Results
RESULTS

(A). Dysdercus koenigii:

Normal life cycle: the pest is active throughout the year and in winter the growth is retarded to some extent. The female lays on an average of 100-160 eggs in loose irregular masses of 70-80 each in moist sand. Eggs are spherical, yellowish-white about 1.2 mm in size and are hatched into active 1 mm long red coloured nymph. As the nymph grow older and changes to next instar, they become more slender and develop black marking on the body. There are five nymphal stages and the final 5th instar moulted to adult which is characterized by developed wings. Development is completed in 40-80 days and the pest completes five generations in a year. The eggs, different instars and normal adult of *Dysdercus koenigii* is shown in Fig 7 (A-F).

(1) Toxicity of Andalin (flucycloxuron)

1.1 Effects on survival rate and mortality:

The mean of the total nymphal mortality and adult mortality by the application of different concentrations of Andalin (flucycloxuron) on 5th instar nymphs of *Dysdercus koenigii* along with control (acetone) and untreated insects is given in Table 1. The highest concentration i.e. 0.1% Andalin gave 21 % nymphal mortality after 24 hours of treatment which comprises 96% of the total mortality upto adult emergence and the
survived 4% adult died with malformed wings. The lowest concentration (0.0025%) showed only 3% mortality within 5th instar which is 2% less than the control, but the total mortality before adult emergence with 0.0025% Andalin was higher (23%) in comparison to control (1.05%) and untreated insects (1.01%). Fig 1. shows the regression between concentration strength and nymphal death of 5th instars which yield a positive linear correlation (y = 167.66x + 5.4542, R² = 0.9013). The mortality during 5th instar nymph-adult moult was quite high i.e. 94.94%, 76.47% and 56.82% at concentrations of 0.1%, 0.05% and 0.025% Andalin respectively (Fig 2) and the concentration v/s mortality during 5th-adult moult showed a linear positive correlation (y = 729.12x + 29.413, R² = 0.9053). The Lc50 and Lc90 values of Andalin during 5th-adult moult were found to be 0.012% and 0.094% respectively (Table 1). The total mortality upto adult emergence was highest at 0.1% Andalin i.e. 96% and lowest at 0.0025% Andalin i.e. 23% (Fig 3). The nymphal mortality of Dysdercus koenigii with the application of Andalin was found to be dose-dependent. The mean total mortality of the control insects upto adult emergence was 1.50±0.28 and is 4% more than the mortality of untreated batch (0.50±0.28) which may be due to acetone irritability (Table 1). Fig 4. shows the total number of adult emerged after complete moulting. The lowest dose of Andalin (0.0025%) produced maximum number of adults i.e. 77% whereas the highest dose produced only 4%. Out of the 77% adults formed at lowest concentration 18.18% were malformed and rest 81.82% showed no morphogenic abnormalities. The regression between concentration v/s malformed adults showed positive linear correlation (y = 793.11x + 25.161, R² = 0.9563) (Fig 5).
1.2 Effect on moulting and metamorphosis:

The bar diagram (Fig 6) represents the mortality during 5th–adult moult of Andalin treated 5th instar nymphs which is in the order of 0.1% > 0.05% > 0.025 > 0.01 > 0.005 > 0.0025%. The mortality during 5th instar nymph to adult moult is due to incomplete or partial moulting and finally death of the intermediate within 24-48 hours of moulting (Fig 9-14). The 5th instar nymphs which died also showed some dose-dependent morphogenic abnormality such as shrunk abdomen (Fig 8-A) or swollen abdomen (Fig 8-B). The malformation during 5th–adult moulting with 0.1% Andalin treated 5th instar nymph is shown in Fig 9 (A and B). The deformity includes incomplete moulting which is characterized by old cuticle (exuviae) attached to the last few segments of the abdomen, legs, proboscis, antennae etc., also the body was deformed (Fig 9-B). In the lower concentrations of Andalin i.e., 0.05%, 0.025% and 0.01%, partial moulting occurred where the exuviae failed to detach from the lower region of the body. The body did not curve too much as in case of higher concentrations, only slightly deformed body was seen (Fig 10-A, 11-A, 12-A). Abnormality of wings which includes crumpled wings also occurred (Fig, 10-B, 11-B & 12-B). At a concentration of 0.005 % Andalin, the exuviae remained attached only to the legs (Fig 13-B), Fig 13-A shows crippled, totally damaged forewings which is extremely reduced in size with the treatment of 0.005% Andalin. In case, where complete ecdysis occurred, different types of wings and legs abnormality were observed. With the application of 0.0025% Andalin, the adults showed wings and legs deformation (Fig 14-B). The forewings and hindwings looks crumpled and reduced in size as compared to the normal adult (Fig 7-F). Also, the deformity of the legs were
seen and sometimes the legs became either straight or curved whereas in normal adults
the legs are bent at a certain angle (Fig 7-F).

