work, the larvae treated with the extract revealed low adult emergence. The percent adult emergence of *E. vittella* was dose-related. *C. phlomidis* chloroform extract did not show any adult emergence which means that there was 100% larval mortality in all the concentrations. No adult emergence was also noticed in hexane extract of *F. leucopyrus* at 5.0 and 2.5% concentrations. This result coincides with the earlier report of Muthu *et al.* (2010a) who reported that the adult emergence was very low in hexane extract (16.66%) at 5% concentration followed by 25% in ethyl acetate extract at 5% concentration of *A. monophylla*. Hexane extract of *A. monophylla* completely inhibited the adult emergence of *H. armigera* at 5.0% concentration (Baskar *et al.*, 2009). Similarly, Baskar *et al.* (2012b) reported that fraction from chloroform extract of *Caesalpinia bonduc* reduced the adult emergence of *S. litura*. Rao *et al.* (2003) reported that all the treatments (neem alone and in combination with pongam and sweet-flag) reduced pupation and adult emergence of *E. vittella*.

## CONCLUSION

The studies clearly indicated that the chloroform extract of *C. phlomidis* and hexane extract of *F. leucopyrus* recorded good antifeedant and larvicidal activities and reduced adult emergence. These plants could be effectively used to develop a new pesticidal formulation for insect pest management since no work has been reported till now for these plants against *E. vittella*.

## ACKNOWLEDGMENT

The authors thank the Entomology Research Institute, Loyola College, Chennai for financial support.

## REFERENCES

Abbott, W.S., 1925. A method of computing the effectiveness of an insecticide. J. Econ. Entomol., 18: 265-267.

Ahmad, M., 2007. Insecticide resistance mechanisms and their management in *Helicoverpa armigera* (Hubner)-A review. J. Agric. Res., 45: 319-335.

Ahmed, S.M., H. Chander and J. Pereira, 1981. Insecticidal potential and biological activity of India indigenous plants against *Musca domestica*. Insect. Pest Control, 23: 170-175.

Ali, A. and P.Q. Rizvi, 2008. Influence of aphid species on the development and predation of *Menochilus sexmaculatus* Fabricius (Coleoptera: Coccinellidae). J. Eco-Friendly Agric., 3: 134-137.

Bami, H.L., 1997. Pesticide use in India-Ten questions. Chem. Weekly, 4: 7-10.

Baskar, K. and S. Ignacimuthu, 2012a. Antifeedant, larvicidal and growth inhibitory effect of ononitol monohydrate isolated from *Cassia tora* L. against *Helicoverpa armigera* (Hub.) and *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae). Chemosphere, 10.1016/j.chemosphere.2012.02.051.

Baskar, K. and S. Ignacimuthu, 2012b. Bioefficacy of violacein against Asian armyworm *Spodoptera litura* Fab. (Lepidoptera: Noctuidae). J. Saudi Soc. Agric. Sci., 11: 73-77.

Baskar, K., S. Kingsley, S.E. Vendan and S. Ignacimuthu, 2008. Feeding Deterrency of some Plant Extracts against Asian Armyworm *Spodotera litura* Fab. (Lepidoptera: Noctuidae). In: Recent Trends in Insect Pest Management, Ignacimuthu, S. and S. Jayaraj (Eds.). Elite Publication, New Delhi, pp: 225-227.

Baskar, K., S. Kingsley, S.E. Vendan, M.G. Paulraj, V. Duraipandiyan and S. Ignacimuthu, 2009. Antifeedant, larvicidal and pupicidal activities of *Atalantia monophylla* (L.) Correa against *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae). Chemosphere, 75: 355-359.

Baskar, K., R. Maheshwaran, S. Kingsley and S. Ignacimuthu, 2010. Bioefficacy of *Couroupita guianensis* (Aubl.) against the cotton bollworm *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae). Spanish J. Agric. Res., 8: 135-141.

Baskar, K., R. Maheswaran, S. Kingsley and S. Ignacimuthu, 2011a. Bioefficacy of plant extracts against Asian army worm *Spodoptera litura* Fab. (Lepidoptera: Noctuidae). J. Agric. Technol., 7: 123-131.

Baskar, K., S. Sasikumar, C. Muthu, S. Kingsley and S. Ignacimuthu, 2011b. Bioefficacy of *Aristolochia tagala* Cham. against *Spodoptera litura* Fab. (Lepidoptera: Noctuidae). Saudi J. Biol. Sci., 18: 23-27.

Baskar, K., G.A. Raj, P.M. Mohan, S. Lingathurai, T. Ambrose and C. Muthu, 2012a. Larvicidal and growth inhibitory activities of entomopathogenic fungus, *Beauveria bassiana* against Asian Army worm, *Spodoptera litura* Fab. (Lepidoptera: Noctuidae). J. Entomol., 9: 155-162.

