**5** Egyptian J. Desert Res., 75, No. 1, 91-110 (2025)

# LATENT EFFECTS OF CERTAIN PLANT EXTRACTS AND PYRIPROXYFEN ON PUPAL, ADULT STAGES AND NEXT GENERATION OF BLACK CUTWORM

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To control the black cutworm (BCW), *Agrotis ipsilon* (Hufnagel) with eco-friendly pesticides, the latent effects of certain plant extracts (PEs) (Camphor, Sea ambrosia, and Thorn apple) and pyriproxyfen were studied on pupae, adults and the next generation that resulted from 3rd larval instar that was treated with $LC_{50}$ values under laboratory conditions. The results suggested that all the investigated compounds decreased pupation% in comparison with control. The reduction % of pupation was 57.39, 44.98, 41.85 and 37.98% for pyriproxyfen, Damsissa, Datoora and Cafoor leaf extracts, respectively. Also, pupal duration was increased significantly by 23.33, 18.89, 12.66 and 12.16% for pyriproxyfen, Damsissa, Datoora and Cafoor, respectively. While pupal weight was reduced by 44.11, 36.22, 27.90 and 20.66% for pyriproxyfen, Damsissa, Datoora and Cafoor, respectively. The reductions in adult emergence were 59.41 (pyriproxyfen), 24.38 (Damsissa), 19.72 (Datoora) and 13.94% (Cafoor). The fecundity, fertility and sterility index of adult females and males resulting from treated larvae showed better effects for all treatments: sterility % was reached to 82.00, 69.78, 49.00 and 29.78% for pyriproxyfen, Damsissa, Datoora and Cafoor, respectively. The male and female longevity (days) was also reduced than untreated control. Next generation stages were affected by all treatments and the general reduction of mortality % were 45.07 (pyriproxyfen), 21.90 (Damsissa), 13.99 (Datoora) and 9.46% from all stages. Generally, pyriproxyfen and plant extracts could be recommended as eco-friendly alternatives to conventional chemical insecticides for control of *A. ipsilon* insect pest.

**Key words:** *Agrotis ipsilon*, Camphor, Sea ambrosia, Thorn apple, IGR

# INTRODUCTION

One of the most important and abundant Noctuidae species in Egypt and other countries is the black cutworm (BCW), *Agrotis ipsilon* (Hufnagel) (Lepidoptera: Noctuidae). This insect pest was promoted as a harmful, destructive lepidopterous pest that attacks nearly every plant family, causing significant damage to plant seedlings and requiring the replanting of the damaged plants. The larvae of BCW were fed aboveground until about the fourth instar, but five and six larval instars were fed near the soil surface, cutting off young plants at the ground surface and sometimes pulling them underground. These larvae cut off the seedlings of any plants of either vegetables or crops 3-5 cm of soil surface, leading finally to duplicates of the costs (Sallam, 2008; Dahi et al., 2009; Ibrahim and Gabr, 2020 and Nasr et al., 2021).

Chemical pesticides certainly have a significant impact on crop output by minimizing pest damage, but they also create a serious risk to human health. They have become known for causing deadly illnesses like cancer and fetal defects. They also don't biodegrade, so they can linger in the environment for years. A better method of managing agricultural pests is necessary because chemical pesticides have adverse impacts on agricultural soils, water sources, human health, and the environment. Biopesticides derived from natural resources are surely more efficient than traditional synthetic/chemical pesticides because they are environmentally friendly, and their use in the agricultural sector as a defense against invasive and infecting pests could significantly enhance agricultural results (Khursheed et al., 2022 and Akbar et al., 2024).

Alternative management tactics have been developed by researchers due to the prohibitive expense of synthetic pesticides and the possibility of insecticide resistance developing in target pests. Plant-based pesticides are a good replacement for chemical pesticides because they are biodegradable and less harmful to organisms besides the target species (Ebeid et al., 2017) and the adverse effects on natural enemies (Abdel-Baset et al., 2023) and also on honey bees (Vattikonda and Sangam, 2017; Abdel-Kader, 2021 and Abdel-Kader et al., 2021). One strategy that lessens the various issues associated with synthetic pesticides is the use of botanical extracts (Nasr et al., 2021). According to Khursheed et al. (2022), plants are the primary source of bioactive natural compounds and offer substantial substitutes for the chemical and synthetic pest-control chemicals currently in use. Since a variety of bioactive substances (chemicals) found in plant extracts (PEs) are readily usable, environmentally benign, non-toxic, and low in toxicity to the environment (Rajendran and Sriranjini, 2008; EL-Kholy et al., 2014; Shaurub et al., 2022 and Farouk et al., 2023). Also, using plant extracts of pesticidal plants is more environmentally friendly and suitable for developing smallholder farmers in developing nations. It has also been noted that using pesticidal plants can successfully control insect pests and be incorporated into sustainable agricultural practices (Seni et al., 2025).