1.3 Effects on fecundity and hatchability:

At 0.1% Andalin concentration only 4% adult emerged which possessed malformed
wings and legs and died within 24 hours of emergence that is why no mating occurred
and hence no fecundity. In case with 0.05 % and 0.025 % Andalin treatment, normal
adult emergence was only 30 % and 47.37 % respectively. In the former dose (0.05%) the
apparently normal adults thus formed could not survived more than 24-48 hours and
during this period no mating occurred and ultimately no oviposition. Whereas, in the later
concentration (0.025%) though normal adults mated but they failed to lay eggs and died
within 4-5 days. Therefore, no fecundity was recorded in the females emerged from 5th
instar nymphs treated with 0.1%, 0.05% and 0.025% Andalin. At lower concentrations of
Andalin i.e. 0.01%, 0.005% and 0.0025%, an average of 27.75±1.25, 38.74±0.85 and
47.75±1.70 number of eggs were laid as compared to control and untreated females
which laid an average of 132.25±0.85 and 144.25±1.49 eggs respectively (Table 2). The
reduction in the fecundity was statistically significant at 0.01% (t=8.2929, P< 0.01),
0.005% (t = 10.4641, P< 0.01) & 0.0025% Andalin (t=8.1319, P< 0.01). The average
number of eggs laid by the females emerged from 0.01% Andalin treated 5th instar
nymphs dropped to more than quarter (approximately) of the control and about one-fifth
of the untreated. The females emerged from the lowest concentration (0.0025%) of
Andalin treated 5th instar nymphs also showed more than half and one-third decrement in
the average number of eggs laid as compared to controlled and untreated fecundity respectively.

1.4 Effects on female reproductive system and development of ovarioles of *Dysdercus koenigii*:

The reproductive system of *Dysdercus koenigii* consists of a pair of ovaries. Each ovary is composed of seven separate egg-tubes or ovarioles (Ov) which open into lateral oviduct (LO). The lateral oviduct of each side join to form median oviduct (MO) which open posteriorly into a genital chamber. The genital chamber develops to form bursa copulatrix for reception of the male genitalia. Spermatheca is also present for storage of the sperm and a pair of accessory glands open into genital chamber (Fig 15-A & B).

A single ovariole is divided into 4 distinct region (i) Terminal filament (TF): which is a thread-like apical prolongation of the peritoneal layer (ii) Germarium (Gr): forms the apex of an ovariole, below the terminal filament and housing anteriorly the nurse cells and posteriorly the young oocytes. (iii) Vitellarium (Vt): constitutes the major portion of an ovariole and composed of a series of oocytes in their follicular sheaths, which become progressively large towards the posterior end, and (iv) Pedicel (Pd): in which the mature eggs are lodged before passing into the lateral oviduct. (Fig 15 A & B).

The ovarioles of the female emerged from different concentrations (0.01%, 0.005% and 0.0025%) of Andalin treated 5th instar nymphs of *Dysdercus koenigii* showed several
disrupted structures. The germarium and vitellarium portion showed either complete of partial damage with resoption of few or all oocytes. (Fig 16, 17 & 18).

