



Evaluate the Effects of Potential Botanical and Conventional Insecticides on the Reproductive and Developmental Aspects of the Pest *Agrotis Ipsilion* (*Lepidoptera: Noctuidae*)

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Authors' contributions

This work was carried out in collaboration between both authors. Authors MAG and ARE were suggested the research idea, designed the experiments, collecting data field, statistically analyzed the data, wrote the manuscript, reviewed data, manages tables, edited and approved the manuscript.

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ABSTRACT

Background: *Agrotis ipsilon* (Hüfn.), is known as a hazardous destructive pest for corn, *Zea mays* (L.) in Egypt, where it negatively affects corn yield production. Using insecticides continuously were sharply affected the progress of pest development in the field. The frequent uses of chemical pesticides to protect field crops leads to the development of insecticide-resistant strains.

Aim: Evaluate the insecticidal effect of four plant extracts with insecticidal properties and a chemical insecticide to control *A. ipsilon* using biological parameters and fertility life table. Also, to estimate the effects of these insecticidal materials on population growth, developmental progress, and nutritional indices and hence make recommendation of the type of insecticides to be used in Integrated Pest Management Programs.

Methodology: 1- Tested materials: (1) chemical insecticide (Chlorfenapyr at 0.5% concentration). (2) Four plant extracts (petroleum ether extracts of both *Melia azedarach* and *Vinca rosea*, and alcohol & hexane extracts of *Conyza aegyptiaca*) at 5% concentration each.

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- 2- Tested insect: *Agrotis ipsilon* (the egg stage and the 4th larval instar).
 3- Bioassay: Eggs and larvae were treated with tested materials separately, then different biological parameters were calculated.
 4- Life table parameters: Life table parameters were calculate using the "Age-stage, two-sex life tables" computer program.

Results: The obtained data revealed that petroleum ether extracts of *V. rosea* and *M. azedarach* were the best antifeedant agents against the 4th larval instar of *A. ipsilon*. The female longevity was significantly shortened under the effect of both treatments of *M. azedarach* and Challenger insecticide. All tested materials reflected an effective decline in the female ability for laying eggs, where this effect was obvious in the case of *M. azedarach* and Challenger insecticide treatments. It was found that the Melia treatment prolonged the incubation and developmental periods for the immature stages leading to a reduction of some life table parameters of *A. ipsilon* and also increase the generation mean time.

Conclusion: The resultant data obtained in this work may help in the usage of plant extracts in the advancement of IPM programs for the greasy cutworm, (*Agrotis ipsilon*) in Egypt.

Keywords: Greasy cutworm; *Agrotis ipsilon*; plant extracts; insecticidal agents; nutritional indices; antifeedant; life table parameters.

ABBREVIATIONS

CI	: Consumption Index
AD	: Approximate Digestability
ECl	: The efficiency of Conversion of Ingested Food
ECD	: The efficiency of Conversion of Digested Food
r^m	: The intrinsic rate of increase
R_0	: Net Reproductive Rate
T_c	: Mean generation time
λ	: Finite rate of increase
IPM	: Integrated Pest Management

1. INTRODUCTION

The greasy cutworm, *Agrotis ipsilon* (Hüfn), is known as a hazardous destructive pest for corn, *Zea mays* (L.) in Egypt, where it negatively affects corn yield production. Using insecticides continuously were sharply affected the progress of pest development in the field [1]. The frequent uses of chemical pesticides to protect field crops were raises up the negative aspect, such as the development of insecticide-resistant strains [2].

Therefore, great attention was paid to find safer alternative methods instead of chemical insecticides used to control such pests [3]. Among such alternatives is the utilization of plant extracts which have considerable effects on several pests and also, because it has low mammalian toxicity and little environmental pollutions [4]. Many investigators studied the effect of different plant extracts on some biological aspects and population consideration dynamics of *A. ipsilon* to exploit as methods of pest population suppression [5,6].

