Journal of Entomology and Zoology Studies 2013; 1 (4): 87-96

Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

ISSN 2320-7078
JEZS 2013; 1 (4): 87-96

Received: 25-07-2013
Accepted: 08-08-2013

Antifeedant activity, developmental indices and morphogenetic variations of plant extracts against *Spodoptera litura* (Fab) (Lepidoptera: Noctuidae)

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ABSTRACT

Crude extracts of twenty five plants were screened for their antifeedant activitiy against the third instar larvae of *Spodoptera litura*. Among the plants tested, maximum antifeedant activity was noted in five promising plants *viz*., ethyl acetate extract of *Strychnos nuxvomica* (88.98), hexane extracts of *Vitex negundo* (86.41) and *Murraya koeingii* (81.46), ethyl acetate extract of *Zanthoxylum limonella* (80.58) and hexane extract of *Abrus precatorius* (78.61) while rest of the plants exhibited varying degree of moderate or lesser toxic effects at one per cent concentration. Amongst, the promising five plants tested, maximum and minimum time taken for larval period was recorded in hexane extract of *Vitex negundo* (23.73) and ethyl acetate extract of *Zanthoxylum limonella* (17.24) respectively and for pupation it was recorded in hexane extract of *Murraya koeingii* (13.12) and ethyl acetate extract of *Strychnos nuxvomica* (9.98) respectively. Adult longevity was maximum in hexane extract of *Murraya koeingii* (9.02) and minimum in ethyl acetate extract of *Strychnos nuxvomica* (7.29) from total number of larvae treated. The treated larvae were unambigusly smaller that its control counterpart and several deformities in head size, body length and darkened colouration on wings were observed.

Keywords: *Spodoptera litura*, antifeedant activity, developmental indices, morphogenetic variations, plant extracts.

1. Introduction

Man suffers extensively due to the nuisance of insect populations both in agriculture and health. In agriculture, insects affect directly the growing part of the crop and causes severe damage, resulting in revenue loss. Crop loss due to insect pests is estimated between ten and thirty per cent for major crops [1]. In a tropical country like India, owing to climatic conditions and its particular environment, agriculture is suffering from severe losses due to pests [2]. Considering the agro-ecosystems with an increase in population and dwindling land resources there is worldwide demand for natural insecticides to increase the agriculture production. Due to these problems, a search is going on to discover new, less damaging pest management tools [3]. Conventional synthetic organic pesticides are handicapped in the green context by their high toxicity, long term persistence and propensity of bioaccumulation [4]. Chemical pesticides have been used for several decades in controlling pests as they have a quick knock down effect. However, their indiscriminate use resulted in several problems such as resistance to pesticides, resurgence of pests, elimination of natural enemies, toxic residues in food, water, air and soil which affect human health and disrupt the ecosystem, leading to the threat that their continued use may further harm the environment. Under such alarming situations, plants and plant derived products offered a tremendous advantage over synthetic pesticides in use as control agents for the pests of agriculture, veterinary and public health since plant kingdom is the most efficient producer of chemical compounds, synthesizing many products that are used in defense against insects [2].

In recent years, attempts are being made to identify plants, including herbs and weeds, for their insecticidal property with a view to find out suitable alternatives to replace hazardous synthetic pesticides utilized in large scale in India. Great emphasis is given on the use of natural products, which are non-toxic, safe and biodegradable alternative to the conventional control of insects by synthetic pesticides [5]. In this juncture, bioactive compounds of plant origin are considered as ecologically safe alternative and the plant extracts with complex mixtures of

Compounds have been widely investigated for their insecticidal, repellent, ovicidal, antifeedant and antiovoposition properties [6, 7].

There is an increasing scientific interest in the role of secondary plant metabolites in insect-plant interaction, particularly in host acceptance and rejection [8]. While plant chemicals may produce toxic effects when ingested by insects, antifeeding activity may determine the extent of insect herbivory. Several papers have been published on the entomotoxic properties of crude extracts from different plant species [9, 10, 11, 12, 13].