The histological longitudinal section of an ovariole of normal *D. koenigii* showed meroistic-telotrophic ovariole which is surrounded by an epithelial sheath (ES), (Fig 19-A) and a inner thin elastic membrane called tunica propria (TP), (Fig 23-C) which covers whole of the ovarioles and the terminal filament. Meriostic-telotrophic ovarioles are characterized by the presence of trophic tissue as well as oogonia and oocytes in the distal germarium and each oocyte is connected to the germarium by a cytoplasmic nutritive cord which extends to the trophic core (TC) (Fig 19-A). Proximal to the trophic tissue (germarium) is the vitellarium which consists of the oocytes (Oc) and the prefollicular tissues (PFT). The longitudinal section of a normal ovariole at different magnifications (50X, 100X and 400X) is shown in Fig 19 (A, B & C). The normal germarium of an ovariole of *Dysdercus koenigii* contains prefollicular tissue and the stem line oogonium. The oogonium develops into an oocyte and as the oocytes passes down the ovariole they enlarge. The oocyte (Oc) leaving the germarium clothed by the prefollicular tissue which forms the follicular epithelium (FE) (Fig 19-B). Oocyte growth continues and the follicular epithelium keeps pace by cell division and the cells become cuboid or columnar. During previtellogenesis, the nutritive cord breaks and the follicle cells (FC) form a complete layer around the oocyte. The cytoplasm of the oocytes contain few microtubules, small Golgi complexes and profuse network of endoplasmic reticulum and many free ribosomes. Finally, as the process of vitellogenesis (vitellarium) proceeds, deposition of yolk in the oocytes occurs (Fig 19-C) in the more proximal parts of the
ovariole which results in increase in size of the oocytes and then the follicle cells become 
stretched over the oocyte as a flattened, squamous epithelium. Numerous yolk spheres 
(YS), lipid droplets and vacuoles are present in the mature oocytes of the normal ovariole 
of *Dysdercus koenigii* (Fig 23- A,B & C).

The ovarioles of females of *Dysdercus koenigii* emerged from treated 5th instar nymphs 
with varying concentrations of Andalin (0.01%, 0.005% and 0.0025%), showed alteration 
in structure of the ovariole (Fig 20, 21 & 22). The epithelium sheath (ES) of an ovariole 
was found to be disrupted (Fig 20-A, 21-A & 22-A), it was almost reduced to a thin 
membrane without any distinct cells. The epithelium lost its cytological organization and 
intercellular spaces (ICS) can be seen in the follicular epithelium. Occasional breakage of 
the follicular epithelium (FE) was observed in the longitudinal section of the ovariole of 
female adults of treated 5th instars nymphs (Fig 20-A, 21-A & 22-A). Also the uniform 
deposition of the yolk in the oocytes was not seen and clumping of the yolk spheres (YS) 
was observed as compared to normal (control) ovarioles. The yolk was markedly shrunk 
and acquired several vacuoles indicating the resorption of the yolk or the reduction in its 
synthesis and deposition due to Andalin treatment (Fig 20-B, 21-B & 22-B). 

Ultrastructure under transmission electron microscope (Fig 23-A) of the control ovariole 
revealed accumulation of large amount of yolk in the oocytes of a meroistic-telotrophic 
ovariole of *Dysdercus koenigii*. The yolk was in the form of small and large spheres 
uniformly distributed in the oocytes. Also the yolk spheres were densely packed in the 
oocytes of an ovariole. Whereas in case of ovarioles of the female of treated nymphs with 
different concentrations (0.01% and 0.0025%) of Andalin, the disruption of the yolk in
the oocytes was seen. Moreover, there were apparent reduction in the amount of the yolk and even the mature oocytes showed the formation of prominent gaps or vacuoles like structure (Fig 24 & 25).
(2) Toxicity of *Triticum vulgaris* lectin (WGA):