Estimation of life table parameters (LTP) for corn pests populations [as the intrinsic rate (r^m), the

net reproduction rate (R_0), and the mean-time of generation (T_c)], probably describe the mass population. It was the main method to forecast the changes in the pest population dynamic [7].

This work was designed to evaluate the effect of some plant extracts with insecticidal properties and a chemical insecticide to control *A. ipsilon* in the field using biological parameters and fertility life table. Also, estimate the effect of these insecticidal materials on population growth of this pest, their developmental progress, and nutritional indices (NI) and hence find out which of them could be recommended to be used in IPM programs.

2. MATERIALS AND METHODS

2.1 Tested Control Agents

2.1.1 Challenger 36% SC

It is a commercial formulation of Chlorfenapyr pesticide, manufactured by BASF-The Chemical Company, New Jersey, USA. The recommended concentration (0.5%) with two drops of Tween-80 as a dispersant (after Gesraha et al. [8]).

2.1.2 Plant materials and preparation of extracts

The plant extracts used for biochemical determinations were petroleum ether extracts of *Melia azedarach*, *Vinca rosea*, and *Conyza aegyptiaca* (alcohol & hexane) extracts. Samples from two local plant species belonging to different families were collected from the Qaluibya Governorate fields to be used for extraction processes.

- Leaves from both Periwinkle, *V. rosea* (Apocynaceae), and Chinaberry, *M. azedarach* (Meliaceae) were dried at room temperatures and then milled into fine powdered, then extracted with petroleum ether solvent according to Freedman et al. [9].
- *Conyza aegyptiaca* (L.) (Order: Asterales; Family: Asteraceae) was collected from Sinai, Egypt. The whole plant was dried, finely powdered and successively extracted with two solvents (hexane and ethanol) until exhaustion. The concentration of 5% for all extracts was prepared by mixing 5 ml of the extract with 100ml water, then three drops of the emulsifier (Triton X-100) was added [10].

2.2 Treated Insect

The black cutworm, *Agrotis ipsilon* strain used in the present study was obtained from the permanent rearing laboratory at the National Research Centre, and reared under laboratory constant conditions at (25±2°C and 75±5% RH).

2.3 Bioassay and Technique of the Treatment

According to Ebeid et al. [10], the eggs were treated with the tested materials, kept separately in wide-opening plastic jars (1000 ml) fitted with filter paper until hatching. Percentage of hatchability was calculated.

Another newly hatched larvae were kept into jars and provided with clean castor bean leaves, *Ricinus communis* for larval feeding. When the larvae reached to 4th instar they reared individually in a separate plastic cup of (11x4cm) to avoid cannibalism then covered with muslin. Cups were divided into 5 groups (each group comprised of 30 replicates). Each of the first 5 groups of them was marked for one of the tested

material, while the 6th group was marked as a check (untreated control). Moreover, each cup was provided daily with a known weight of fresh castor bean leave disks treated with one of the aforementioned concentrations of each tested material [*M. azedarach* and *V. rosea* extracts, *Conyza* alcoholic and hexane extracts (5%), and Challenger insecticide (0.5%), and water only as a control] until pupation. The pupae were transferred into glass jars embedded with filter paper until adult emergence. Couples of female and male moths were kept in glass jars (9.5cm diameter, 15 cm height). Ten pairs of newly emerged moths, previously treated as larvae were fed on a 20% sucrose solution under the aforementioned constant conditions.

Egg hatchability percentage, larval duration, pupal duration, incubation periods, female longevity and number of laid eggs per female (F1), the weight gained of larvae (weight of larvae at the end of the experiment minus its weight at the beginning), faeces weight, eaten food and remaining food was calculated daily during the feeding period to estimate the life table, food indices, food consumption, and food utilization.

2.4 Calculation of Nutritional Indices (NI)

At the end of the experiment, all above-recoded weights were expressed as a percentage according to the equations summarized by Waldbauer [11] to calculate the following: Relative growth rate (RGR), Consumption index (CI), Approximate digestibility (AD), Efficiency of conversion of ingested food (ECI) and Efficiency of conversion of digested food (ECD).