Amongst various group of agricultural pest, *Spodoptera litura* is one major polyphagous pest which attacks economically important crops thereby causing extensive damage. *Spodoptera litura* (Fab). (Lepidoptera: Noctuidae) is a major pest of various economically important crops *viz*., cotton, groundnut, chilly, tobacco, castor and pulses [14] in India, China and Japan [15]. The search for plant derived chemicals that have potential use as crop protectants (insecticides, antifeedants, and growth inhibitors) often begins with the screening of plant extracts [16]. Therefore, the present study focuses on the antifeedant activity, developmental indices and morphogenetic variations of plant extracts against *Spodoptera litura*.

2. Materials and Methods

2.1 Collection of plants

A total of twenty five plants belonging to diverse families and genera were collected from Siruvani Hills (near Coimbatore) Western Ghats of Tamil Nadu, India. The plants were selected based on available literature, abundant availability, medicinal and insecticidal properties. List of plants collected and utilized for the present study are presented in Table 1.

2.2 Extraction of plant materials

Plants collected from various families were brought to the laboratory, washed with dechlorinated water, shade dried under room temperature and the plant materials were powdered individually using an electric blender. Each powdered plant material were sieved using a kitchen strainer. One kilogram of each powdered plant material was sequentially extracted with hexane, diethyl ether, dichloromethane and ethyl acetate for a period of seventy two hours and then filtered. The filtered content was then subjected to rotary vacuum evaporator until solvents were completely evaporated to get the solidified crude extracts. The crude extracts thus obtained were stored in sterilized amber coloured bottles maintained at 4 ºC in a refrigerator. Standard one per cent stock solution (10000 ppm) was prepared by dissolving 100 mg of crude extract in 100 ml of acetone.

2.3 Establishment of *Spodoptera litura*

Spodoptera litura egg masses were collected from the groundnut field at Vellore and Kancheepuram districts of Tamil Nadu, India. After egg hatching, castor (*Ricinus communis*) leaves were provided for larval feeding till the pupal stage under laboratory condition (28±2 ºC and 80±5% R.H.) (Figure 1). Sterilized soil was provided for pupation. After pupation, the pupae were collected from the soil and placed inside cage for adult emergence. Ten per cent honey solution mixed with few drops of multi-vitamin was provided for adult feeding to increase the rate of fecundity. Folded filter papers were provided for egg laying. After egg laying, egg masses were collected from the filter paper and was allowed for hatching. This process of culture method was repeated and the culture was maintained throughout the study period.

2.4 Antifeedant activity

Antifeedant activities of plant extracts were studied using leaf disc no choice bioassay method. Fresh castor leaf disc (1350sq.mm) were dipped in one per cent concentration of each plant extracts. After solvent evaporation at room temperature, leaf disc was kept in individual petriplate (9 cm dia). In each petriplate a single pre starved third instar larva of *Spodoptera litura* was introduced. The larva was allowed to feed on treated discs for twenty four hours (Figure 2). The leaf discs sprayed with acetone and water served as negative and positive control respectively. A total of three trials with five replicates per trial were carried. At the end of the experiment, unconsumed area of leaf disc was measured with the aid of a leaf area meter and per cent antifeedant activity calculated based on the formula of Singh and Pant [17] and data subjected to analysis of variance. Larval mortality and pupal deformities were also recorded.

$$\textbf{Per cent antifeedant activity} = \frac{\text{Leaf disc consumed by the larvae in control} - \text{Leaf disc consumed by the larvae in treated}}{\text{Leaf disc consumed by the larvae in control} + \text{Leaf disc consumed by the larvae in treated}} \times 100$$

$$\textbf{Per cent larval mortality} = \frac{\text{Number of dead larvae}}{\text{Total number of treated larvae}} \times 100$$

2.5 Developmental indices

Developmental indices of *Spodoptetra litura* third instar larvae was studied by treating castor leaves with crude extracts of plants which showed promising antifeedant activity at 0.05% concentration. Fresh castor leaf was dipped in 0.05% concentration of ethyl acetate extracts of *Strychnos nuxvomica* and *Zanthoxylum limonella* and hexane extracts of *Abrus precatorius, Murraya koeingii* and *Vitex negundo* and then placed in a glass trough containing twenty third instar larvae. After twenty four hours of feeding the larvae were transferred to fresh castor leaves and were grown up to adult. Acetone and water treated leaves were considered as negative and positive control respectively. A total of three trials were carried with five replicates per trial. At the pre-pupal stage, each trough was provided with 2 to 3 inch of thick sterilized moist sand for pupation. Pupae were kept individually in separate glass troughs for adult emergence. Adults were provided with twenty per cent sucrose solution soaked in cotton which served as food. The pupal period, adult longevity, per cent pupation, per cent adult emergence from larvae and pupae, sex ratio were recorded and growth index calculated.

