Phagodeterrent bioefficacy of Gynendropsis pentaphylla, Withamnia somnifera and Alpinia galanga against chickpea bruchids, Callosobruchus chinensis (Linn.) (Coleoptera: Bruchidae)

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Abstract

Experiments were conducted to test phagodeterrent bio-potency of ten naturally occurring indigenous plant extracts in the Biopesticides and Toxicological research Laboratory, Department of Zoology, Entomology, D.B.S. College, Kanpur, U.P., India. Therefore, it becomes necessary to look for the suitable ten asteraceous plant extracts, which are known to be eco-friendly. Different formulations of asteraceous plant extracts were tested for their repellent activity against the early emerged pulse beetle, Callosobruchus chinensis Linn. (Coleoptera: Bruchidae). Among them, only three extracts viz. Gynendropsis pentaphylla, Withamnia somnifera and Alpinia galanga extracts were proved most effective repellent in compare to other. Based on relative ECso values G. pentaphylla extract showed highest repellency (6.18) to the early emerged adult beetle, C. chinensis followed by W. somnifera (5.67) and A. galanga (4.83) times repellent than A. calamus against C. chinensis, which is taken as unit. Beside above the selected rest of the plants exhibited varying degree of lesser or moderate repellent effects. Thus, Gynendropsis pentaphylla and Withamnia somnifera formulations can be used as an effective option of commercial fumigants for the storage of chickpea seeds against pulse beetle, Callosobruchus chinensis Linn.

Keywords: Callosobruchus chinensis, Gynendropsis pentaphylla, repellent activity and plant extracts

Introduction

The chickpea beetle, Callosobruchus chinensis (L.) (Coleoptera: Bruchidae) has been reported to cause serious damage to pulses in India and many countries of the world. (Pandey et al, 1992, 2010 [17, 18], Ramzan, 1994 [21], and Shaaya et al. 1997 [23]). Qualitative and quantitative deterioration of pulses provoked by insects accounts for considerable loss of economic importance at international level. The C. chinensis are polyphagous nature and causing serious economic damage to several agricultural stored grains and pulses in India. (Ahmed et al.1999) [4] and many countries of the world Valsaia and Gokuldas, 2015 [29]. Callosobruchus chinensis has a wide range of host, feeding on 112 species worldwide of which 40 species are known from India Chandel and Singh, 2016 [7]. Ketker 1989 [10], Pandey and Singh, 1997 [19], Lale, 1992 [13], Reddy and Singh, 1998 [22], Lale, 2000 [12]. Broad spectrum insecticides used for control of C. chinensis has resulted in development of resistance to many of the registered pesticides for its control [4, 5]. The absence of resistance to C. chinensis in stored grains and the lack of adequate control measures make it difficult to manage this pest in the storage. In this scenario, new types of botanical products as insecticide originating from natural products, targeting C. chinensis could be a useful alternative for integrated pest management Singh, 2003 [23]. Plants are important natural sources of bioactive compounds and many such plant compounds have been included in commercial botanical pesticides Srivastava et al.1988 [28]. Many plant products are safer to non-target organisms and effective against phytophagous insects, Yankanchi and Gadache [13]. Several plant products have been tested against C. chinensis and some promising plants have been reported Zoubiri and Baaliouamer [34]. However the screening of plant extracts against insects are still continuing throughout the world to find out different kinds of effects of botanicals to obtain an ecofriendly, naturally occurring and economic biopesticide. [31, 32, 34]. Very few reports are present pertaining to the repellent activity of plant extracts against C. chinensis Tripathy et al.2001 [29], Al- Lavati et al. 2002 [5], Liu et al. 2006 [13], Govindan and Nelson (2008) [25, 26].
Therefore the present study deals with screening of various plant extracts for their repellent activity against *C. chinensis*. The use of botanical pesticides in pulse protection has a long account [7, 28] and there are a number of bibliographic records on the use of essential oils from different plants against stored product insect pests by researchers in developing countries were found [30, 31, 32]. So far, the effect of plant essential oils on *Callosobruchus* species has been investigated using fumigant toxicity [2], repellent activity [8, 9, 13, 20, 24, 28] as well as feeding deterrent activity. [2].

