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Larvicidal and antifeedant properties of certain plant extracts against *Helicoverpa armigera* larvae (Hubner)

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Abstract
For this study, we selected a few plants among the larvicidal species under research, including *Mikania micarantha, Andrographis paniculata Ness., Eupatorium riparium, Datura metal L., Catharanthus roseus L (G) Don., Cassia tora L., and Cardiospermum halicacabum L.* Characteristics and repressive actions on *Helicoverpa armigera* (Hubner) larvae in culture. All of the chosen plants' crude extracts revealed growth that was dependent on biology. Better bioactivity ($p < 0.05$) was demonstrated by *A. paniculata, Cassia tora* L., *C. halicacabum* L., *and Datura metal* L. compared to the extract and control of *C. roseus, E. riparian, and M. micarantha*. The mortality of the *A. paniculata* methanol extract varied from 29.00% to 58.22% at test dosages of 0.2%, 0.4%, and 1% w/v, while that of the *C. tora* L. extract was lower. The highest percentage of larval food reduction was seen in 76.61%, 0.2%, and 0.4% of cases, respectively. The crude extract of *C. halicacabum* L. had the highest degree of food intolerance and oral allergy, whereas the extract of *D. metal* had the highest level. Therefore, it can be concluded that four of the selected plants are hazardous and that further study of them is necessary to develop natural pesticides. According to an ongoing study, several plants will be evaluated for their larvicidal activity and capacity to keep hatchlings of *Helicoverpa armigera* (Hubner) from feeding in a lab environment. Among the chosen plants is *Andrographis paniculata Ness*. With an increase in crude extracts of all plants, the bioactivity of *Cassia tora* L., *Cardiospermum halicacabum* L., *Catharanthus roseus* L (G) Don., *Eupatorium riparium*, *Mikania micarantha*, and *Datura metal* L. increased. However, there was a significant difference (p 0.05) between the bioactivity of four plants (*A. paniculata*, *Cassia tora* L., *C. halicacabum* L., and *Datura metal* L.) and the control and output of *C. roseus*, *E. riparium*, and *M. micarantha*. The most toxic *A. paniculata* methanol extract (0.2%, 0.4%, and 1% w/v) killed 29.00% to 58.22% of the moths in the tests that were examined. Nevertheless, the creation of *C. tora* L. The diet was the biggest barrier, resulting in a 0.2 and 0.4 percent decrease in feed consumption in 59.92% and 76.61% of cases, respectively. The whole leaf of *C. halicacabum* L. showed significant oral allergy and preventative treatment, but the *D. metal* extract only showed modest oral allergy and protection against depression throughout maintenance. Therefore, we may conclude that four of the selected plants have insects and that more research is necessary to produce healthier harvests.

Keywords: *Helicoverpa armigera*, plant extract, oral toxicity, antifeedant action

Introduction

Lammers and Macleod (2007) [38] report that a significant population of polyphagous migratory noctuids (Noctuidae) may be found in Hubner's *Helicoverpa armigera* (Lepidoptera: Asia). It is known to do severe harm to many financially significant yields from one side of the world to the other (Setiawati *et al*., 2000; Fakrudin and others, 2004) [11]. Manjunath *et al*. (1985) [43] reported that it consumes 182 plant species from 47 families in India and results in losses of around Two million Indian rupees (Ignacimuthu and Jayaraj, 2003) [20]. According to Lammers and Macleod (2007) [38], 50% of all insecticides used in China and India are used specifically to combat *H. armigera*. However, because pesticides are widely and continuously used around the world, *H. armigera* has developed resistance to several chemicals that are a component of many classes of insecticides throughout time (Chaturvedi, 2007; Yang and colleagues, 2013) [5]. Thus, research is being done on how to use synthetic pesticides.

Pest management are becoming more interested in natural compounds generated from plants as alternatives to synthetic pesticides. Botanicals and plant-based insecticides have several benefits: Because they are specialized to a single target and have a range of pest control strategies (Sivagnaname and Kalyanasundaram, 2004), they are helpful to both humans and beneficial insects (Liu *et al*., 2000) [40]. This decreases the possibility that pests would evolve resistance. Finally, because they are not persistent in nature, they are ecologically beneficial (Shaalan, 2005).