$$\text{Growth index} = \frac{\text{Per cent pupation}}{\text{Average duration of larval period}}$$

2.6 Morphogenetic variations
Observation was continued in treated and control pupae kept separately in glass trough for adult emergence. Morphological abnormalities of adults from treated and control were compared. Any notable difference in appearance between treated and control was recorded as deformity.

3. Results
3.1 Antifeedant activity
Antifeedant activity of crude plant extracts was assessed based on antifeedant index. Higher antifeedant index normally indicate decreased rate of feeding. In the present study, the antifeedant activity varied significantly based on the solvents used for extraction. Antifeedant effects of different plant extracts were evaluated based on leaf area consumed by *Spodoptera litura*. Table 2 lists out the antifeedant effect of various plant species tested. Increase in number of plus signs against the extracts of a plant reflects the degree of antifeedant activity. Among the twenty five plant species tested, the extracts of *Abrus precatorius*, *Murraya koeingii*, *Strychnos nuxvomica*, *Vitex negundo* and *Zanthoxylum limonella* were found to be effective against the third instar larvae of *Spodoptera litura.* Maximum antifeedant activity was recorded in ethyl acetate extract of *Strychnos nuxvomica* (88.98), hexane extracts of *Vitex negundo* (86.41), and *Murraya koeingii* (81.46), ethyl acetate extract of *Zanthoxylum limonella* (80.58) and hexane extract of *Abrus precatorius* (78.61) whereas minimum in diethyl ether extracts of *Abrus precatorius* (40.51), *Murraya koeingii* (22.35), *Strychnos nuxvomica* (21.15) and dichloromethane extracts of *Vitex negundo* (20.78) and *Zanthoxylum limonella* (15.88%) (Table 3).

3.2 Developmental indices
Spodoptera litura third instar larvae treated with 0.05% concentration of ethyl acetate extracts of *Strychnos nuxvomica* and *Zanthoxylum limonella* and hexane extracts of *Abrus precatorius*, *Murraya koeingii* and *Vitex negundo* for twenty four hours were then transferred to fresh castor leaves to record the time taken for larval duration (in days), pupal duration (in days), adult longevity (in days) and egg hatchability (in days). Among the promising five plants tested, maximum time taken for larval period was recorded in hexane extract of *Vitex negundo* (23.73) and minimum in ethyl acetate extract of *Zanthoxylum limonella* (17.24). Maximum time taken for pupation was recorded in hexane extract of *Murraya koeingii* (13.12) and minimum in ethyl acetate extract of *Strychnos nuxvomica* (9.98). However, in all five promising plants, larvae showed more time for pupation when compared to control (Table 4).

Table 1: List of plants collected from Siruvani hills, Western Ghats, Tamil Nadu, India