Baskar, K., R. Maheswaran and S. Ignacimuthu, 2012b. Bioefficacy of *Caesalpinia bonduc* (L.) Roxb against *Spodoptera litura* Fab. Lepidoptera: Noctuidae). Arch. Phytopathol. Plant Protect. 10.1080/03235408.2012.657931.

Bentley, M.D., D.E. Leonard, W.F. Stoddard and L.H. Zalkow, 1984. Pyrrolizidine alkaloids as larval feeding deterrents for spruce budworm *Choristonewa fumiferana* (Lepidoptera: Tortricidae). Ann. Entomol. Soc. Am., 7: 393-397.

Berenbaum, M.R., 1986. Target Site Insensitivity in Insect Plant-Interactions. In: Molecular Aspects of Insect-Plant Association, Brattsten, L.B. and S. Ahmad (Eds.). Plenum Press, New York, USA.

Bharvad, N.J., 2005. Control of worms in cotton, brinjal, sesame and chilli. J. Honey Bee, 16: 15-15.

Bouchard, M.F., D.C. Bellinger, R.O. Wright and M.G. Weisskopf, 2010. Attention-deficit/hyperactivity disorder and urinary metabolites of organophosphate pesticides. Paediatrics, 125: 1270-1277.

Charpot, R.T., 1998. Leaves of *Clerodendron phlomidis* for preserving grains. J. Honey Bee, 9: 16-16.

Finney, D.J., 1971. Probit Analysis. 3rd Edn., Cambridge University Press, Cambridge, UK., pp: 333.

Fox, J.E., J. Gulledge, E. Engelhaupt, M.E. Burow and J.A. McLachlan, 2007. Pesticides reduce symbiotic efficiency of nitrogen-fixing rhizobia and host plants. Proc. Nnatl. Acad. Sci. USA., 104: 10282-10287.

Fraenkel, G.S., 1959. The raison d'etre of secondary plant substances. Science, 129: 1466-1470.

Gandhi, R.A., 1998. Controlling green worm in tuvar. Honey Bee, Vol. 9,

Gogoi, I., I. Rahman and A.K. Dolui, 2003. Antifeedant activity of some plant extracts against tea mosquito bug, *Helopeltis theivora* water house. J. Entomol. Res., 27: 321-324.

Isman, M.B., 1997. Neem and other botanical insecticides: Barriers to commercialization. Phytoparasitica, 25: 339-344.

Isman, M.B., 2008. Perspective botanical insecticides: For richer, for poorer. Pest Manage. Sci., 64: 8-11.

Isman, M.B., O. Koul, A. Luczynski and J. Kaminski, 1990. Insecticidal and antifeedant bioactivities of neem oils and their relationship to azadirachtin content. J. Agric. Food Chem., 38: 1406-1411.

Iyengar, S.P., 2010. Spurious pesticides spoil crop worth Rs. 6,000 crore. Bus. Line.

Jeyasankar, A., N. Raja and S. Ignacimuthu, 2012. Impact of novel crystal compound 2, 5-diacetoxy-2-benzyl-4,4,6,6-tetramethyl-1,3-Cyclohexanedione on feeding physiology and developmental indices of armyworm, *Spodoptera litura* Fab. (Lepidoptera: Noctuidae). J. Entomol., 9: 231-238.

Kulkarni, N., K.C. Joshi, and P.K. Shukla, 2003. Antifeedant activity of *Annona squamosa* Linn. against *Crypsiptya coclesalis* Walker (Lepidoptera: Pyralidae). Entomon, 28: 389-392.

Kumar, B.H. and S.S. Thakur, 1988. Certain non-edible seed oils as feeding deterrents against. *Spodoptera litura* Fab. J. Oil Seed Technol. Assoc. India, 20: 63-65.

Lingathurai, S., S.E. Vendan, M.G. Paulraj and S. Ignacimuthu, 2011. Antifeedant and larvicidal activities of *Acalypha fruticosa* Forssk. (Euphorbiaceae) against *Plutella xylostella* L. (Lepidoptera: Yponomeutidae) larvae. J. King Saud Univ.-Sci., 23: 11-16.

Mahapatro, G.K. and G.P. Gupta, 1998. Bio-potency test of some commercial formulation of *Bacillus thuringiensis* against spotted bollworm, *Earias vittella* Fab. Pestology, 22: 22-26.

Mishra, L.C., 2003. Scientific Basis for Ayurvedic Therapies. CRC Press, Florida, pp: 105-106.

