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

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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\textsubscript{50} and LC\textsubscript{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\textsubscript{50} and LC\textsubscript{90} values for larvicidal activity were 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, *Baris vitella* 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 phlomis* 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. phlomis* 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. phlomis* (*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. phlomis* and *F. leucopyrus* against *B. vitella*.

**MATERIALS AND METHODS**

**Collection and extraction of crude extracts**: The leaves of *Clerodendrum phlomis* 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. phlomis*-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:

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

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

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):

\[
\text{Antifeedant activity = \frac{\text{Consumption in control - Consumption in treated}}{\text{Consumption in control}}} \times 100
\]

**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):

\[
\text{Abbott corrected mortality} = \frac{\text{Mortality in treatment} \times \text{Mortality in control} - \text{Mortality in control}}{100 - \text{Mortality in control}} \times 100
\]

**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 ≤ 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 1.38 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***

<table>
<thead>
<tr>
<th>Crude extracts</th>
<th>Concentrations (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Clerodendrum phlomidis</strong></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>45.90±2.21</td>
</tr>
<tr>
<td>Chloroform</td>
<td>48.92±3.88</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>35.32±3.92</td>
</tr>
<tr>
<td><strong>Flueggea leucopyrus</strong></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>54.90±4.32</td>
</tr>
<tr>
<td>Chloroform</td>
<td>24.16±5.49</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>6.73±3.59</td>
</tr>
<tr>
<td><strong>Control</strong></td>
<td>4.68±1.72</td>
</tr>
</tbody>
</table>

Values are Means±SD of five replicates. Values followed by similar alphabets in a column do not differ significantly using Tukey’s test at p≤0.05.
Table 2: Effective concentrations (%) for antifeedant activity of *E. vittella*

<table>
<thead>
<tr>
<th>Crude extracts</th>
<th>LC50 (Lower)</th>
<th>LC50 (Upper)</th>
<th>LC90 (Lower)</th>
<th>LC90 (Upper)</th>
<th>χ²*</th>
<th>Intercept</th>
<th>Regression coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Clerodendrum phlomidis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>1.92</td>
<td>1.31</td>
<td>2.57</td>
<td>6.16</td>
<td>4.92</td>
<td>8.63</td>
<td>243.00</td>
</tr>
<tr>
<td>Chloroform</td>
<td>1.36</td>
<td>0.61</td>
<td>2.00</td>
<td>5.11</td>
<td>4.00</td>
<td>7.47</td>
<td>346.00</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>2.74</td>
<td>2.19</td>
<td>3.46</td>
<td>7.44</td>
<td>6.04</td>
<td>10.06</td>
<td>170.00</td>
</tr>
<tr>
<td><em>Fuegaea leucopyrus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>1.21</td>
<td>0.38</td>
<td>1.87</td>
<td>4.96</td>
<td>3.85</td>
<td>7.42</td>
<td>396.00</td>
</tr>
<tr>
<td>Chloroform</td>
<td>3.28</td>
<td>2.86</td>
<td>3.82</td>
<td>7.45</td>
<td>6.43</td>
<td>9.01</td>
<td>189.44</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>5.91</td>
<td>5.14</td>
<td>7.09</td>
<td>11.08</td>
<td>9.39</td>
<td>13.77</td>
<td>64.95</td>
</tr>
</tbody>
</table>

*Chi-square values are significant at p<0.05

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

<table>
<thead>
<tr>
<th>Crude extracts</th>
<th>0.5 (%)</th>
<th>1.0 (%)</th>
<th>2.5 (%)</th>
<th>5 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Clerodendrum phlomidis</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>8.38±2.70*</td>
<td>21.04±4.49</td>
<td>32.38±3.61</td>
<td>43.71±3.72</td>
</tr>
<tr>
<td>Chloroform</td>
<td>52.09±3.16*</td>
<td>81.71±3.89</td>
<td>97.14±3.91</td>
<td>100.00±0.00</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>0.00±0.00*</td>
<td>7.04±0.21*</td>
<td>12.66±3.11*</td>
<td>23.90±3.49*</td>
</tr>
<tr>
<td><em>Fuegaea leucopyrus</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>20.76±4.42*</td>
<td>45.80±3.01*</td>
<td>74.95±4.06*</td>
<td>87.52±3.01*</td>
</tr>
<tr>
<td>Chloroform</td>
<td>23.52±2.86*</td>
<td>49.90±4.27*</td>
<td>58.28±5.28*</td>
<td>66.57±3.91*</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>19.42±2.96*</td>
<td>44.38±2.08*</td>
<td>76.38±3.79*</td>
<td>80.57±2.99*</td>
</tr>
</tbody>
</table>

Values are Mean±SD of five replicates, Values with similar alphabets in a column do not differ significantly using Tukey's test at p<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 73.38% at 5 and 2.5% concentration, respectively.