S.No.	Plant name	Family	Vernacular name (Tamil)	Part used
1.	*Abrus precatorious* Linn	Papilionaceae	Kundumani	Seed
2.	*Aegle marmelos* (L) Corr	Rutaceae	Vilvam	Leaf
3.	*Alstomia scholaris* (L) R Br	Apocynaceae	Mukampalai	Leaf
4.	*Aristolochia indica* Linn	Aristolochiaceae	Karudakkodi	Root
5.	*Cassia fistula* Linn	Caesalpiniaceae	Sarakonnai	Flower
6.	*Cinnamomum zeylanicum* Breyn	Lauraceae	Sirunagapoo	Bark
7.	*Cleistanthus collinus* (Roxb) Benth	Euphorbiaceae	Oduvan	Leaf
8.	*Cymbopogon citrates* (Dc) Stapt	Poaceae	Vasanapullu	Whole plant
9.	*Drosera indica* Linn	Droceracea	Azukanni	Leaf
10.	*Evolvulus alsinoides* (L) Linn	Convolvulaceae	Vishnukarandi	Whole plant
11.	*Garcinia morella* (Gaertn) Desr	Clusiaceae	Makki	Leaf
12.	*Hydrocotyle javanica* Thunb	Apiaceae	Malaivallarai	Leaf
13.	*Ichnocarpus frutescens* (L) R Br	Apocyanaceae	Palvalli	Leaf
14.	*Lantana camara* Linn	Verbenaceae	Unnichedi	Leaf
15.	*Leucas aspera* (Willd) Link	Lamiaceae	Thumbai	Whole plant
16.	*Memecylon malabaricum* (Cl) Cong	Melastomataceae	Malamthetti	Leaf
17.	*Murraya koeingii* (L) Spreng	Rutaceae	Kariveppilai	Leaf
18.	*Ocimum americanum* Linn	Lamiaceae	Nayithulasi	Whole plant
19.	*Plumbago zeylanica* Linn	Plumbaginaceae	Neelakodaveri	Leaf
20.	*Sphaeranthus indicus* Linn	Asteraceae	Kottakkarandai	Whole plant
21.	*Strebulus asper* Lour	Moraceae	Pirayam	Leaf
22.	*Strychnos nuxvomica* Linn	Loganiaceae	Yetti	Fruit
23.	*Syzygium cumini* (L) Skeets	Myrtaceae	Neredom	Leaf
24.	*Vitex negundo* Linn	Verbenaceae	Notchi	Leaf
25.	*Zanthoxylum limonella* (Roxb) Dc	Rutaceae	Veersingapattai	Bark

Longevity (in days) of the adults was reduced in treated individuals when compared to control. Adult longevity was maximum in hexane extract of *Murraya koeingii* (9.02) and minimum in ethyl acetate extract of *Strychnos nuxvomica* (7.29) from total number of larvae treated. Average female longevity was more when compared to male in all treated individuals. The sex ratio was also observed after adult emergence (Table 4).

Per cent pupation was maximum in ethyl acetate extract of *Strychnos nuxvomica* (46.70) and minimum in hexane extract of *Abrus precatorius* (19.72). Per cent adult emergence was very low from the larvae when compared to pupae. Adult emergence from larvae was 6.72 from the hexane extract of *Abrus precatorius* and 19.24% from the ethyl acetate of *Strychnos nuxvomica*. Per cent pupae resulted very low in all five plants tested thus indicating high mortality during larval-pupal moulting. This indirectly indicates the presence of certain substances which hinder the formation of pupa (Table 5).

3.3 Morphogenetic variations

Visible metamorphic abnormalities occurred among the larvae exposed to 0.05% concentrations of the extracts of promising five plants used. The treated larvae and pupae were unambigusly smaller that its control counterpart and several deformities in head size, body length and darkened colouration on wings of the adults which emerged from the treated pupae were observed (Figure 3a, 3b, 4a, 4b, 5a, 5b).

Table 2: Screening of plant extracts at 1.0% concentration for antifeedant activity against *Spodoptera litura*

S.No.	Plant	Hexane	Diethyl ether	Dichloromethane	Ethyl acetate
1	*Abrus precatorious*	++++	++	++	+++
2	*Aegle marmelos*	++	+	-	++
3	*Alstomia scholaris*	-	-	-	+
4	*Aristolochia indica*	+	+	-	+
5	*Cassia fistula*	+++	-	-	++
6	*Cinnamomum zeylanicum*	++	-	-	++
7	*Cleistanthus collinus*	+++	-	+	++
8	*Cymbopogon citrates*	++	-	+	+++
9	*Drosera indica*	-	-	-	+
10	*Evolvulus alsinoides*	++	-	-	++
11	*Garcinia Morella*	-	-	-	++
12	*Hydrocotyle javanica*	-	-	-	-
13	*Ichnocarpus frutescens*	++	-	+	++
14	*Lantana camara*	+	-	+	++
15	*Leucas aspera*	+	-	-	-
16	*Memecylon malabaricum*	-	+	-	-
17	*Murraya koeingii*	++++	+	+	+++
18	*Ocimum americanum*	+	-	-	++
19	*Plumbago zeylanica*	++	-	-	+
20	*Sphaeranthus indicus*	+	-	-	-
21	*Strebulus asper*	++	-	-	+
22	*Strychnos nuxvomica*	+++	+	++	++++
23	*Syzygium cumini*	+	-	+	+++
24	*Vitex negundo*	++++	++	+	+++
25	*Zanthoxylum limonella*	+++	+	+	++++