**Materials and method**

Present study was undertaken during the period from August 2016 to July 2017, at the Biopesticides and Toxicological research Laboratory, Post Graduate Department of Zoology, Entomology, D.B.S. College, Kanpur, U.P., India.

**Procurement of raw plant materials:** For the experimental purposes asteraceous botanical parts were collected from wasteland and cultivated fields of the farmers. Among them, only ten asteraceous plants viz., aerial parts of *Cichorium intybus* (L.), *Chromolaena odorata* Linn., *Chrysanthemum cinerariaefolium* (trev.) Vis., *Indula racemosa* Hook. F., *Mantisica duriaeri* Burq. Et Cavill., *Recharadia tingitana* (L.) Roth, *Rhaponticum acaule* (L.) DC, *Scorzonera undulate* Vahl, *Sipalinthes paniculata* Well ex DC and *Tangetes minuta* Linn. were collected from different vicinity of from U.P. and India.

**Preparation of powder:** Fresh collected green plant parts (leaves, Flowers and seeds, rhizomes etc) were washed with distilled water and kept in the laboratory for 7 days for air drying followed by one day sun drying before making powder. Electric grinder was used to have coarse powder then drying followed by one day sun drying before making powder. Powders were kept in polythene bags at room temperature and properly sealed to prevent quality loss as powder. Powders were kept in polythene bags at room temperature and properly sealed to prevent quality loss as powder.

**Preparation of Stock Solution:** For stock solution, 50ml extract in each case was taken into reagent bottles and 50ml benzene was added in it to dissolve the constituents of the materials. The mouth of the bottles were stopper with airtight corks after which, these bottles containing the solutions were kept in refrigerator.

**The Insecticidal Formulations:** Five concentrations (0.25, 0.5, 1.0, 1.5, 2.0 percent) were used for experiments on repellent tests in the laboratory experiment. The different concentrations of the herbal extracts were prepared from the stock solution using benzene as solvent and Triton X-100 as emulsifier. The level of solvent and emulsifier were kept constant.

**Test insect and Host grain**

In the present investigation, indigenous naturally occurring certain asteraceous plant parts extracts have been used for their phagodeterrent biological efficacy against *Callosobruchus chinensis* L. (pulse beetle) on stored gram, chickpea, *Cicer arietinum* L. (Fabales: Fabaceae) genotypes Kabuli variety Mexican white were used in preliminary trial under laboratory condition.

**Establishment of *Callosobruchus chinensis* L. (Coleoptera: Bruchidae)**

The adult *Callosobruchus chinensis* L. (pulse beetle) were collected from Collector Gange Mandi, Kanpur Nagar and farmers godowns of farmers at Kanpur nagar Districts of Uttar Pradesh, India were cultured and reared on in the laboratory with uniparietal ad libitum population for various investigations. Rearing was done according to the method reported by Chandel and Singh, 2016 [7].

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Scientific Name / Technical Name</th>
<th>Vernacular / Local Name</th>
<th>Family</th>
<th>Part used</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Acorus calamus</em> Linn.</td>
<td>Sweet flag</td>
<td>Araceae</td>
<td>Rhizome</td>
</tr>
<tr>
<td>2.</td>
<td><em>Adhatoda vasica</em> Nees.</td>
<td>Arusa</td>
<td>Acanthaceae</td>
<td>Aerial parts</td>
</tr>
<tr>
<td>3.</td>
<td><em>Alpinia galanga</em> L.Willed.</td>
<td>Greater Galangal</td>
<td>Zingiberacea</td>
<td>Rhizome</td>
</tr>
<tr>
<td>4.</td>
<td><em>Azadirachta indica</em> A.Juss</td>
<td>Neem</td>
<td>Meliaceae</td>
<td>Seeds kernel</td>
</tr>
<tr>
<td>5.</td>
<td><em>Cassia tora</em> Linn.</td>
<td>Chukund</td>
<td>Caparadaceae</td>
<td>Areal parts</td>
</tr>
<tr>
<td>6.</td>
<td><em>Gynendropsis pentaphylla</em> L.</td>
<td>Hullul</td>
<td>Capridaceae</td>
<td>Seeds</td>
</tr>
<tr>
<td>8.</td>
<td><em>Momordica charantia</em> Linn.</td>
<td>Bitter gourd</td>
<td>Cucurbitaceae</td>
<td>Unripe fruits</td>
</tr>
<tr>
<td>9.</td>
<td><em>Vitex negundo</em> Linn.</td>
<td>Lagundi</td>
<td>Verbenaceae</td>
<td>Aerial parts</td>
</tr>
<tr>
<td>10.</td>
<td><em>Withania somnifera</em> Dun</td>
<td>Winter Cherry</td>
<td>Solanaceae</td>
<td>Aerial parts</td>
</tr>
</tbody>
</table>