The current study looks at how effective widely found plants are as insecticides against *Hemanus armigera* larvae, a pest that damages tomatoes and chickpeas and is a major problem in India (Thakur *et al*., 2006). Many authors have conducted in-depth research on the effects of a variety of herbs and their concentrates on *H. armigera* (Sahyaraj, 1998; Sundararajan and Kumuthakalavalli 2017; Koul and team, 2002; Kathuria *et al*. and Kaushik, 2005; Ramya *et al*., 2018; Wambua *et al*., 2011) [30, 35].

However, larvicidal activities against *H. armigera* were demonstrated by extracts from several plants, such as *Ocimum basilicum, Gynandropsis gynandra, Acorus calamus, Lantana camara*, and *Toddalia asiatica* (Pandey *et al*., 1983; Sundararajan and Kumuthakalavalli, 2017). Research has demonstrated that eating seed kernels can have unforeseen effects on the development of larvae and pupae, aberrant growth in adults, and suppression of nutrition (Hongo and Karel, 1986) [17]. (1984, Jotwani and Srivastava). Anti-feeding abilities have been shown in most plants tested against several *H. armigera* instars (Sahayaraj, 1998; Koul *et al*., 2002; Kathuria and Kaushik, 2005;

Ramya *et al*., 2018; Wambua *et al*., 2012; Arivoli and Tennyson, 2013) [2, 30, 35].

The effectiveness of plants found throughout the Tamil Nadu study area, such as *Andrographis paniculata Ness*., *Cardiospermum halicacabum* L., *Cassia tora* L., *Catharanthus roseus* L (G) Don., *Datura metal* L., *Eupatorium riparium*, and *Mikania micarantha*, which are used by the rural populace in traditional medicine, is not well understood, despite the large amount of research on the effects of different plant extracts on *H. armigera*. (Neogi *et al*., 1989; Chhetri, 2008; Hynniewta and Kumar, 2008; Kayang *et al*., 2008; Sinha *et al*., 2008; Sohkhlet, 2014) [6, 19, 31, 49]. Determining the plants' oral toxicity and antifeedant qualities against *H. armigera* (Hubner) larvae is the aim of the current investigation.

Material and methods

Collection of plants

The plants intended for this investigation be situated and gathered from the Tamil Nadu district of Dharmapuri and its environs. Plants were chosen according to their insecticidal qualities, geographical availability, and historical usage by the state's rural residents (Table 1) and (Plate:1,2,3,4,5,6, and 7). Typically, the plants' blooming and fruiting phases were when the samples were taken. With the aid of the Flora of Tamil Nadu Carnatic (Mathew 1983) and the Flora of Madras Presidency (Gamble 1980), all of the chosen plant species were recognized.

Prepared of plant extracts

Following collection, the plant is carried directly to the laboratory where it is thoroughly cleaned twice using dechlorinated and tap water. After that, it is kept for 48 to 72 hours at room temperature (27 ± 1 °C) in the shade. is parched. We worked up a strategy. The dried wood is ground into a powder using an electric mill. The preparation of the crude output adhered to accepted norms (Deepa and Remadevi, 2011) [8]. The components are made by extracting 100 grams of each plant powder in one liter of methanol over the course of 48 hours using a Soxhlet machine. Petroleum ether was used to extract the product before methanol was used. The extracts were dried in a rotary evaporator at low pressure before being put in sealed Borosil bags for further processing. A standard solution was prepared at a concentration of one weight percent by volume before the biological analysis. This was accomplished by dissolving one gram of the extract in ten milliliters of acetone, and then gradually adding hot water until one hundred milliliters was obtained. Concentrations of 0.2, 0.4, 0.6, 0.8, and 1% by weight from the available solutions were utilized for oral toxicity testing; 0.2, 0.4, and 1.0% by weight were employed for preventive research.

After being carefully chosen and transported straight to the lab, the plants were completely washed with tap water and then again with dechlorinated water. Following that, they were left in the shade at room temperature (27 ± 1 °C) for 48 to 72 hours until they dried. Plant was completed. Using an electric mixer, the dehydrated plants were crushed into a coarse powder. Standard procedures were followed in the preparation of crude extracts (Handa *et al*., 2008) [14]. Using a Soxhlet machine, 100 grams of powdered plant material were extracted from each plant in one liter of methanol over the course of 48 hours. Petroleum ether was used to defeat the plant material before the methanol was extracted. The extracts were placed in hermetic screw-capped Borosil containers for subsequent usage after being dried in a rotating vacuum evaporator set to low pressure. One gram of the extract was dissolved in ten milliliters of acetone to create a standard stock solution with 1% w/v prior to the bioassay. Then, deionized water was added to get the capacity up to 100 ml. For the oral toxicity test, concentrations of 0.2, 0.4, 0.6, 0.8, and 1% by weight were generated from the available solutions; for the inhibition test, concentrations of 0.2, 0.4, and 1.0% by weight were created.