The percent reduction was computed according to the equation summarized by Atay-Kadiri et al. [12]

$$\% \text{ Reduction} = (\text{control} - \text{treated}) * 100 / \text{control}$$

The following equation was used for calculating the antifeeding activity [13]

$$\% \text{ Antifeeding activity} = [1 - (\text{eaten treated disc} / \text{eaten untreated disc})] * 100$$

2.5 Life Table Parameters

Life table parameters, described by Chi and Su [7], were derived from the obtained data; net reproductive rate (R_0), finite rate of natural

increase (λ), generation time (T) and intrinsic rate of natural increase (r^m) for Black cutworm fed on each host plant was constructed.

2.6 Statistical Analysis

Corrected mortality was applying by Abbott's formula [14]. Data were subjected to ANOVA test throughout the SPSS computer program to discriminate differences between treatments. Differences between mean values were compared using Duncan's Multiple Range test [15]. The life table parameters were analyzed according to "Age-Stage, Two-Sex Life Tables" computer program [7].

3. RESULTS

3.1 Developmental Progress of *A. ipsilon* Treated with Different Tested Materials

Extracts of *M. azedarach*, *V. rosea*, *Conyza aegyptiaca* alcohol or hexane extracts, and Challenger insecticide were discussed under laboratory conditions comparing with the untreated control (check). All tested materials were negatively affected the developmental progress of *A. ipsilon*, especially on consuming, and utilizing food (Tables 1 and 2).

Data obtained under constant temperature and relative humidity in Table 1 concluded the effect of the insecticidal agents on the incubation periods where *M. azedarach* and Challenger insecticide induced significant prolongation that varied significantly with control ($F_{5,24}=23.660^{**}$, $P=0.000$).

In addition, all treatments were significantly varied with the check. Challenger was the most effective one, where it induced the least hatchability percentage, followed by *Conyza*-hexane extract ($F_{5,24}=89.820^{**}$, $P=0.000$).

As for larval duration, nearly the same trend was observed, where Challenger was the most effective one, while *M.azedarach* had insignificant variance with the check ($F_{5,24}=61.942^{**}$, $P=0.000$).

The pupal duration was significantly varied with the check in only the two extracts of *M.azedarach* and *V. rosea* which recorded more and less days, respectively, while the rest of tested materials had no variance with the check ($F_{5,24}=10.909^{**}$, $P=0.000$).

The percentage of pupation subsequently was affected too with treated materials, where all recorded percentages were less significantly than that in case of the check, except in the case of *Conyza*-hexane extract and; ($F_{5,24}=21.405^{**}$, $P=0.000$).

Female longevity was affected sharply in case of *M. azedarach* extract and Challenger insecticide, which reduced the longevity by about 50% compared with the check ($F_{5,24}=34.340^{**}$, $P=0.000$).

Finally, it was observed that the main biological aspects of *A. ipsilon* were affected by Challenger treatment at the 4th instar larvae, where the majority of larvae died during the moulting process, while a few number of individuals complete their development (Table 1). The fecundity and fertility of each resultant female were considerably varied significantly compared with the check, and among each other. The mean number of deposited eggs/ female varied significantly with the check in one side and between each other on the other side, except in the case of *M. azedarach* and Challenger ($F_{5,24}=82.705^{**}$, $P=0.000$)(Table 1).

3.1.1 Effect of five control agents on nutritional indices of *Agrotis ipsilon*

Table 2 showed the achieved data of *A. ipsilon* larvae that fed on castor bean leaves treated with the tested experimental agents as the following.

3.1.2 Consumption index (CI)

Values of (CI) were decreased significantly ($P<0.05$) when the larvae fed on castor bean leaves treated with all tested insecticidal agents especially *Conyza* extracts, followed by *M. azedarach* and then Challenger insecticide, compared with control ($F_{5,24}=36.201^{**}$, $P=0.000$).