The lectin was initially dissolved in deionized water to prepare 1% stock solution but it is diluted in acetone so as to prepare desired concentrations for application on 5th instar nymphs of *Dysdercus koenigii*. Acetone is chosen as suitable solvent because acetone has the property of easily penetrating through the cuticle. 2μl of three concentrations of lectin viz., 0.5%, 0.25% and 0.125% were applied topically on the 5th instar nymphs. The 5th instar nymph treated with *Triticum vulgaris* lectin showed low mortality at all the above mentioned concentrations compared to negligible mortality of control and untreated nymphs. The died 5th instar nymphs did not show any morphological change during mortality. No deterioration in the nymphal growth and nymphal period occurred. The treated 5th instar nymphs with *Triticum vulgaris* lectin at different concentrations (0.5%, 0.25% and 0.1%) moulted successfully and emerged out as normal adults. No morphogenic deformity during molting has occurred. The longevity of the adult emerged from the treated *Triticum vulgaris* lectin was found to be similar as in control and untreated. The lectin did not influence adult emergence as no inhibition of adult formation occurred. Survived adult did not show any remarkable abnormality and mated successfully. The ovary of the females of the lectin treated nymphs showed normal anatomy and histology as the meriostic-telotrophic ovarioles and no alteration/aberration during development occurred. The mated females laid normal number of eggs and the eggs hatched within 4-5 days. The F1 generation of the treated 5th instar nymphs survived and flourished normally under maintained lab conditions. The *Triticum vulgaris* lectin which is a glycoprotein did not show any remarkable abnormality like anti-nutritive,
deterrent, insecticidal and growth inhibitory effects during the development of *Dysdercus koenigii* via topical treatment.
Table 1. Showing nymphal mortality and adult malformation following the topical application of different concentrations of Andalin on freshly moulted (12-16 hours) 5th instar nymphs of Dysdercus koenigii.

<table>
<thead>
<tr>
<th>Concentration (%)</th>
<th>Nymphal mortality (Mean±SE)</th>
<th>Values of Lc50 and Lc90</th>
<th>Total mortality upto adult emergence (Mean±SE)</th>
<th>Total number of adult emerged (Mean±SE)</th>
<th>Number of adult with malformed wings (Mean±SE)</th>
<th>Total number of normal adults formed (Mean±SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>5.25±0.25</td>
<td>18.75±0.25</td>
<td>24.00±0.00</td>
<td>1.00±0.00</td>
<td>1.00±0.00</td>
<td>Nil</td>
</tr>
<tr>
<td>0.05</td>
<td>3.75±0.25</td>
<td>16.25±0.61</td>
<td>20.00±0.41</td>
<td>5.00±0.41</td>
<td>3.50±0.50</td>
<td>1.50±0.64</td>
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<tr>
<td>0.025</td>
<td>3.00±0.41</td>
<td>12.50±0.50</td>
<td>15.50±0.28</td>
<td>9.50±0.28</td>
<td>5.00±0.41</td>
<td>4.50±0.29</td>
</tr>
<tr>
<td>0.01</td>
<td>2.25±0.25</td>
<td>9.00±0.41</td>
<td>11.25±0.25</td>
<td>13.75±0.25</td>
<td>5.00±0.41</td>
<td>8.75±0.48</td>
</tr>
<tr>
<td>0.005</td>
<td>1.25±0.25</td>
<td>6.75±0.25</td>
<td>8.00±0.41</td>
<td>17.00±0.41</td>
<td>4.50±0.28</td>
<td>12.50±0.64</td>
</tr>
<tr>
<td>0.0025</td>
<td>0.75±0.25</td>
<td>5.00±0.41</td>
<td>5.75±0.47</td>
<td>19.25±0.47</td>
<td>3.50±0.28</td>
<td>15.75±0.63</td>
</tr>
<tr>
<td>Control (acetone)</td>
<td>1.25±0.25</td>
<td>0.25±0.25</td>
<td>1.50±0.28</td>
<td>23.50±0.28</td>
<td>0.50±0.28</td>
<td>23.00±0.58</td>
</tr>
<tr>
<td>Untreated</td>
<td>0.25±0.25</td>
<td>0.25±0.25</td>
<td>0.50±0.28</td>
<td>24.50±0.28</td>
<td>0.00±0.00</td>
<td>24.50±0.29</td>
</tr>
</tbody>
</table>

Note: 100 insects treated in 4 replicates of 25 each.
Table 2. Showing fecundity and hatchability of female emerged from the treated 5th instar nymphs of *Dysdercus koenigii* with Andalin.