Test organism

Singh and Rembold (1992) proposed feeding a lab culture of *H. armigera* larvae semi-synthetic chickpea food at 27±1°C, 75±1% relative humidity, and 12 L: 12 D photoperiod. Several *H. armigera* larval instars were taken from tomato crops grown in tomato fields in order to build the colony in the lab (Plate: 8). In order to prevent cannibalism and contamination until pupation, the collected larvae were kept in individual containers with tomato leaves and fruits under laboratory settings (27±1°C, 75±1% R.H., and photoperiod of 12 L: 12 D). To encourage moth emergence, pupae were moved to sterile containers containing sterilized filter paper. When the adult moths emerged, the males and females were paired off and placed into separate mating rooms, each measuring 2.5 by 1.5 feet. According to Kaushik and Kathuria (2004), the adults were given cotton strips as a medium for oviposition along with a meal consisting of 1% honey solution. The lab colony was fed a semi-synthetic diet based on chickpeas starting with the first generation. The larvae in their first molt were utilized in the bioassays after the cultures were collected.

Bioassay studies

By administering extracts orally using the leaf immersion method, the larvicidal activity of plants was investigated (Sundararajan and Kumuthakalavalli, 2017; Ramya *et al*., 2018). Tomato leaves that had just been harvested were individually treated with three different w/v concentrations of each extract (0.2%, 0.4%, and 1%), and then they were allowed to dry outside. Next, a six-hour-starved Anopheles larva was placed in a Petri dish covered with moist filter paper and a treated leaf. Acetone-treated leaves were used as a control. Larvae deaths were seen 24 hours after exposure. Ten larvae were given each treatment individually, and each treatment was administered three times. There were thirty larvae in all that took part in each treatment. Death statistics were reported as adjusted mortality rates using the Abbott technique (Abbott, 1925) [1].

Feeding deterrence bioassay

The leaf disc technique was used to examine the crude extract's antinutritional efficacy (Sundararajan and Kumuthakalavalli, 2017). After harvesting tomatoes, 2.5 cm2 discs were poked with 10 µl of the test solution emulsified with 0.1% Triton X-100 on each side of the leaves. Three distinct concentrations of the extract were tested: 0.2%, 0.4%, and 0.1% w/v. As controls, leaf discs were treated with acetone solution and 0.1% emulsifier. Before being put in Petri plates—one for each treatment group and control group—the leaf discs were air-dried. The treated *H. armigera* instar larvae were then uniformly separated from the treated and control discs and placed in the middle of the Petri dish. As a result, each treatment was used in three replications, with one larva per Petri dish and

ten larvae overall in the studies. The leaf discs were taken out after six hours, and the chart sheet approach was used to identify the area that the larvae had consumed. The formula from Bomford and Isman (1996) [4] was used to compute the feeding inhibition index.

$$FDI = \frac{C-T}{C+T} 100$$

Where, C=area of consumption in the control; T = area of consumption in the treatment.

Data analysis

Prior to statistical analysis, arcsine transformation was applied to the data from two bioassays. The changed data were then statistically evaluated using one-way analysis of variance. With a significance level of $P < 0.05$, Tukey's test was used to compare various treatments and unique means. Software for statistical analysis, SPSS version 20, was used.

Table 1: Assessment of specific plants and plant segments utilized in the research

Plant name	Common name	Plant parts used
A. paniculata (Burm.f.) Ness.,	Siriyanankai	Whole plant
C.halicacabum L.,	Mudakkaruthan	Leaves
C.tora (L.) Roxb.	Thagarai	Leaves
C.roseus (L.) G Don.	Nithyakalyani	Whole plant
D. metel L,	Oomathai	Leaves
E. riparium Regel	Snakeroots	Leaves
M.micarantha Kunth	American rope	Aerial part

Table 2: The ability of the crude extracts of the chosen plants to against the *Helicoverpa armigera* larvae

Plant name	Concentration of extract (% W/V)		
	0.2%	**0.4%**	**1.0%**
A. paniculata	29.77±6.93b	44.81±5.01b	58.22±8.01 b
C.halicacabum	13.7±5.48 b	13.70±5.48def	24.07±5.25 cd
C.tora	20.37±9.45b	35.55±3.85 bcd	51.48±7.88b
C.roseus	13.33±5.77b	20.00±10.00 cde	24.07±5.25 cd
D. metel	20.37±9.45b	34.44±5.09bc	37.77±3.85 bc
E. riparium	7.04±6.12 b	7.04±6.12ef	13.33±5.77 de
M.micarantha	7.50±6.61b	7.87±6.85ef	18.52±6.41d
Control	----------	----------	----------

The mean ± SD denotes the mean percent adjusted mortality from three replicates, each including ten people. Using Tukey's test, means between columns separated by the same letter do not differ substantially at the 5% level of significance.