Pyriproxyfen is a powerful JHA that alters the hormone balance of several vital processes in insects and has a strong effect on the adult stage, such as embryogenesis, metamorphosis (Barbosa et al., 2018 and Maharajan et al., 2018) and adult reduce the fecundity and viability of eggs and oviposition of insects (Aribi et al., 2006; Ohba et al., 2013; Singh and Kumar 2015 and Meng et al., 2018).

Based on the previous reports by researchers, we evaluated the latent effects of three plant extracts (Camphor, Sea ambrosia, and Thorn apple) and pyriproxyfen (when treated the third larval instar of *Agrotis ipsilon*) on pupal and adult stages and their effects on the next generation under laboratory conditions.

## MATERIALS AND METHODS

### 1. Rearing Technique of The Black Cutworm *Agrotis ipsilon*

The eggs of the BCW were obtained from the Department of Economic Entomology and Pesticides, Faculty of Agriculture, Cairo University without exposure to any pesticides for several generations. The rearing technique was performed according to Abdin (1979). The larvae were fed on fresh young castor bean leaves (*Ricinus communis* L.) from the farm and area of Faculty of Agriculture (Cairo), Al-Azhar University. The larvae were reared in glass jars (1 L) and provided with sawdust to absorb the humidity and replaced every day (Abdel-Rahim, 2002 and EL-Hosary et al., 2013) with some modifications. In the laboratory at 25±2°C and 65±5% R.H. and a 12hr. photoperiod, the larvae were observed daily until the third instar; then the larvae were reared separately in plastic cups (5 cm in diameter and 5 cm in height with sawdust on the bottom and covered with tissue, to avoid crowding and cannibalism until pupation (Gesraha et al., 2018). The larvae were treated with the tested materials at the $3^{rd}$ instar for 24 h and fed on untreated leaves until pupation. The pupae were kept from each treatment in plastic jars (1 L) until the emergence of moths. The emerged moths were fed on a 10% sucrose solution according to Shaurub et al. (2018).

### 2. The Tested Materials

Three plant extracts, namely *Eucalyptus globulus* L. (Camphor), *Ambrosia maritima* L. (Sea ambrosia), and *Datura stramonium* L. (Thorn apple or Worm wood) were collected from the farm and area of the Faculty of Agriculture (Cairo), Al-Azhar University and identified in the Department of Agricultural Botany in the same faculty. The IGR pyriproxyfen ($C_{20}H_{19}NO_3$, Admafin 10% E.C.) was obtained from Kanza Group Co. for Chemicals and Pesticides.

**3. Extraction of Tested Plants**

Samples from three local plant species belonging to different families were used for extraction processes according to EL-Torkey (2008). The young fresh leaves were cleaned from any dust and/or debris by sterilized distilled water (SDW) (three times) and then dried with tissues under room temperature. The leaves were dried at room temperature for 7 days, then grounded individually in mill, then immersed in 95% ethanol for seven days, during which time the soaked leaves were shacked for an hour each day with an electric shaker. Filter paper Whatman's No.1 and the anhydrous $Na_2SO_4$ were used to filter the PEs. A rotary evaporator and hot water bath were used to evaporate the solvent under vacuum, and it was then stored in a refrigerator at -4°C for further studies. The crude extract yields of different treatments were 80.52, 111.64 and 94.4 g $Kg^{-1}$ leaves of Cafoor, Damsissa and Datoora, respectively.

**4. Toxicity and Determination the $LC_{50}$ Value**

To evaluate the possible toxicity of these PEs in comparison with pyriproxyfen, the $LC_{50}$ value was calculated after 72 h from treatments (Finney, 1971). Different concentrations (from each treatment) were used to calculate the $LC_{50}$ values. Larval mortality was noted and if the larva did not react to touch stimulation, it was regarded as dead (Osman and Mahmoud, 2009). The mortality % corrected by Abbott's formula (Abbott, 1925).

To calculate the $LC_{50}$ values, we used serial concentration of different materials. pyriproxyfen was the most efficient ($LC_{50}$ = 275.40 ppm) as compared with Damsissa leaf extract (DAMLE), Cafoor leaf extract (CAFLE) and Datoora leaf extract (DATLE). The $LC_{50}$ values were 3850.36, 4230.15 and 4375.22 ppm for DAMLE, CAFLE and DATLE, respectively.

**5. Effect of Treatments on Biological Parameters**

The castor bean leaves were dipped in an $LC_{50}$ concentration of the tested materials for 15 seconds and then fed to newly molted 3$^{rd}$ larval instar for 24 hours. After that, they were fed untreated leaves until they pupated. The following parameters were recorded at the pupal and adult stages and next generation.