Muthu, C., K. Baskar, S. Kingsley and S. Ignacimuthu, 2010a. Bioefficacy of *Atalantia monophylla* (L.) Correa. against *Earias vittella* Fab. J. Central Eur. Agric., 11: 27-30.

Muthu, C., K. Padmapriya, K. Baskar, S. Kingsley and S. Ignacimuthu, 2010b. Antifeedant and larvicidal activities of *Gracilania carticata* and *Entenomorpha flexuosa* against *Earias vittella* Fab. J. Adv. Zool., 31: 78-82.

Pavunraj, M., K. Baskar and S. Ignacimuthu, 2012. Efficacy of *Melochia corchorifolia* L. (Sterculiaceae) on feeding behavior of four lepidopteran pests. Int. J. Agric. Res., 7: 58-68.

Pitan, O.O.R., O.O. Ayelaagbe, H.L. Wang and C.Z. Wang, 2009. Identification, isolation and characterization of the antifeedant constituent of *Clausena anisata* against *Helicoverpa armigera* (Lepidoptera: Noctuidae). Insect Sci., 16: 247-253.

Rao, N.S., S. Raguraman and R. Rajendran, 2003. Laboratory assessment of the potentiation of neem extract with the extracts of sweet-flag and pungam on bhendi shoot and fruit borer, *Earias vittella* (Fab.). Entomon, 28: 277-281.

Rawat, R.R. and H.R. Sahu, 1973. Estimation of losses in growth and yield of okra due to *Empoasca devastans* Dist and *Earias* spp. Indian J. Entomol., 35: 252-254.

Reena and R. Sing, 2007. Efficacy of methanolic extracts of karanj (*Pongamia pinnata*) seeds against *Earias vittella* (Fabricius). Ind. J. Entomol., 69: 141-148.

Roy, B., R. Amin, M.N. Uddin, A.T.M.S. Islam, M.J. Islam and B.C. Halder, 2005. Leaf extracts of *Shyalmutra (Blumea tacera* Dc.) As botanical insecticides against leser grain borer and rice weevil. J. Biol. Sci., 5: 201-204.

Sankaranarayanan, S., P. Bama, J. Ramachandran, P.T. Kalaichelvan and M. Deccaraman *et al.*, 2010. Ethnobotanical study of medicinal plants used by traditional users in Villupuram district of Tamil Nadu, India. J. Med. Plants Res., 4: 1089-1101.

Sankari, S.A. and P. Narayanasamy, 2007. Bio-efficacy of flyash-based herbal pesticides against pests of rice and vegetables. Curr. Sci., 92: 811-816.

Shafi, M.S., M.Y. Ashraf and G. Sarwar, 2001. Wild medicinal plants of Cholistan area of Pakistan. Pak. J. Biol. Sci., 4: 112-116.

Sharma, R.K. and R.S. Bisht, 2008. Antifeedant activity of indigenous plant extracts against *Spodoptera litura* Fabricius. J. Insect Sci., 21: 56-60.

Solangaarachchi, S.M. and B.M.S. Perera, 1993. Floristic composition and medicinally important plants in the under storey of the tropical dry mixed evergreen forest of the Hurulu reserve of Sri Lanka. J. National Sci. Counc. Sri Lanka, 2: 209-221.

Sundararajan, G., 2002. Control of caterpillar *Helicoverpa armigera* using botanicals. J. Ecotoxicol. Environ. Monit., 12: 305-308.

Suresh, K., R. Kottaimuthu, S.J. Normon, R. Kumuthakalavalli and S.M. Simon, 2011. Medicinal plants used by Malayali tribals in Kolli hills of Tamil Nadu. Int. J. Res. Ayurveda Pharm., 2: 502-508.

Tewary, D.K., A. Bhardwaj and A. Shanker, 2005. Pesticidal activities in five medicinal plants collected from mid hills of western Himalayas. Ind. Crop Prod., 22: 241-247.

Upadhyay, K.K., K.G. Mukerji and B.P. Chamola, 2002. Biocontrol Potential and its Exploitation in Sustainable Agriculture. Springer, New York, pp: 97.

Ved, D.K. and G.S. Goraya, 2008. Demand and Supply of Medicinal Plants in India. Bishen Singh, Mahendra Pal Singh, Dehra Dun, India..

WCS, 1980. International Union for the Conservation of Nature and Natural Resources. World Conservation Strategy, Gland, Switzerland.

Zapata, N., F. Budia, E. Vinuela and P. Medina, 2009. Antifeedant and growth inhibitory effects of extracts and drimanes of *Drimys winteri* stem bark against *Spodoptera littoralis* (Lepidoptera: Noctuidae). Ind. Crop Prod., 30: 119-125.