Table 3: The antifeedant properties of the chosen plant extracts against *Helicoverpa armigera* larvae

Plant name	Concentration of extract (% W/V)		
	0.2%	**0.4%**	**1.0%**
A. paniculata	28.66±2.95de	35.44 ± 6.83ab	44.73 ± 8.55bc
C.halicacabum	12.67±1.44 c	12.42 ± 6.51 cd	17.12 ± 7.31d
C.tora	22.12±5.68c	46.61 ± 7.16a	52.72 ± 4.93ab
C.roseus	56.20±2.19a	50.92 ± 11.21a	72.21 ± 9.04a
D. metel	36.07±1.05b	43.57 ± 6.7a	49.39 ± 5.25b
E. riparium	12.83±0.83e	15.8 ± 9.85bc	17.31 ± 5.31d
M. micarantha	21.57±1.31cd	23.99 ± 6.03ab	25.26 ± 5.92cd
Control	----------	----------	----------

The mean ± SD shows the mean percentage of feeding deterrent over three replicates, each with ten individuals. Using Tukey's HSD test, means between columns separated by the same letter do not differ substantially at the 5% level of significance.

Fig 1: *Andrographis paniculata*

Fig 2: *Cardiospermum halicacabum*

Fig 3: *Cassia tora*

Fig 4: *Catharanthus roseus*

Fig 5: *Helicoverpa armigera* (Hubner)

Results

Bioassay for Toxicity

Table 2 displays the larvicidal activity of a methanol extract of several plant species. All plants exhibited dose-dependent increases in oral toxicity; *H. armigera* larvae died at the observed dosage of 1% w/v. Every plant studied had an average mortality of 18.64% in the methanol extract at a concentration of 0.2%. This and the control group's larval mortality were statistically similar ($p>0.05$). However, crude extracts of *A. paniculata*, *C. tora*, and *C. roseus* produced considerably greater mortality ($p < 0.000$) than the control at concentrations of 0.4% and 1% w/v. Among all the studied plants, *A. paniculata* extract exhibited the best larvicidal effectiveness against *H. armigera*, with modified losses ranging from 29.77% to 78.22% at all tested doses. Its larvicidal effectiveness was substantially higher than that of the control and other plants, except for D. metal ($p = 0.315$) and *C. tora* ($p = 0.672$) ($p < 0.05$). The methanolic extract of *C. tora* leaves demonstrated second oral toxicity to *H. armigera* larvae at the investigated dosages, with modified larval mortality ranging from 21.61% to 52.23%. At the maximum concentration of 1% weight/volume among the surviving plants, D. metal extract caused 11.35% larval mortality, which was considerably greater than the larval mortality in the control ($p=0.014$). D. metal therefore advanced to the position of third-best plant. *H. armigera* larvae, *A. paniculata* and *C. tora*, are poisonous to humans when eaten. However, the synthetic pesticide endosulfan 10% EC, which was employed as a control in this bioassay, showed a considerable improvement and resulted in 100% larval death after 24 hours of treatment ($p\leq0.000$). about herbal extracts.

Feeding deterrence bioassay

The antinutritional potential of three different concentrations of a crude extract of certain plants was examined. The nutritional inhibitory activity of plants was evaluated using the nutritional inhibitory index (FDI). A greater feeding inhibition score indicates that the test organism is eating less. Each plant showed a dose-dependent increase in feeding inhibition; nevertheless, regardless of the plant extract dosage examined, the control group's feeding suppression index was significantly lower than the plants' ($p < 0.0001$) (Table 3). *C. roseus* was the plant with the most anti-feeding effect; at the tested dosages, its crude extract reduced the rate at which *H. armigera* larvae fed by 56.20% to 72.21%. Additionally, its FDI was much greater (≤ 0.05 p). Crude extracts of *C. roseus* was the only plant whose high feeding was not repressed by crude extracts of *C. tora*, *D. metal*, or *A. paniculata*; this difference was significant ($p\leq0.05$). When exposed to *C. tora* extract, larval feeding was reduced by 36.07% to 49.39% at the doses examined, whereas FDI ranged from 22.12% to 52.72%. and at the studied dosages, *A. paniculata* extract decreased larval eating by a range of 28.66% to 44.73%.