**5.1. Effect on pupal stage**

The pupation %, the pupal weight (24 h old), pupal duration (days) from the start of pupation to the emergence of adult moths and pupal mortality % were recorded. All results were recorded at the end of pupal stage except pupation % was recorded at the start.

Pupation % = (Number of pupae /Total number of larvae) × 100

Reduction of pupation % and pupal weight was calculated by C-T / C ×100

Increase % of pupal duration was calculated by T-C / T×100

Where:

C = untreated control

T = treatment

**5.2. Effect on adult stage**

The adult emergence %, reproduction parameters (fecundity and fertility), sterility index % and longevity of adults were calculated.

Adult emergence % = (No. of moths / Total no. of larvae) X100

The fertility egg or hatchability was calculated using the following equation:

Egg hatchability % = A / B × 100

Where:

A = total number. of hatched eggs

B = total number of eggs laid

The sterility index % was recorded by the following equation:

Sterility Index % = 100 – [(a × b / A × B) × 100] according to Toppozada et al. (1966).

Where:

a = No. of eggs laid female$^{-1}$ in the treatment

b = percent of hatchability in the treatment

A= No. of eggs laid female$^{-1}$ in the untreated control

B= Percent of hatchability in the untreated control

**5.3. Effect on next generation**

The effects of treatments on the next generation (resulting from treated 3$^{rd}$ larval instar in the previous generation) were recorded as the latent effects of these treatments and the mortality % of larval, pupal and adult stages was recorded. The experiment was started with 100 larvae of *Agrotis ipsilon* that resulted from the previous generation and the mortality % was corrected according to Abbott's formula (Abbott, 1925).

**6. Statistical Analysis**

The results were analyzed using one-way ANOVA through the SAS (2004) program and significant difference between treatments were calculated by using Duncan's Multiple Range Test (Duncan,1955) at *P=0.05*.

## RESULTS

The data obtained from Table (1) show the effect of different treatments on the pupal stage of BCW at the $LC_{50}$ values. In general, all the tested materials significantly increased the pupal stage in comparison with the control; where pyriproxyfen was the most effective on pupation% followed by Damsissa leaf extract (DAMLE), Datoora leaf extract (DATLE), and Cafoor leaf extract (CAFLE), respectively. The corresponding reduction percentages recorded 57.39, 44.98, 41.85 and 37.98% for pyriproxyfen, DAMLE, DATLE, and CAFLE, respectively in comparison with untreated treatment. Pyriproxyfen was the most effective, increasing the pupal duration and significantly (*P=0.05*) giving a higher effect than other treatments followed by DATLE, CAFLE and DAMLE, respectively. The increase in pupal duration (days) reached 23.33, 18.89, 12.66 and 12.16% for pyriproxyfen, DAMLE, DATLE and CAFLE, respectively. On the other

**Table (1).** Effect of treatments on pupation %, pupal duration, pupal weight and pupal mortality % of black cutworm *Agrotis ipsilon* under laboratory conditions.

| Treatments | Pupated larvae resulted from treated larvae at 3rd larval instar of BCW | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Pupation % | | Pupal duration | | Pupal weight | | Pupal mortality % | |
| | % | Reduction % | Days ± S.E | Increase % | (mg pupa$^{-1}$) ± S.E. | Reduction % | % | Corrected Pupal mortality |
| Untreated | 95.55 | 00.00 | 13.87 ± 0.85 $^{c}$ | 00.00 | 408.60 ± 30.41 $^{a}$ | 00.00 | 01.00 | 00.00 |
| Cafoor leaf extract | 59.26 | 37.98 | 15.79 ± 1.11 $^{b}$ | 12.16 | 324.20 ± 26.66 $^{b}$ | 20.66 | 8.40 | 07.78 |
| Damsissa leaf extract | 52.57 | 44.98 | 17.10 ± 1.67 $^{ab}$ | 18.89 | 260.60 ± 20.05 $^{d}$ | 36.22 | 9.20 | 08.00 |
| Datoora leaf extract | 55.56 | 41.85 | 15.88 ± 1.00 $^{b}$ | 12.66 | 294. 60 ± 18.61 $^{c}$ | 27.90 | 8.60 | 08.63 |
| Pyriproxyfen | 40.71 | 57.39 | 18.09 ± 1.02 $^{a}$ | 23.33 | 228.40 ± 10.71 $^{e}$ | 44.11 | 13.0 | 12.64 |
| L.S.D. 0.05 | -- | -- | **1.54** | -- | **29.5** | -- | -- | -- |

• S.E. = Standard error

• Mean values followed by different letters in the column are significantly different ($P \leq 0.05$)

hand, the data in Table (1) indicate that all the tested materials reduced significantly (*P=0.05*) pupal weight (mg pupa$^{-1}$) and pyriproxyfen was the most effective, followed by DAMLE, DATLE and CAFLE, respectively. The reduction in pupal weight was 44.11, 36.22, 27.90 and 20.66% for pyriproxyfen, DAMLE, DATLE and CAFLE, respectively. Concerning the pupal mortality%, it is seen that all treatments caused pupal mortality % and the values were 12.64, 8.63, 8.00 and 7.48% for pyriproxyfen, DATLE, DAMLE and CAFLE, respectively.