3.1.3 Approximate digestibility (AD)

The calculated (AD) estimates that the efficiency of *A.ipsilon* larvae to digest then absorb of engulfed food was being significantly ($P>0.05$) decreased when the larvae were fed on castor leaves treated with the tested insecticidal resources, compared to the check. Where the highly significant decrease showed in the case of larvae fed on treated castor leaves with both extracts of *M. azedarach* and *Conyza*-alcohol ($F_{5,24}=51.137^{**}$, $P=0.000$).

Table 1. Developmental progress of *A. ipsilon* treated with different insecticidal agents under laboratory condition

Treatments	Incubation period (days)	Hatchability (%)	Larval duration (days)	Pupal duration (days)	Pupation (%)	Female longevity (days)	Egg/female (F1)
	Means ± SE						
<i>Melia azedarach</i>	4.90±0.19 a	86.50±0.27 b	30.50±0.67 a	13.41±0.10 a	25.60±0.20 e	6.71±0.22 d	116.00±1.60 e
<i>Vinca rosea</i>	3.49±0.09 cd	77.20±0.64 d	24.20±0.47 c	10.03±0.55 c	33.01±0.08 c	15.60±0.29 a	131.00±0.71 d
<i>Conyza-hexane</i>	3.80±0.05 bc	71.10±0.23 e	23.30±0.20 c	12.01±0.11 b	46.10±0.19 a	11.80±0.20 c	236.00±2.07 b
<i>Conyza-alcohol</i>	3.06±0.13 d	81.90±0.47 c	27.10±0.51 b	11.40±0.41 b	36.40±0.14 b	14.40±0.16 b	167.00±0.71 c
Challenger	4.21±0.07 b	60.80±0.31 f	17.90±0.44 d	11.60±0.32 b	32.50±0.22 d	7.30±0.26 d	115.00±1.14 e
Control	3.10±0.24 d	100.00±3.37 a	30.20±1.02 a	12.06±0.26 b	45.90±0.15 a	15.40±0.11 a	515.00±2.86 a
F_{5,24}-value	23.660**	89.820**	61.942**	10.929**	21.405**	34.340**	82.705**
P-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

** Highly Significant

Means in a column followed with a different letter(s) are significantly different

Table 2. Effects of five control agents applied at low concentrations on some nutritional indices of *A. ipsilon* 4th larval instar

Treatments	CI (%)	AD (%)	ECI (%)	ECD (%)	RGR (%)	Antifeedant (%)
	Means ± SE					
<i>Melia azedarach</i>	0.38±0.01 cd	77.30±0.32 d	33.61±0.05 a	43.48±0.61 a	0.13±0.003 b	33.70±0.30 b
<i>Vinca rosea</i>	0.71±0.01 b	83.90±0.54 b	13.17±0.19 d	15.64±0.17 d	0.09±0.005 c	55.67±2.28 a
<i>Conyza-hexane</i>	0.38±0.01 cd	80.00±0.76 c	09.90±0.05 f	12.38±0.16 e	0.04±0.013 d	27.11±1.03 c
<i>Conyza-alcohol</i>	0.30±0.02 d	77.39±1.49 d	11.44±0.17 e	16.57±0.10 cd	0.04±0.007 d	27.47±0.25 c
Challenger	0.50±0.04 c	80.39±0.75 c	19.50±0.31 b	28.03±0.56 b	0.10±0.013 bc	28.89±0.50 c
Control	0.99±0.09 a	91.50±0.42 a	16.11±0.53 c	17.62±0.28 c	0.16±0.014 a	0 d
F_{5,24}-value	36.201**	51.137**	102.113**	99.073**	21.511**	28.445**
P-value	0.000	0.000	0.000	0.000	0.000	0.000

** Highly Significant

Means in a column followed with a different letter(s) are significantly different

Table 3. Effects of tested control agents applied to *A. ipsilon* 4th larval instar on some Life Table parameters