Lethal concentrations for different crude extracts, their chi-square, intercept and regression coefficient values are presented in Table 4. Chloroform extract of *C. phlomidis* recorded minimum LC50 value of 0.51% against the larvae of *E. vittella* with LC90 value of 1.74% followed by hexane extract of *F. leucopyrus* which recorded LC50 value of 1.74% with LC90 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 coefficient 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 vitella*

<table>
<thead>
<tr>
<th>Extract</th>
<th>95% fiducial limit</th>
<th>95% fiducial limit</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>Lower Limit</th>
<th>Upper Limit</th>
<th>(\chi^2)</th>
<th>Intercept</th>
<th>Regression coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clerodendrum phlomidis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>5.32</td>
<td>4.63</td>
<td>6.41</td>
<td>10.98</td>
<td>9.20</td>
<td>13.99</td>
<td>43.40</td>
<td>1.21±0.067</td>
<td>0.22±0.180</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.51</td>
<td>0.29</td>
<td>0.66</td>
<td>1.74</td>
<td>1.57</td>
<td>1.99</td>
<td>44.77</td>
<td>0.53±0.860</td>
<td>1.05±0.070</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>7.36</td>
<td>6.42</td>
<td>8.95</td>
<td>12.13</td>
<td>10.24</td>
<td>15.30</td>
<td>37.42</td>
<td>1.98±0.981</td>
<td>0.27±0.020</td>
</tr>
<tr>
<td><strong>Flueggea leucopyrus</strong></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>1.74</td>
<td>1.38</td>
<td>2.08</td>
<td>4.69</td>
<td>4.11</td>
<td>5.56</td>
<td>89.26</td>
<td>0.50±0.065</td>
<td>0.44±0.021</td>
</tr>
<tr>
<td>Chloroform</td>
<td>2.28</td>
<td>1.76</td>
<td>3.03</td>
<td>8.47</td>
<td>6.77</td>
<td>12.02</td>
<td>77.06</td>
<td>0.76±0.065</td>
<td>0.21±0.017</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>1.88</td>
<td>1.36</td>
<td>2.35</td>
<td>5.37</td>
<td>4.52</td>
<td>6.85</td>
<td>131.00</td>
<td>0.69±0.065</td>
<td>0.36±0.019*</td>
</tr>
</tbody>
</table>

*Chi-square values are significant at \(p<0.05\)*

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

<table>
<thead>
<tr>
<th>Crude extract</th>
<th>0.5</th>
<th>1</th>
<th>2.5</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Clerodendrum phlomidis</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>100.00±0.00a</td>
<td>89.50±4.02a</td>
<td>81.9±4.69a</td>
<td>73.80±1.78a</td>
</tr>
<tr>
<td>Chloroform</td>
<td>0.00±0.00a</td>
<td>0.00±0.00a</td>
<td>0.00±0.00a</td>
<td>0.00±0.00a</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>100.00±0.00a</td>
<td>100.00±0.00a</td>
<td>100.00±0.00a</td>
<td>95.00±5.00a</td>
</tr>
<tr>
<td><strong>Flueggea leucopyrus</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hexane</td>
<td>70.30±3.31b</td>
<td>61.42±2.39b</td>
<td>0.00±0.00a</td>
<td>0.00±0.00a</td>
</tr>
<tr>
<td>Chloroform</td>
<td>100.00±0.00a</td>
<td>100.00±0.00a</td>
<td>100.00±0.00a</td>
<td>100.00±0.00a</td>
</tr>
<tr>
<td>Ethyl acetate</td>
<td>69.09±3.31b</td>
<td>52.50±5.59b</td>
<td>40.0±0.12a</td>
<td>36.66±7.46b</td>
</tr>
</tbody>
</table>

Values are Means±SD of five replicates. Values with similar alphabets in a column do not differ significantly using Tukey’s test at \(p<0.05\)

**Adult emergence**: Adult emergence of different solvent crude extracts of the selected plants against *E. vitella* 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 vitella* 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. vitella*. 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 Cryptsipta 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 LC50 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 Ptilotella xylostella; they observed maximum antifeedant activity of 92.8 and 78.35% at 5 and 2.5% concentration, respectively with the LC50 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 Helopetis 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 Vitez negundo showed higher larval mortality at 82.5% at 2% concentration. Berenbaum (1983) observed that the postigestive 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*.

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REFERENCES