The results of the adult stage as affected by the plant extracts are given in Table (2). It is worth noting that all plant extracts negatively affected emergence, reproductive parameters and sterility percentage. The reductions in adult emergence recorded 59.71, 21.37, 24.04 and 13.94% for pyriproxyfen, DATLE, DAMLE and CAFLE, respectively. Also, the pyriproxyfen was more effective on emergence (*P=0.05*) and significantly more so than all plant extracts. Among plant extract treatments, DAMLE and DATLE were more effective than CAFLE and all treatments were higher than untreated control in reducing the emergence. Also, the treatments significantly (*P=0.05*) reduced the fecundity (No. of eggs female$^{-1}$) more than untreated treatment except for CAFLE, where the higher effect was observed with pyriproxyfen, DAMLE and DATLE, respectively. The reduction percentages in eggs female-1 were 62.10, 52.38, 31.10 and 14.73% for pyriproxyfen, DAMLE, DATLE and CAFLE, respectively. The hatchability percentage recorded 45.0, 60.0, 70.20 and 77.40% for Pyriproxyfen, DAMLE, DATLE and CAFLE, respectively. The corresponding reduction values of fertility were 52.13, 36.17, 25.32 and 17.66% for the abovementioned treatments. The pyriproxyfen caused sterility by 82.0 % followed by 69.78 % for DAMLE and 49.00% for DATLE and the least was CAFLE which recorded 29.78%. Finally, pyriproxyfen was significantly (*P=0.05*) more effective than other treatments.

The effect of treatments on longevity (days) are recorded in Table (3). The results indicated that all the tested materials decreased longevity of male and female (days) in comparison with untreated control. On the other hand, the effect of treatments on female longevity was more than on male longevity. Pyriproxyfen was the most effective in reducing the male longevity followed by DAMLE, DATLE and CAFLE, respectively. The reduction% was 43.72, 34.87, 28.70 and 17.98% for pyriproxyfen, DAMLE, DATLE and CAFLE, respectively. The same trend recorded on female longevity, where pyriproxyfen and DAMLE were the most effective followed by DATLE and the least was CAFLE compared with untreated control. The reduction% was 49.72, 42.70, 33.11 and 19.81% for pyriproxyfen, DAMLE, DATLE and CAFLE, respectively.

The next generation of *Agrotis ipsilon* insect pest as affected by pyriproxyfen, Damsissa, Datoora and Cafoor treatments is shown in Table

**Table (2).** Effect of treatments on adult emergence, reproductive parameters and sterility index % of back cutworm *Agrotis ipsilon* under laboratory conditions.

| Treatments | Adult emergence % ± S.E. | Reduction % | Reproductive parameters | | | | Sterility Index % ± S.E. |
|---|---|---|---|---|---|---|---|
| | | | Fecundity (No. of egg female)$^{-1}$ | | Fertility (hatchability %) | | |
| | | | No. of eggs ± S.E. | Reduction % | Hatchability % ± S.E. | Reduction % | |
| Untreated | 92.33 ± 3.94 $^{a}$ | 00.00 | 559.40 ± 85.12 $^{a}$ | 00.00 | 94.00 ± 3.32 $^{a}$ | 00.00 | 05.95 ± 1.67 $^{e}$ |
| Cafoor leaf extract | 79.46 ± 2.97 $^{b}$ | 13.94 | 477.00 ± 83.60 $^{a}$ | 14.73 | 77.40 ± 4.33 $^{b}$ | 17.66 | 29.78 ± 5.01 $^{d}$ |
| Damsissa leaf extract | 72.59 ± 4.80 $^{c}$ | 21.37 | 266.40 ± 65.76 $^{c}$ | 52.38 | 60.00 ± 3.16 $^{c}$ | 36.17 | 69.00 ± 11.06 $^{b}$ |
| Datoora leaf extract | 70.13 ± 5.45 $^{c}$ | 24.04 | 385.40 ± 60.93 $^{b}$ | 31.10 | 70.20 ± 6.83 $^{c}$ | 25.32 | 49.00 ± 7.80 $^{c}$ |
| Pyriproxyfen | 37.20 ± 3.54 $^{d}$ | 59.71 | 212.00 ± 21.50 $^{c}$ | 62.10 | 45.00 ± 6.52 $^{b}$ | 52.13 | 82.00 ± 5.70 $^{a}$ |
| L.S.D. 0.05 | **05.60** | -- | **83.00** | **--** | **10.01** | **--** | **9.3** |