<table>
<thead>
<tr>
<th>Concentration (%)</th>
<th>Number of eggs laid (Mean±SE)</th>
<th>Number of eggs hatched (Mean±SE)</th>
<th>% hatching</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.05</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.025</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.01</td>
<td>27.75±1.25</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.005</td>
<td>38.75±0.85</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.0025</td>
<td>47.75±1.70</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Control (acetone)</td>
<td>132.25±0.85</td>
<td>127.50±2.50</td>
<td>96.41</td>
</tr>
<tr>
<td>Untreated</td>
<td>144.25±1.49</td>
<td>141.50±1.26</td>
<td>98.09</td>
</tr>
</tbody>
</table>
Fig 1. Showing % nymphal mortality at different concentrations of Andalin on the 5th instar nymphs of Dysdercus koenigii.

![Graph showing % nymphal mortality](image1)

y = 167.66x + 5.4542

R² = 0.9013

Fig 2. Showing % nymph-adult mortality at different concentrations of Andalin on the 5th instar nymphs of Dysdercus koenigii.

![Graph showing % nymph-adult mortality](image2)

y = 729.12x + 29.413

R² = 0.9053
Fig 3. Showing % total mortality before adult emergence at different concentrations of Andalin on the 5th instar nymphs of *Dysdercus koenigii*.

Fig 4. Showing % total adult emerged with Andalin treatment on the 5th instar nymphs of *Dysdercus koenigii*. 
Fig 5. Showing % total malformed adults with Andalin treatment on the 5th instar nymphs of *Dysdercus koenigii.*

\[ y = 793.11x + 25.161 \]
\[ R^2 = 0.9563 \]

Fig 6. Showing % mortality during nymphal-adult moult with Andalin treatment at different concentrations on 5th instar nymphs of *Dysdercus koenigii.*
(B). *Spodoptera litura:*

**Normal life cycle:** The pest breeds throughout the year, although its development is considerably retarded during extreme temperatures. Moths are active at night, they mate and female lays about 300-400 eggs in clusters. Eggs are spherical, somewhat flattened, 0.6 mm in diameter and light green in color. The clusters of eggs are covered with hair scales. The eggs hatch in about 3-5 days. The larvae feed gregariously for the first few days and then disperse to feed individually. The larvae attain 35-45 mm in length and are hairless, blackish-grey in color with dark and light longitudinal bands and semi-lunar spots on the dorsal side. Fully grown 6th instar larvae dig into the moist sand and pupate. The pupal stage last for 7-12 days and the moths emerge to live for 7-10 days. Development is completed in 25-50 days and pest completes eight generations in a year. The eggs, different larval instars, pupation in sand, pupa and adult of *Spodoptera litura* are shown in Fig 29 (A-I).

(1) Toxicity of Andalin (Flucycloxuron)

1.1 Effects on survival rate and mortality:

The average number of larvae, pre-pupae and pupae died by the topical application at different concentrations of Andalin on the 6th instar larvae of *Spodoptera litura* is shown in Table 3. At highest concentration (0.1%) of Andalin, 14 % of the larvae died within 24
hours of the treatment and all the survived larvae died at pre-pupal stage which together comprises 100% mortality before pupa formation. On the other hand, the lower concentrations of Andalin i.e., 0.01%, 0.005% and 0.0025% gave only 6%, 4% and 3% larval mortality (Fig 26). The larval mortality at 0.005% Andalin coincides with the larval mortality of the control which is 4% whereas 1% larval mortality was recorded in untreated insects. The regression between concentration strength and percent larval mortality yields a positive linear correlation \( y = 107.58x + 4.215, R^2 = 0.917 \) (Fig 26).