**Experimental Protocol**

Repellent activity were studied at 0.25, 0.5, 1.0, 1.5 and 2.0% concentration treated for two minutes for testing. The repellent effect stored gram, chickpea, *Cicer arietinum* L. (Fabales: Fabaceae) (channa) seeds ver were used as food for the adults of *C. chinensis*. and chickpea seeds ver xxxx. The treated seed were kept under electric fan for about half an hour, to make a dry film of the extracts on the seeds for each set of extract and one control. The treated seeds were kept in jar (23cm x 10cm) on moist filter paper. The untreated seeds...
were dipped in Benzene + emulsified water only. Five paired (male and female) C. chinensis beetle was introduced into a cage having treated stored chickpea seeds. Five paired (male and female), 24 hours starved adults were released in each jar along with control. Three replicates per treatments were maintained. The treated jars either repelled the insects or forced them to move from treated jars (T) to an empty jar (C) through the plastic pipe. The ones found in plastic pipe were considered repelled individuals. Total number of beetle reached to the food/repelled to untreated empty jars were recorded at an interval of 24 hours for each observation recorded and computed (Abbott W. S. 1925) \[11\].

### Table 1: Calculation of log conc. / Probit Repellency Regression histogram Summary of repellency test on emerging adults beetle C. chinensis.

<table>
<thead>
<tr>
<th>Plant Extracts</th>
<th>H*</th>
<th>X²</th>
<th>Regression Equation</th>
<th>EC50</th>
<th>Fiducial Limit</th>
<th>Relative EC50</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. calamus</td>
<td>3</td>
<td>0.52</td>
<td>(Y=0.88X+4.42)</td>
<td>0.8397</td>
<td>M1=1.8678 M2=0.1251</td>
<td>1.00</td>
</tr>
<tr>
<td>A. vasica</td>
<td>3</td>
<td>0.20</td>
<td>(Y=0.84X+4.50)</td>
<td>0.6470</td>
<td>M1=1.9418 M2=0.0432</td>
<td>1.29</td>
</tr>
<tr>
<td>A. galanga</td>
<td>3</td>
<td>1.93</td>
<td>(Y=1.64X+3.26)</td>
<td>0.1735</td>
<td>M1=1.4512 M2=0.2168</td>
<td>4.83</td>
</tr>
<tr>
<td>A. indica</td>
<td>3</td>
<td>0.52</td>
<td>(Y=0.88X+4.42)</td>
<td>0.8090</td>
<td>M1=1.8678 M2=0.1251</td>
<td>1.29</td>
</tr>
<tr>
<td>C. tora</td>
<td>3</td>
<td>0.83</td>
<td>(Y=0.66X+2.98)</td>
<td>0.3115</td>
<td>M1=2.9870 M2=1.1284</td>
<td>4.83</td>
</tr>
<tr>
<td>G. pentaphylla</td>
<td>3</td>
<td>4.02</td>
<td>(Y=1.07X+2.70)</td>
<td>0.1358</td>
<td>M1=2.3256 M2=1.9392</td>
<td>6.18</td>
</tr>
<tr>
<td>L. camara</td>
<td>3</td>
<td>0.96</td>
<td>(Y=0.72X+3.19)</td>
<td>0.3592</td>
<td>M1=2.9870 M2=1.1284</td>
<td>2.33</td>
</tr>
<tr>
<td>M. charantia</td>
<td>3</td>
<td>1.95</td>
<td>(Y=0.88X+4.37)</td>
<td>0.4122</td>
<td>M1=1.5188 M2=0.0148</td>
<td>2.03</td>
</tr>
<tr>
<td>V. negundo</td>
<td>3</td>
<td>0.28</td>
<td>(Y=0.75X+4.1)</td>
<td>0.6872</td>
<td>M1=2.1368 M2=1.278</td>
<td>1.22</td>
</tr>
<tr>
<td>W. somnifera</td>
<td>3</td>
<td>1.59</td>
<td>(Y=1.08X+2.66)</td>
<td>0.1480</td>
<td>M1=2.3362 M2=1.9781</td>
<td>5.67</td>
</tr>
</tbody>
</table>