• S.E. = Standard error
• Mean values followed by different letters in the column are significantly different ($P \leq 0.05$)

(4). Data clearly indicated that all treatments recorded affects at different stages in larval, pupal and adult stages. Among different treatments, the highest effect was observed with pyriproxyfen as compared with untreated control and plant extract treatments. Among plant extracts, Damsissa exhibited more superiority than Datoora and Cafoor plant extracts. The larval mortality % was 17, 13, 8 and 6% in comparison with untreated control for pyriproxyfen, DAMLE, DATLE and CAFLE, respectively. On pupal stage, pyriproxyfen gave 19.39 followed by DAMLE (10.20) followed by DATLE (6.12) and CAFLE (5.10%) pupal mortality. The adult mortality was 15.15, 7.07, 6.06 and 5.05 % for Pyriproxyfen, DATLE, DAMLE and CAFLE, respectively. They observed that the accumulative mortality during the next generation were 45.07, 21.90, 13.99 and 9.46% for pyriproxyfen, DAMLE, DATLE and CAFLE, respectively.

**Table (3).** Effect of treatments on adult males and females longevity of black cutworm *Agrotis ipsilon* under laboratory conditions.

| Treatments | Male longevity (days) | | Female longevity (days) | |
|---|---|---|---|---|
| | Days ± S.E | Reduction % | Days ± S.E | Reduction % |
| Untreated | 14.57 ± 0.76 [a] | 00.00 | 17.82 ± 0.60 [a] | 00.00 |
| Cafoor leaf extract | 11.95 ±1.30 [b] | 17.98 | 14.29 ± 1.02 [b] | 19.81 |
| Damsissa leaf extract | 09.49 ±0.80 [c] | 34.87 | 10.21 ± 1.40 [d] | 42.70 |
| Datoora leaf extract | 10.38 ±1.10 [c] | 28.76 | 11.92 ± 0.60 [c] | 33.11 |
| Pyriproxyfen | 08.20 ±0.30 [d] | 43.72 | 08.96 ± 1.10 [d] | 49.72 |
| L.S.D. 0.05 | 01.20 | -- | 01.30 | -- |

• S.E. = Standard error
• Mean values followed by different letters in the column are significantly different (*P≤0.05*)

## DISCUSSION

To reduce the environmental hazard effects of chemical pesticides, our research focused on eco-friendly alternative materials such as pyriproxyfen as an IGR and three plant extracts. Our finding is in harmony with the results recorded by Akbar et al. (2024), where the comparison between plant extracts and pesticides was extensively researched in order to decrease the use of synthetic pesticides, increase their toxicity, improve environmental safety, and reduce pesticide resistance and found that all life stages of insect pests are poisoned by leaf extracts. This is consistent with our results in this study.

Our study found that in the pupal stage, pyriproxyfen was the most effective in reducing pupation%, followed by DAMLE, DATLE, and CAFLE. Also, pyriproxyfen increased pupal duration and pupal mortality, but significantly reduced pupal weight. The most effective was pyriproxyfen,

**Table (4).** Effect of treatments on different stages of the next generation resulted from treated 3rd larval instar in the previous generation under laboratory conditions.

| Treatments | Larval stage | | Pupal stage | | Adult stage | | Accumulative mortality % | | General Reduction |
|---|---|---|---|---|---|---|---|---|---|
| | Larval mortality% | Corrected larval mortality% | Pupal mortality % | Corrected Pupal mortality% | Adult mortality % | Corrected adult mortality% | Total mortality % | Corrected total mortality% | |
| Untreated | 03.00 | 00.00 | 02.00 | 00.00 | 01.00 | 00.00 | 06.00 | 00.00 | 00.00 |
| Cafoor leaf extract | 06.00 | 3.09 | 07.00 | 05.10 | 07.00 | 05.05 | 20.00 | 14.89 | 09.46 |
| Damsissa leaf extract | 13.00 | 10.31 | 12.00 | 10.20 | 06.00 | 06.06 | 31.00 | 26.59 | 21.90 |
| Datoora leaf extract | 08.00 | 05.16 | 08.00 | 06.12 | 08.00 | 07.07 | 24.00 | 19.15 | 13.99 |
| Pyriproxyfen | 17.00 | 14.43 | 21.00 | 19.39 | 16.00 | 15.15 | 54.00 | 51.07 | 45.07 |