The LC50 and LC90 values of Andalin against 6th instar larvae of Spodoptera litura were found to be 0.42% and 0.79% respectively (Table 3). There was 100% mortality with 0.1% and 0.05% Andalin treatment of the 6th instar larvae (Fig 28). Even the lower doses i.e., 0.005% and 0.0025% produced very high mortality rate upto pupal formation which is 94.79% and 93.87% as compared to control and untreated which have a mortality of 3.085% and 3% respectively. The concentration vs pre-pupal mortality shows a linear positive correlation \( y = 53.238x + 95.873, R^2 = 0.5692 \) (Fig 27). At higher concentrations of 0.1% and 0.05% no pupae were formed i.e., 100% mortality occurred before pupa formation and they either died at larval stage or at pre-pupal stage (Table 3).

It was recorded that at lower concentrations of Andalin, there is a decrease in the number of successful larvae-pupae transformation (Table 3). 0.025% Andalin produced only 1.10% apparently normal pupae and at lowest concentration i.e., 0.0025% Andalin 6.59% pupae formation occurred whereas the control and untreated insects produced 96.88% pupae and 96.97% pupae respectively. However, the pupae which were formed at lower concentrations i.e. 0.025%, 0.01%, 0.005% and 0.0025% failed to transform into adults and died in the pupal stage only, whereas, the pupae of the control and untreated larvae
moulted to normal adult and flourished successfully in maintained lab conditions (Fig 29, A-I).

1.2 Effects on moulting and metamorphosis:

The bar diagram (Fig 28) shows the mortality caused during moulting from larvae to pupae of *Spodoptera litura* by treatment with different concentrations of Andalin. The two higher concentrations (0.1% and 0.05%) of Andalin showed highest mortality which is 100% during larval-pupal moulting and the lower concentrations i.e. 0.01%, 0.005% and 0.0025% Andalin resulted in heavy mortality during larval-pupae moulting (Fig 28). The controlled and untreated larvae showed normal moulting during larval-pupal transformation and resulted into normal pupae. After 24 hours of Andalin treatment at varying concentrations (0.1%, 0.05%, 0.025%, 0.01%, 0.005% and 0.0025%), different mortality rate of the larvae occurred (Fig 30 A,B & C). The mortality rate of the 6th instars larvae treated with different concentrations of Andalin was found to be dose-dependent. Fig 31 (A & B) showed deformity during 6th instar larval-pupae moulting with 0.1% Andalin treatment and the resultant is the intermediate forms which includes individuals having larval characteristics more pronounced. The remaining concentrations of Andalin (0.05%, 0.025%, 0.01%, 0.005% and 0.0025%) showed morphogenic abnormalities and formed larval-pupae mosaics which are characterized by anterior larval portion and posterior (abdomen) pupal portion (Fig 32-34). The visible malformation of the treated larvae includes: head and thoracic legs with larval characteristics and untanned skin at the dorsal part and rest of the body was pupal with slightly or completely tanned ventral part of the body. Some other types of abnormalities
were also seen such as constriction on the first one or two segments of the abdomen (Fig 32-B); reduction in the thickness of the pupal cuticle which is formed at the posterior region (Fig 33-B). In lower concentrations of Andalin application, morphologically normal pupae formed but these pupae did not develop any adult characteristics and remained in the pupal stage whereas the pupae of normal and untreated larvae developed as adult with all the functional moth characters (Fig 29-1).

1.3 Effects on fecundity and hatchability:

At all the six concentrations viz. 0.1%, 0.05%, 0.025%, 0.01%, 0.005%, 0.0025% of Andalin, there were complete inhibition of adult emergence i.e., no adult emerged from the treated 6th instar larvae. The treated larvae died either at larval stage or at pre-pupal/pupal stages and showed 100% mortality before adult emergence. Since the moths did not emerged out from the pupae of the treated larvae, no mating occurred and that is why no fecundity recorded (Table 4). In case of control and untreated larvae, normal adult emergence occurred (Table 3) and the normal adults laid an average of 920.75±2.43 (control) and 977.5±1.93 (untreated) number of eggs which hatched out in 3-4 days. The percent hatching of the control and untreated females were found to be 97.91% and 98.44% respectively (Table 4).
1.4 The reproductive system of *Spodoptera litura*:

The reproductive system of female of the *Spodoptera litura* consists of a pair of ovaries, each ovary is composed of four separate egg-tubes or ovarioles which opens into lateral oviduct. Lateral oviduct join to form median oviduct which open posteriorly into a genital chamber, the genital chamber often developed to form bursa copulatrix for reception of the male genitalia. For storage of the sperms spermatheca is present along with accessory glands.