In case of \(X^2\) was found non-significant heterogeneous at \(P=0.05\), \(Y=\)Probit Repellency, \(X=\)Log Concentration \(X\) 10\(^{D.F.}\)=Degree of Freedom, EC \(_{50}\) = Conc. Calculated at given 50% Repellency

### Results and Discussion

The results are summarized in Table-1 and Fig. which showed that all the plant extracts have proved to more or less repulsive against the emerging adults of C. chinensis. Among all selected plant extracts, only three plant extracts gave promising repellency with value less than 0.50 and rest seven showed less repellent effect to C. chinensis. On the basis of EC \(_{50}\) values order of merit can be arranged in following manner as: G. pentaphylla (0.1358) > W. somnifera (0.1480) > A. galanga (0.1735) > C. tora (0.3115) > L. camara (0.3192) > M. charantia (0.4122) > A. vasica (0.6470) > V. negundo (0.6872) > A. indica (0.8090) > A. calamus (0.8397), respectively.

The data depicted in table 2 indicated that maximum relative adults repellency was found in following order of effectiveness in descending order as: G. pentaphylla (6.18) > followed by W. somnifera (5.67) and A. galanga (4.83) times repellent than A. calamus against the emerging adults of C. chinensis. Beside above the remaining plant extract showed moderate repellency as C. tora (2.69) > L. camara (2.33) > M. charantia (2.03) > A. vasica (1.29) > A. indica (1.03)> A. calamus (1.00), respectively, whereas A. calamus taken as unit.

Various botanical products and their extractives works as repellent and has been reported by several researchers against pulse beetle. Different oils of neem, coconut, and castor was observed as surface protectants on green gram to check the pulse beetle and among them neem oil was the best surface protectant (Pandey et al. 1976 \[18\], Jilani et al. 1988 \[9\], Ketker 1989 \[10\]).
Cotton seed, sunflower, groundnut, soybean and mustard oils, when mixed with cowpea, completely suppressed adult emergence of C. maculatus (Ramzan, 1994 [23]). The edible oils are potential control agents against C. maculatus and can play an important role in stored-grain protection (Shaaya et al.1997) [23]. Neem and sesame oils completely inhibited adult emergence and appeared to be most promising as a seed protectant against C. chinensis (Ahmed et al. 1999) [4]. It has been observed that the volatile oil from the leaves of Curcuma domestica could effectively protect the seeds, against C. chinensis, at a low concentration (Yalamanchilli and Punakollu 2000). Neem extracts and their isolates biobit and biolop tested against various crop pest and stored grain insect-pest and reported as promising repellency to the C. chinensis, (Sighamony et al. 1984, Maredia et al. 1992, Won-Sik et al. 2002) [24, 16, 13]. Several workers were tested a number of indigenous plants extracts, derivatives for their repellent activity to their test insect and found significant results when mixed with different varieties of grain seeds against pulse beetle. (Jilani et al. 1985, Jilani et al. 1988, Bhuiyan et al. 1990, Mendes et al. 1997, Abubakar et al. 2000, Tripathi et al. 2000, Pavela et al. 2011, Manish Kumar et al. 2017 [8, 9, 6, 15, 2, 28, 20, 7, 14]).

**Conclusion**

The findings of the present investigations indicate that botanical derivatives might be useful as insect control agents for commercial use. Among ten plant extract, only G. pentaphylla (6.18) showed highest repellency followed by W. somnifera (5.67) and A. galanga (4.83) times repellent than A. calamus against the emerging adults of C. chinensis. All the extracts tested were effective to some degree of repellency reducing the feeding and destruction rates. More studies on major biochemical constituents responsible for repellent activity to the test insect on chickpea seeds against C. chinensis need to be investigated.

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**References**