then other (PEs). While, Damsissa was more effective than Datoora and Cafoor leaf extracts. A similar trend was observed by Sallam (2008) when used bran bait on 4th and 6th of *A. ipsilon* larval instar. El-Hosary et al. (2013) found that PEs achieved a significant increase in pupal longevity of *A. ipsilon* 4th larval instar and reduced the pupal weight, besides the pupation %. In another study, EL-Kholy et al. (2014) reported that PEs caused increased pupal durations and pupal mortality, whereas pupal weight and adult emergence were decreased and they found that variation between PEs tested in the results on larvae of *S. littoralis*. The same results were supported by Shaurub et al. (2018) found that the IGRS (chlorfluazuron and flufenoxuron) enhanced the larval and pupal duration and reduced pupation %. Bakr et al. (2021) mentioned that pyriproxyfen caused pupal duration to be prolonged and suppressed pupation % when treated larvae of *A. ipsilon* at 4th and 5th instars. A similar trend of results was observed by Amein and Mohammad (2022) found that pyriproxyfen increased the larval and pupal durations, whereas significantly decreased the pupation % and adult emergence. Kokila and Jeyabalan (2023) demonstrated that pupal duration also extended after the treatment of *A. ipsilon* insect with *C. winterianus* than *A. citradera* plant extract. To explain the above results, Alhuraysi et al. (2021) suggested that IGRs and compounds extracted from plants that were tested to control insects could alter specific physiological processes like the neuroendocrine system, the endocrine control of insect growth, or the production of certain hormones. It also showed that the pupal period is when the most significant hormonal changes are occurring in holometabolous insects. In addition, these outcomes could be the consequence of our medication inhibiting the action of digestive enzymes, which agrees with Jagajothi et al. (2024). According to their findings, the application of andrographolide has a significant impact on the mortality and transformation of Diamondback Moth (*Plutella xylostella*) larvae and pupae, affecting their adult development and leading to morphological defects. Because the treatment significantly decreased the activity of digestive enzymes compared to the control, they hypothesized that the administration of the plant extract from *A. paniculata* would have inhibited *P. xylostella* typical pupal-to-adult transition. Additionally, the phytotoxic effects of the extract from *A. paniculata* were found to affect metabolism.

Our results showed the effect of treatments on adult stage (emergence, fecundity, fertility and sterility %). The IGR pyriproxyfen was significantly the most effective on emergence, fecundity, fertility, sterility and PEs were differed in these results. We noticed that DAMLE and DATLE were more effective than CAFLE in emergence. Also, DAMLE is more effective on fecundity, followed by DATLE and CAFLE, respectively. Also, the hatchability % was different between these treatments and also the sterility %. Many researchers recorded the effect of IGRs and PEs on the adult stage of the *A. ipsilon* insect pest in previous researches. Lafont et al.

(2005) mentioned that, in lepidopterans, moths supply growing embryos and pre-hatching larvae with a high concentration of ecdysteroids in their eggs. Dhadialla et al. (2005) demonstrated that treatment with flufenoxuron causes interference with the ecdysteroid hormone, which may lead to abnormal oocyte growth, egg formation and embryogenesis, which may lead to a loss of progeny. Sallam (2008) mentioned that a significant reduction in female fecundity was brought about by feeding (on toxic baits) $4^{th}$ and $6^{th}$ larval instar of *A. ipsilon* on rice bran bait containing *M. indica* dry leaves and gave a strong and significant reduction. She added that feeding on 4th larval instar by wheat and rice bran baits induced earlier oviposition and caused lower fecundity to the emerged mated female moths. A higher reduction in female fecundity was caused by feeding $4^{th}$ larval instar on wheat and rice bran baits treated with 5% and 10% *M. indica* leaf powder and also reduced female fecundity. El-Shershaby (2010) noticed that *Capparis aegyptia* plant leaves caused a malformation percentage of emerged adults and also caused a reduction in fecundity (eggs female$^{-1}$). Abdel-Aal (2012) reported that the sterilization of either sperm and / or eggs may be the cause of the decrease in hatchability %. El-Kholy et al. (2014) found that PEs caused a reduction in adult emergence and in reproductivity parameters (fecundity and fertility), while they increased the sterility % on *S. littoralis* insect pest. They found that DAMLE was a more pronounced toxic followed by DATLE and CAFLE, respectively. El-Sappagh (2015) observed that flufenoxuron caused the embryo components to separate and the eggs to be missing a solid chorion. Hexaflumuron caused undifferentiated tissue to be apparent. Also, when applied to eggs of *A. ipsilon* between 24 and 48 hours, lufenuron had the least effect, whereas a low of embryonic growth occurred. Abdel-Hakim et al. (2016) found that methoprene (Juvenile hormone) caused different abnormal histological structures of the mid-gut to be noticed, such as destruction of the gut epithelium and its separation from the basement membrane. Taha and Al-Hadek (2017) found that the IGRs (chlorfluazuron and diflubenzuron) induced morphological abnormalities in all stages of *A. ipsilon* and also decreased fecundity and fertility. Similar results were found by Karimzadeh and Rabiei (2020); they indicated that the efficacy of extracts from different parts of Jonsonweed (*Datura stramonium* L.) as larvicides and oviposition deterrents against *P. xylostella* (diamondback moth) was found that the flower extract exhibited a potent larvicidal activity with a 63% mortality rate against *P. xylostella* larvae.