- No antifeedant activity
+ Antifeedant activity below 25%
++ Antifeedant activity between 25-50%
+++ Antifeedant activity between 50-75%
++++ Antifeedant activity above 75%

Table 3: Per cent antifeedant activity of promising plant extracts against *Spodoptera litura*

Plants	Hexane	Diethyl ether	Dichloromethane	Ethyl acetate
Abrus precatorius	78.61 ±4.46[c] (62.44)	40.51 ±6.17[b] (39.52)	41.23 ±5.71[b] (39.93)	66.26 ±9.18[c] (54.45)
Murrya koeingii	81.46 ±4.32[d] (64.45)	22.35 ±3.96[b] (28.18)	24.27 ±3.94[b] (29.47)	73.30 ±3.07[c] (58.89)
Strychnos nuxvomica	74.35 ±5.57[c] (59.54)	21.15 ±3.79[b] (27.35)	39.75 ±6.83[b] (38.88)	88.98 ±1.66[d] (70.54)
Vitex negundo	86.41 ±1.99[d] (68.36)	37.36 ±3.24[b] (37.64)	20.78 ±3.19[b] (27.06)	68.13 ±6.39[c] (55.61)
Zanthoxyllum limonella	69.93 ±3.88[c] (56.73)	18.38 ±2.39[b] (25.33)	15.88 ±4.41[b] (23.42)	80.58 ±4.42[d] (63.79)
Control (-)	6.13 ±4.24[a]	3.98 ±3.26[a]	3.21 ±1.85[a]	3.28 ±1.58[a]
Control (+)	2.42 ±2.40[a]	2.34 ±2.40[a]	2.32 ±3.00[a]	2.86 ±2.68[a]

Values are mean of the five replicates of three trials ±Standard deviation; Values in parentheses are angular transformed; ANOVA followed by TUKEY test performed; Different superscripts in the column indicate significance difference at P <0.05 levels.

Table 4: Developmental period (days) and sex ratio of *Spodoptera litura* on promising plant extracts at 0.05% concentration

Plant extracts	Average larval periods (in days)	Average pupal periods (in days)	Average male longevity (in days)	Average female longevity (in days)	Average adult longevity (in days)	Sex ratio
Abrus precatorius (Hexane extract)	22.60	11.03	8.04	9.40	8.24	1.41: 1
Murraya koeingii (Hexane extract)	21.19	13.12	8.89	9.12	9.02	0.67 : 1
Vitex negundo (Hexane extract)	23.73	10.09	7.73	8.31	8.09	0.94: 1
Strychnos nuxomica (Ethyl acetate extract)	19.50	9.98	6.12	8.46	7.29	0.62: 1
Zanthoxylum limonella (Ethyl acetate extract)	17.24	11.19	7.51	8.96	8.23	0.74: 1
Control (-)	15.04	8.12	12.60	10.80	9.70	1.09: 1
Control (+)	16.06	8.66	12.82	10.54	10.21	0.84: 1

Table 5: Per cent pupation, adult emergence and growth index values of *Spodoptera litura* against promising plant extracts at 0.05% concentration

Plant extracts	Per cent pupal formation	Adult emergence (%)		Growth index
		From larvae	From pupae	
Abrus precatorius (Hexane extract)	19.72	6.72	42.80	0.85
Murraya koeingii (Hexane extract)	20.14	8.63	16.28	0.95
Vitex negundo (Hexane extract)	36.15	12.18	37.10	1.52
Strychnos nuxomica (Ethyl acetate extract)	46.70	19.24	29.18	2.39
Zanthoxylum limonella (Ethyl acetate extract)	23.12	13.0	41.69	1.34
Control (-)	97.74	92.14	96.71	6.49
Control (+)	98.93	93.25	98.14	6.16

4. Discussion

Antifeedant activity of botanicals against insects has been studied in many countries. Quantification of antifeedant effect of botanicals is of great importance in the field of insect pest management. From an ecological point of view, antifeedants are very important since they never kill the target insects directly and allow them to be available to their natural enemies and help in the maintenance of natural balance. Higher antifeedant index normally indicate decreased rate of feeding. Antifeedant is a chemical that inhibits the feeding without killing the insect pests directly, while it remains near the treated foliage and dies through starvation [18, 19]. Antifeedant chemicals play a major role in the unsuitability of non-host plants as food for insects [20]. Unsuitable plants are avoided by detection of other chemical cues; such chemical substances may have repellent or toxic properties against insects [21].