An ovariole in its epithelial sheath (ES) of *Spodoptera litura* is of meriostic-polytrophic type in which the ovarioles have trophocytes enclosed in the follicles with each oocyte (Oc). A single ovariole consists of the terminal filament, the germarium, the vitellarium and the pedicel containing a chain of developing ova which have defined spherical shape and are greenish in colour. The distal end of the germarium is occupied by the oogonia. An oogonium divides to produce an oocyte and a trophocyte and these two cells remain attached by a narrow cytoplasmic bridge. As each oocyte with its trophocytes leaves the germarium and occupy the vitellarium, the oocyte occupies a proximal position with respect to the base of the ovariole. The nurse cells (trophocytes) of the oocytes are well differentiated whereas the follicular cells covering the oocytes are columnar in shape. Intrafollicular tissue (IFT) is present between the oocytes. The normal (control) ovariole of *Spodoptera litura* showed oocyte enclosed in the follicular epithelium (FE). The ovariole of S. litura at 100X magnification is shown in Fig 35 (A&B). The follicular
epithelium of the oocytes changes to cuboidal in shape with the subsequent growth. In the proximal part of the vitellarium, there is an accumulation of the yolk in the oocytes while the nurse cells are declining and their cytoplasm is reduced to a thin film surrounding the depressed nuclei (Fig 35). The accumulated yolk in the oocyte can be shown in the normal ovariole of *Spodoptera litura*. The yolk deposited in the normal meristic-polytrophic ovariole is in the form of spheres and granules (Fig 36 A,B & C).
(2) Toxicity of *Triticum vulgaris* lectin (WGA):

Different concentrations of lectin viz 0.5%, 0.25% and 0.125% were topically tested on newly moulted larvae of *Spodoptera litura*. From the stock solution of 1% *Triticum vulgaris* lectin in deionized water, the above mentioned three concentrations were prepared in acetone. 2 µl of each concentrations were applied topically on the 6th instar larvae. Very low percentage of mortality of the treated larvae occurred just after treatment. However, there were no remarkable reduction observed in the larval growth and larval period. The 6th instar *Triticum vulgaris* lectin treated larvae fed voraciously on castor leaves for 2-3 days, the larvae moulted to pupae and the transformation of the larvae-pupae occurred normally as in control and untreated larvae-pupae moulting. Neither retardation in pupal growth nor prolongation of the pupal period was recorded. None of the lectin treated larvae died during pre-pupal stage. The normal pupae were formed and remained in pupal stage for 6-7 days, the longevity of the pupal period was equivalent as that in control and untreated and finally the pupae of the lectin treated larvae emerged out as normal adults. Topical treatment with different concentrations of lectin to 6th instar larvae did not influence reduction in adult emergence. No inhibition of the adult emergence occurred as wings, legs and other morphological structures showed normal characteristics by each treatment of *Triticum vulgaris* lectin with varying concentrations (0.5%, 0.25% and 0.0125%). The adult thus formed fed on honey solution and mated successfully. The ovaries of successfully emerged adults did not show any anatomical change by lectin treatment via topical application on the 6th instar larvae of *Spodoptera litura*. The number of eggs laid by the female of the treated larvae were
nearly equal to the number of eggs laid by females of control and untreated batches. The eggs hatched within 2-3 days and showed no deterioration. The F1 generation of the treated larvae survived and flourished successfully under maintained lab conditions. *Triticum vulgaris* lectin, a wheat germ agglutinin did not show any anti-nutritive, insecticidal and growth inhibitory activity when tested at different concentrations viz., 0.5%, 0.25% and 0.125% applied topically to last larval instar (6th) of *Spodoptera litura*. 
Table 3. Showing larval, pre-pupal and pupal mortality following the topical application of different concentrations of Andalin on freshly moulted (12-24 hours) 6th instar larvae of Spodoptera litura.