The result found in this investigation is somewhat in conformity with the findings of Shaurub et al. (2018) demonstrated that the two CSI (Chitin Synthesis Inhibitors) chlorfluazuron and flufenoxuron caused declined in emergence and adult longevity, fecundity and fertility compared with the untreated control and also, decreased the total protein, total carbohydrates and total lipids content in ovaries. They concluded that both compounds overlap with vitellogenesis of *A. ipsilon*. By affecting the growth and reproductive ability of insect species, they may be reducing their population size. In another experiment, Amein and Mohammad (2022) mentioned that flufenoxuron at $LC_{50}$ value decline the adult emergence, adult longevity, fecundity and fertility. Also, they found many histological aberrations to the ovary of adult female moths. Kokila and Jeyapalan (2023) found that *Cymbopogan winterianus* and *Aloysia citrodora* leaves extracts significantly reduced the fecundity and they concluded that *Cymbopogan winterianus* leaves extract was more toxic and effective than *Aloysia citrodora* extracts on *A. ipsilon* insect pest.

Amein and Mahammad (2022) found that the compound's interference with oogenesis may be the cause of the reduction of the reproductive ability of mated moths that emerge from larvae treated with flufenoxuron as the second instar of *A. ipsilon* at the $LC_{50}$ value. Bakr et al. (2021) reported that it may be important that adult emergence is an essential process in the insect life cycle. The adult emergence was partially blocked in no certain trend of treatment of $4^{th}$ instar larvae, but in a dose-dependent course of treatments, $5^{th}$ larval instar with pyriproxyfen. The same trend was observed with methoxyfenozide and novaluron.

The result also demonstrated that the effect of treatment on the longevity of adult moths of this insect, all treatments decreased the male longevity compared with untreated control. Pyriproxyfen was the most effective in reducing the male longevity and significantly more so than other PEs. DAMLE was toxic and reduced this result, followed by DATLE and CAFLE, respectively. Also, pyriproxyfen and DAMLE were more effective than DATLE and CAFLE, where all treatments reduced female longevity. The previous results by authors recorded this trend El-Shershaby (2010) mentioned that extracts from *C. aegyptia* plant leaves caused a malformation percentage of emerged adults and also a reduction in fecundity when treated $4^{th}$ larval instar of the black cutworm *A. ipsilon*. El-Hosary et al. (2013) indicated that PEs caused a reduction in adult longevity and also, an increase in secretion in both glucosidase and trehalase enzymes and a decrease in the secretion of AchE (acetylcholine esterase) in $4^{th}$ larval instar of *A. ipsilon*. Bakr et al. (2021) referred that pyriproxyfen, methoxyfenozide or novaluron led to a general shortening of total adult longevity. As mentioned by Akbar et al. (2024), insects' high mortality rates may be caused by plant extracts interfering with their main metabolic, behavioral, biochemical and physiological components and by damaging their nerve cells.

A decline in the mean of adult emergence, longevity, fecundity and fertility was found by usage of chlorfluazuron and flufenoxuron (Shaurub et al., 2018) and both compounds significantly decreased total content of protein, total carbohydrates and lipids in the ovaries and both compounds overlap with vitellogenesis of *A. ipsilon*. So, they could be suppressing the population size of this insect species by affecting its development and reproductive ability. Amein and Mohammad (2022) found that flufenoxuron was declining adult emergence and adult longevity. They found many histological aberrations in the ovary of *A. ipsilon* female moth.

Various stages of the black cutworm, *A. ipsilon*, such as eggs, larvae, pupae, and adults, were affected by treatment with pyriproxyfen and three PEs. These results may be due to our treatment inhibiting digestive enzyme activity, which is consistent with Jagajothi et al. (2024). According to their findings, the application of andrographolide has a significant impact on the mortality and transformation of Diamondback Moth (*Plutella xylostella*) larvae and pupae, affecting their adult development and leading to morphological abnormalities. It is a labdane diterpenoid that was extracted from *Andrographis paniculata*'s stem and leaves. Andrographolide is an extremely bitter substance. They proposed that the application of the plant extract from *A. paniculata* may have prevented the normal pupal-to-adult transition of *P. xylostella*, as the treatment dramatically reduced the activity of digestive enzymes in comparison to the control. It was also discovered that the phytotoxic effects of *A. paniculata* extract had an impact on metabolism, as previously mentioned.