According to Isman [22], the concept of using insect antifeedants as crop protectants is intuitively attractive. For most antifeedants, the modes of action are directed at the taste cells. A typical gustatory sensillum in an insect contains receptors selective for deterrents and others for stimulants (sugars and amino acids). Although most antifeedants likely act by stimulating a deterrent receptor, that in turn sends a signal ("do not feed") to the feeding center in the insect's central nervous system, some antifeedants are thought to block or otherwise interfere with the perception of feeding stimulants, whilst others may cause erratic bursts of electrical impulses in the nervous system preventing the insect from acquiring appropriate taste information on which it may choose an appropriate feeding behavior.

Antifeedants offer first line of crop protection against notorious insects. Any substance that reduces food consumption by an insect can be considered as an antifeedant or feeding deterrent [22]. In general, antifeedants have profound adverse effects on insect feeding behavior [23]. Antifeedants can be described as allomone substances which inhibit feeding and do not kill the insect pests directly, but rather limit its developmental potential considerably and act as a phagodeterrent or phagorepellent over test as well as permanent insect pests feeding on the plant [24]. Plant substances acting as antifeedants are found in all the compound groups of secondary plant metabolism. However, the most effective insect feeding inhibitors come from terpenoids, alkaloids, saponins and polyphenols [25]. Several plant secondary metabolites are known antifeedants and they possess various chemicals such as triterpenes [26], sesquiterpene lactones and alkaloids [27], cucurbitacines, quinines and phenols [28]. Some plant families include numerous species containing bioactive substances, amongst which are volatile oils especially terpenes [29] are reported to contain antifeedant properties against various lepidopteran agricultural pests.

Discovery of novel toxins and/or antifeedants from plant extracts has been recently emphasized as a potential method for the development of "ecologically safe pesticides" [30]. There is ample precedent for screening crude plant extracts for biological activity as botanical insecticides against lepidopterans. Results obtained from the leaf disc bioassays may be more reliable because the quality of plant's surface plays a crucial role in determining the acceptance or avoidance [31, 32].

In many countries, plant derived products are being used by the farmers from ancient times and it triggered the scientists to search for ecofriendly insecticides from plant kingdom. Crude extracts from the leaf, stem, root and seeds of various plant species have been reported to possess antifeedant, insecticidal, and/or growth inhibitory properties [33]. Crude extracts of plants often consist of complex mixtures of active principles [34] and most potent insect antifeedants are sesquiterpene lactones, diterpinoids, triterpinoids, quinoline and indole alkaloids [35]. Hummelbrunner and Isman [23] reported that synergistic effects of complex mixtures (crude extracts) of phytochemicals are also thought to be important in plant defenses against insect herbivores.

In the present investigation, the food consumption of third instar larvae of *Spodoptera litura* treatment was highly reduced by the extracts of *Abrus precatorius*, *Murraya koeingii*, *Strychnos nuxvomica*, *Vitex negundo* and *Zanthoxylum limonella.* Maximum antifeedant activity was recorded in ethyl acetate and hexane whereas minimum in diethyl ether and dichloromethane extracts. Frazier [36] signified that antifeedants can be found amongst all the major classes of secondary metabolites *viz*., alkaloids, phenolics and terpenoids which are the most probable toxic substances against insects. The ethyl acetate extract of the plant reduced the feeding rate of *Spodoptera litura*. This indicated that the active principles present in the plants inhibit larval feeding behaviour or make the food unpalatable or the substances directly act on the chemosensilla of the larva resulting in feeding deterrence.

Several investigators have already reported that botanicals offer antifeedant activity against *Spodoptera litura* [12, 37, 38]. Mikolajczak and Reed [39] stated that the seed extracts of *Trichilia prieureana*, *Trichilia roka* and *Trichilia connaraides* exhibited high levels of antifeedant activity in leaf disc method against *Spodoptera frugiperda*. The extract of *Adhatoda vasica* leaves was found to have feeding deterrent properties when applied on leaf disc method [10].