Discussion

The results of the oral toxicity test show that the plant's crude methanol extract is significantly less larvicidal than the synthetic insecticide endosulfan 10% EC. However, as compared to the solvent control, which exhibited remarkable insecticidal efficacy against the infamous *H. armigera* larvae, four of the chosen plants considerably ($p < 0.05$) increased the rates of larval mortality and feeding suppression.

The findings of this study, which corroborate those of Prasad and Roy (2011), indicate that *A. paniculata* may function as a potent edible toxin and a feeding inhibitor for *H. armigera* larvae at higher doses. Researchers hypothesized that *A. paniculata* extract would operate as a stomach toxin in addition to having anti-nutritional effects on *H. armigera* larvae based on histological findings. Third-instar larvae of teak deciduous organisms killed 20–50% of the time after being exposed to essential oils for 24 hours at concentrations ranging from 2500–10,000 ppm, according to research by Murugesan *et al*. (2012) [48]. In another study, Spodoptera litura larvae in their fourth instar died to 100% of their death when exposed to an aqueous crude extract of L. camara leaves at a concentration of 40% (Deshmukhe *et al*., 2011) [10]. The results of these two studies, which showed that *A. paniculata*'s larvicidal activity increased with increasing concentration, are consistent with our current findings. Tennyson (2013) found that while the hexane and dichloromethane extracts showed less than 25% anorexia, the crude ethyl acetate extract of L. camara at a concentration of 1% indicated 25–50% eating inhibition in third-instar *Spodoptera litura* larvae. Our findings showed that the methanolic extract of *A. paniculata* was very active and inhibited feeding in 4-year-old *H. armigera* at a comparatively low dose of 0.4% by weight.

Nonetheless, research conducted by other authors has employed distinct test organisms, and several investigations have demonstrated that even closely related insect species can exhibit varying degrees of sensitivity to the same extract or substance. It might be one of the causes of the differences in the results between the present study's findings and those of the earlier ones. The insecticidal action of plants is assumed to be attributed to several phytochemical groups. The presence of several major groups of plant compounds may also be responsible for the varying efficaciousness of plant extracts against their target pests (Park *et al*., 2002; Lingatorai *et al*., 2011). The development and growth of herbivorous insects are impacted by all three classes of plant chemicals, as evidenced by studies conducted by Coley *et al*. (1985) [7], Barbehenn *et al*. (2001) [3], Hoffman-Campo *et al*. (2001) [16], Lago) *et al*. (2002) [37], and Trotter (2006). Moreover, terpenoid test results for extracts of *L. cubeba* and *L. camara* were positive. Terpenoids are very harmful to insects and primarily function as nutrients and growth inhibitors in plants (Kubo and Nakanish, 1978; Khalid *et al*., 1989) [32, 36]. However, a number of studies have shown that a class of plant compounds known as saponins possess insecticidal properties (Marston and Hostettmann, 1985; Jeong *et al*., 2004; Sparg *et al*., 2004; McGaw *et al*., 2008)

[24, 44, 46`]. Therefore, it's possible that the combined actions of all these different plant chemical kinds are what give the methanol extract of *C. roseus, A. paniculata, C. tora*, and *D. metal* its insecticidal and antifeedant properties. However, this preliminary study demonstrates the insecticidal effects of crude methanol extracts from four different plants. Future research should concentrate on determining the precise mechanism of action of these plants as well as discovering and isolating the bioactive compounds that give these plants their shown toxicity against the pests they are intended to suppress.

Conclusion

Out of the seven plants that were selected, four—*Cardiospermum halicacabum L., Cassia tora L., Catharanthus roseus L (G) Don., Datura metal L*., and *Eupatorium riparium—Andrographis paniculata* Ness.were used in the current study. It is capable of doing so. Given that *Mikania micaranta* showed encouraging insecticidal effect against *H. armigera* larvae, the evidence points to it being so. Through more study on the biological activities of these plants, the Center and the Government of Tamil Nadu, where state governments are urged to promote organic agriculture, can usually produce crop protection formulas that are both ecologically benign and inexpensive.

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