The effect of treatments on the next generation (resulted from treated larvae at the $3^{rd}$ larval instar) showed that these treatments may have given latent effects. Pyriproxyfen was the most effective, followed by DAMLE, DATLE and CAFLE, respectively. Where, PEs has insecticidal activity against the black cutworm (BCW) and inhibits detoxification enzyme activity and increase CAT and lipid peroxidase activity (Moustafa et al., 2021). That may aid in the development of *A. ipsilon* control measures based on natural products that are less damaging to the local ecosystems (Shaurub et al., 2022). Therefore, pyriproxyfen and PEs could be recommended as an eco-friendly alternative to systemic insecticides for the IPM program to control *A. ipsilon* insect pest and *S. littoralis* (Basu and Maddheshiya, 2023). This study has shown that pyriproxyfen and low-cost plant extracts from common plants can be used as affordable alternatives to synthetic insecticides for plant protection.

## CONCLUSION

Generally, from the results, it was observed that all PEs from original plants and IGR (pyriproxyfen) were possibly used as alternative to conventional chemical insecticides. The finding found that DAMLE, DATLE and CAFLE have insecticidal activity against *A. ipsilon* insect pest. The processes underlying these benefits could be investigated further, focusing on the chemicals found in the plant extract. Additionally, assessing the broader ecological impact and potential applicability in integrated pest management strategies would be valuable for optimizing the utilization in sustainable pest control practices.

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# التأثيرات المتأخرة لبعض المستخلصات النباتية ومركب البيريبروكسفين على العذارى والحشرة الكاملة والجيل التالى للدودة القارضة

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لمكافحة الدودة القارضة *Agrotis ipsilon* باستخدام مبيدات حشرية صديقة للبيئة، تم دراسة التأثيرات المتأخرة لبعض المستخلصات النباتية (الكافور، الدمسيسة والداتورة) بالإضافة لمركب البيريبروكسفين على كل من العذارى، الحشرة الكاملة والجيل التالى الناتج عن العمر اليرقى الثالث الذى تم معاملته سابقاً بقيم الـ $LC_{50}$ معملياً بتلك المواد تحت الاختبار. أشارت النتائج إلى أن جميع المواد المختبرة قد أدت الى خفض فى نسب التعذير مقارنة بالمجموعة غير المعاملة. بلغت نسبة انخفاض التعذير ٥٧,٣٩٪، ٤٤,٩٨٪، ٤١,٨٥٪ و٣٧,٩٨٪ لمركب البيريبروكسيفين ولمستخلصات أوراق الدامسيسة، الداتورة والكافور، على التوالي. كما زادت مدة التعذير بشكل ملحوظ بنسبة ٢٣,٣٣٪، ١٨,٨٩٪، ١٢,٦٦٪ و١٢,١٦٪ لمركب البيريبروكسيفين ولمستخلصات أوراق الدامسيسة، الداتورة والكافور، على التوالي. بينما انخفض وزن العذراى بنسبة ٤٤,١١٪، ٣٦,٢٢٪، ٢٧,٩٠٪ و٢٠,٦٦٪ لمركب البيريبروكسيفين ولمستخلصات أوراق الدامسيسة، الداتورة والكافور، على التوالي. بلغ الانخفاض فى نسبة خروج الحشرة الكاملة ٥٩,٤١٪ للبيريبروكسيفين و٢٤,٣٨٪ للدامسيسة، ١٩,٧٢٪ للداتورة و١٣,٩٤٪ للكافور. أظهرت مؤشرات الخصوبة والعقم لفراشات الإناث والذكور الناتجة عن اليرقات المعالمة نتائج أفضل لجميع المعاملات؛ حيث بلغت نسب العقم ٨٢٪، ٦٩٪ ،٦٩,٤٩٪ و٢٩,٧٨٪ للبيريبروكسيفين والدامسيسا والداتورة والكافور، على التوالي. كما انخفض أيضًا متوسط عمر الذكور والإناث. بلغ الانخفاض فى نسبة الموت العامة فى جميع المراحل معاً ٤٥,٠٧٪ (بيريبروكسيفين)، و٢١,٩٠٪ (دامسيسة)، و١٣,٩٩٪ (داتورة)، و٩,٤٦٪ (الكافور). بشكل عام يُمكن التوصية باستخدام مركب البيريبروكسيفين ومستخلصات النباتات المستخدمة فى الدراسة كبدائل صديقة للبيئة لمبيدات الحشرات الكيميائية التقليدية لمكافحة الدودة القارضة.