Caasi [40] observed the water extract of *Aristolochia tagala* to exhibit antifeedant activity against *Spodoptera litura*. Sahayaraj [41] reported that plant extracts of *Azadirachta indica*, *Citrus sinensis*, *Vitex negundo* and *Zingiber officinale*, were evaluated for their antifeedant and growth inhibition of *Spodoptera litura*. Deterrent effects were found in all plant extracts. The strongest deterrent effect was found in *Vitex negundo* and was indicated by very low food consumption and digestibility, faecal pellets production, and reduced body weight. The methanol extract of *Melia dubia* inhibited growth and exhibited antifeedant activity [42]. The crude methanolic extract of *Trichilia* a*mericana* also exhibited strong antifeedant activity against *Spodoptera litura* [43]. The root extracts of *Pedalium murex* exhibited good antifeedant activity against *Spodoptera litura* [44]. Elumalai *et al*. [45] also reported that the hexane extract of *Acorus calamus* leaf showed highest and significant antifeedant activity (77.8%) followed by *Lobelia leschenaultiana* on *Spodoptera litura*. Devanand and Rani [46] reported that acetone extracts of fifteen plant leaves showed excellent antifeedant and toxic properties against *Spodoptera litura*. Recently, Anandan *et al*. [47] reported *Hyptis suaveolens* and *Melochia corchorifolia* of all fractions to exhibit antifeedant activity against *Spodoptera litura*. Krishnappa *et al*. [48] reported *Tagetes patula* essential oil against the fourth instar larvae of *Spodoptera litura* for their antifeedant activity by leaf disc bioassay. The leaf and root extracts of *Aristolochia tagala* revealed a higher antifeedant activity (56.06%) against *Spodoptera litura* [49]. Duraipandiyan *et al*. [50] reported antifeedant activities of rhein isolated from *Cassia fistula* flower against lepidopteran pests *Spodoptera litura* and *Helicoverpa armigera* with significant antifeedant activity at 1000 ppm concentration. Pavunraj *et al*. [51] stated that leaf extract and its column eluted ethyl acetate fraction from *Pergularia daemia* exhibited good antifeedant activity against *Spodoptera litura*.

Due to the toxic effect of plant extracts, maximum number of treated larvae died inspite of less food consumption. Leatemia and Isman [34] reported that high concentrations of extracts caused high mortality of larvae even though only very small portions of the leaf discs were consumed. Warthen *et al*. [52] reported neem seed kernel extract showed insecticidal, antifeedant and growth regulatory properties against many species of lepidopteran larvae. The crude extract of *Aristolochia elegans* against *Spodoptera litura* showed pronounced deformation and malformation in the larval, pupal and adult stages and were toxic and growth inhibitory [53]. Malarvannan *et al*. [54] observed that *Argemone mexicana* extracts reduced adult emergence and increased pupal mortality in *Spodoptera litura*. In conclusion, extended larval and pupal days and also adult longevity could either be due to the presence of toxic ingredients in the extract or the imbalances between growth stimulating and growth inhibiting hormones. It is not clear whether mimicking of the juvenile hormone is due to blocking hormone degradation or to some other physiological interference which is in agreement with the reports of Ray *et al*. [55]. The results obtained from the present investigation clearly suggests that further studies on isolation and identification of the active antifeedant principle present in the promising five plants will emerge as an alternative method or tool for the control of *Spodoptera litura*.

Figure 1: Rearing and culturing of *Spodoptera litura* larvae on *Ricinus communis* leaves

Figure 2: Antifeedant bioassay (Leaf disc no choice bioassay method)

Figure 3a: Healthy larva of *Spodoptera litura*

Figure 3b: Treated larvae of *Spodoptera litura*

Figure 4a: Healthy pupa of *Spodoptera litura*

Figure 4b: Treated pupae of *Spodoptera litura*

Figure 5a: Healthy adult of *Spodoptera litura*

Figure 5b: Treated adult of *Spodoptera litura*

5. Acknowledgements

The first author is thankful to Dr. Gunasekaran, Vice-Chancellor,

Dr. M. Jayakumar, Registrar and Dr. B. Senthilkumar, Professor and Head, Department of Zoology, Thiruvalluvar University for giving opportunity to continue and carry research in the above mentioned University.

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