Treatments	Life table parameters			
	R_0	r^m	λ	T_c
<i>Melia azedarach</i>	91.00±1.40c	0.076±0.0068bc	1.078±0.0069b	59.39±0.613a
<i>Vinca rosea</i>	108.65±0.76b	0.080±0.0071bc	1.080±0.0114b	56.81±0.506b
<i>Conyza</i> -hexane	48.31±0.37f	0.080±0.0447bc	1.085±0.0022b	54.09±0.606c
<i>Conyza</i> -alcohol	61.02±0.34d	0.060±0.0140c	1.072±0.0089b	59.27±0.336a
Challenger	55.33±0.17e	0.093±0.0049ab	1.090±0.0079b	42.97±0.406e
Control	544.70±0.59a	0.120±0.0141a	1.130±0.0095a	52.05±0.308d
F_{5,24}-value	71.298**	4.564**	6.352**	16.652**
P-value	0.000	0.005	0.001	0.000

** Highly Significant

Means in a column followed with a different letter(s) are significantly different

3.1.4 The efficiency of conversion of ingested food (ECI)

Estimated values of (ECI) that measures the overall ability of the insect to convert ingested food to body tissues (Table 2) was decreased significantly ($P<0.05$) as a result of all insecticidal agents, especially in case of *Conyza*-hexane (9.90%) treated leaves. While there was an exception in the case of larvae fed on leaves treated with both *M. azedarach* and Challenger insecticide, that gained more values over the control ($F_{5,24}=102.113^{**}$, $P=0.000$).

3.1.5 The efficiency of Conversion Digested food (ECD)

Likewise, the metabolic efficiency expressed to provide the body with required nutrients (ECD) (Table 2) decreased effectively due to the application of some tested extracts, *i.e.*, *V. rosae* and both extracts of *Conyza*, while the opposite tendency appeared in the case of *M. azedarach* and Challenger insecticides-treatment compared to the check ($F_{5,24}=99.073^{**}$, $P=0.000$).

3.1.6 Relative growth rate (RGR)

Data in Table 2 also indicated the effect of the tested control materials, which significantly decreased the growth rate of the 4th larval instar, that being significantly varied with the check. The most significant decline appeared on larvae fed on castor leaves treated with both *Conyza* extracts, followed by *V. rosae* then the Challenger insecticide as compared with the check ($F_{5,24}=21.511^{**}$, $P=0.000$).

3.1.7 Antifeedant effect (AFE)

Data in the Table 2 recorded that extracts of *V. rosea* and *M. azedarach* were the most excellent

AFE against *A. ipsilon* larvae, as they gave the maximum percentage of protection (the best repellent plants), respectively against the 4th larval instar of *A. ipsilon*. On the other hand, Challenger and alcoholic and hexane extract of *Conyza* showed lower antifeedant activities, being statistically varied with the check ($F_{5,24}=28.445^{**}$, $P=0.000$).

3.1.8 Life table parameters (LTP)

Data illustrated in Table 3 summarized the effects of tested insecticidal resources on LTP for *A. ipsilon*, where it was observed that (r^m), (R_0), and (λ) decreased significantly for insects exposed to tested insecticidal resources. In contrast, all agents significantly prolonged the mean generation time (T_c), while the insecticide Challenger treatment resulted in lower significant varied, compared with the control group treatment.

3.1.9 Values of R_0 , r^m , and λ

These values were clearly decreased; being significantly varied with the check (Table 3); especially in the case of both extract of *C. aegyptiaca* treatment followed by that of Challenger insecticide as compared with the control group.

The generation time (T_c) was elongated in all treatments; being significantly varied compared to the control ($F_{5,24}=16.652^{**}$, $P=0.000$) except in the case of Challenger treatment, which recorded shorter time compared to all other treatments (Table 3).

4. DISCUSSION

Our present study discussed the disturbance that happened to the *A. ipsilon* normal development

by the effects of some insecticidal materials, *i.e.*, [*M. azedarach*, *V. rosea* (petroleum ether extracts), *Conyza* (alcohol and hexane extracts) and Challenger insecticide]. Where, these agents resulted in prolongation of the larval phase, falling down the level of pupation and longevity. Also, the number of deposited eggs and hatchability of larvae that fed on castor leaves treated with these agents were significantly decreased especially under the effect of both *Conyza*-alcohol extract and Challenger treatments, these results were matched with the conclusion discussed by EL-Shall and Mohamed [16] on *A. ipsilon*.