<table>
<thead>
<tr>
<th>Concentrations (%)</th>
<th>Larval mortality (Mean±SE)</th>
<th>Values of Le50 and Le90</th>
<th>Pre-pupal mortality (Mean±SE)</th>
<th>Pupae formed (Mean±SE)</th>
<th>Pupal mortality (Mean±SE)</th>
<th>Total number of adult emerged (Mean±SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>3.50 ± 0.29</td>
<td></td>
<td>21.5 ± 0.29</td>
<td>Nil</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.05</td>
<td>2.75 ± 0.25</td>
<td>0.42% and 0.79%</td>
<td>22.25 ± 0.25</td>
<td>Nil</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.025</td>
<td>2.00 ± 0.41</td>
<td></td>
<td>22.75 ± 0.25</td>
<td>0.25 ± 0.25</td>
<td>0.25 ± 0.25</td>
<td>-</td>
</tr>
<tr>
<td>0.01</td>
<td>1.50 ± 0.29</td>
<td></td>
<td>23.00 ± 0.41</td>
<td>0.50 ± 0.29</td>
<td>0.50 ± 0.29</td>
<td>-</td>
</tr>
<tr>
<td>0.005</td>
<td>1.00 ± 0.41</td>
<td></td>
<td>22.75 ± 0.48</td>
<td>1.25 ± 0.25</td>
<td>1.25 ± 0.25</td>
<td>-</td>
</tr>
<tr>
<td>0.0025</td>
<td>0.75 ± 0.48</td>
<td></td>
<td>22.75 ± 0.25</td>
<td>1.50 ± 0.29</td>
<td>1.50 ± 0.29</td>
<td>-</td>
</tr>
<tr>
<td>Control (Acetone)</td>
<td>1.00 ± 0.41</td>
<td></td>
<td>0.75 ± 0.25</td>
<td>23.25 ± 0.25</td>
<td>0.50 ± 0.29</td>
<td>22.75 ± 0.48</td>
</tr>
<tr>
<td>Untreated</td>
<td>0.25 ± 0.25</td>
<td></td>
<td>0.75 ± 0.48</td>
<td>24.00 ± 0.41</td>
<td>0.25 ± 0.25</td>
<td>23.75 ± 0.48</td>
</tr>
</tbody>
</table>

Note: 100 insects treated in 4 replicates of 25 each.
Table 4. Showing fecundity and hatchability of female adult emerged from the treated 6th instar larvae of *Spodoptera litura* with Andalin.

<table>
<thead>
<tr>
<th>Concentration (%)</th>
<th>Number of eggs laid (Mean±SE)</th>
<th>Number of eggs hatched (Mean±SE)</th>
<th>% hatching</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.05</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.025</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.01</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.005</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>0.0025</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Control (acetone)</td>
<td>920.75±2.43</td>
<td>901.50±2.428</td>
<td>97.91</td>
</tr>
<tr>
<td>Untreated</td>
<td>977.5±1.93</td>
<td>962.25±2.87</td>
<td>98.44</td>
</tr>
</tbody>
</table>
Fig 26. Showing % larval mortality at different concentrations of Andalin on the 6\textsuperscript{th} instar larvae of \textit{Spodoptera litura}.

\begin{align*}
\text{Concentration (\%)} & \\
% \text{larval mortality} & \\
\end{align*}

\begin{align*}
y = 107.58x + 4.2152 \\
R^2 = 0.9172
\end{align*}

Fig 27. Showing % pre-pupal mortality at different concentrations of Andalin on the 6\textsuperscript{th} instar larvae of \textit{Spodoptera litura}.

\begin{align*}
\text{Concentration (\%)} & \\
\% \text{pre-pupal mortality} & \\
\end{align*}

\begin{align*}
y = 53.238x + 95.873 \\
R^2 = 0.5692
\end{align*}
Fig 28. Showing % mortality during larval-pupal moult with Andalin treatment at different concentrations on 6th instar larvae of *Spodoptera litura*.