Thus, after the application of all treatments, the fecundity was significantly decreased, due to the treatments effects on mating and oviposition behaviour. Similar studies have shown nearly the same findings [17,18]. Also, the inhibition of *A. ipsilon* population by the effect of the tested insecticidal agents were matched with that reported by some authors [19,20].

Our results also showed that *M. azedarach* treatment increases the time required for incubation, larval, and pupal durations as a result of diverted energy of the larvae due to the cessation of feeding and toxification. The previous conclusion matched with that previously discussed [19,21].

The present study recorded a significant decrease in all food utilization indices for *A. ipsilon* larvae treated with (petroleum ether extract of *M. azedarach*, *V. rosea*, alcohol, and hexane extract of *Conyza* and Challenger insecticide with respect to the check. All tested insecticidal agents caused significant reduction in (CI), (RGR), (AD), (ECI) and (ECD) except in case of ECI, ECD for larvae fed on leaves treated with *M. azedarach*. Such results are in accordance with many authors who used different plant extracts and botanical oils against different lepidopterous larvae. Ramachandran et al. [22] using azadirachtin against *Achaea janata* and *Spodoptera litura*. Sridhar and Chetty [23] using *Azadirachta indica* and *Pongamia glabra* extracts against *Euproctis fraternal*, and EL-Shall and Mohamed [16] using the barnof extract against 5th and 6th instar larvae of *A. ipsilon*.

Moreover, the antifeedant activity of the tested insecticidal agents was evaluated based on the feeding ratio of the treated and untreated leaf discs. Our results showed that petroleum ether extracts of *V. rosea* and *M. azedarach* were the

best antifeedant agents against *A. ipsilon*, as they were the most repellent plants, respectively against the 4th larval instar. These results were similar to those studied by some authors as [24] showed that the leaf extract of *M. azedarach* had a significant antifeedant effect on the larvae of *S. littoralis*. Atay-Kadiri et al. [12] tested the antifeedant effect of seed extract of *M. azedarach* against gypsy moth (*L. dispar*) larvae (second to fifth instars) fed with cork oak (*Quercus suber*) foliage. On the other hand, alcohol and hexane extract of *Conyza* showed lower insignificant antifeedant activities, where these results matched with [5] who evaluated the deterrent effect of whole plant petroleum ether extract of *Azadirachta indica* [neem], on the last instar larvae of *Spodoptera litura*, and indicating lack of antifeedant activity.

The Life Table Parameters data is known as an effective means for evaluating the effects of insecticides on target insects at the population level [25,26]. Consequently, the tested insecticidal agents resulted in reduction of some LTP values of *A. ipsilon*, *i.e.*, (r^m), (λ), and (R_0), which were significantly low compared to the check. The increase of (T_C) was the most useful test of reproductive potential for pest populations. Therefore, the outcome obtained may offer a progress for IPM strategies, that is because of the retardation in generation time may subjected the population to unexpected adverse environment.. These results were also in agreement with an earlier study carried out [27]. The implication of these results about the succession of plant extract should be considered in the development of future IPM programs for BCW control in Egypt.

5. CONCLUSION

The present study indicated that the biological activity of *A. ipsilon* fed on leaves treated with insecticidal agents was more remarkably affected. Consequently, a significant decrease in all food utilization indices for the larvae treated with petroleum ether extract of *M. azedarach*, *V. rosea*, alcoholic, and hexane extract of *Conyza* and Challenger compared to the check, except in case of ECI, ECD for *M. azedarach*. Moreover, our results showed that petroleum ether extracts of *V. rosea* and *M. azedarach* were the most repellent plants against the 4th larval instar of *A. ipsilon*. All the treatments resulted in a significant decrease in the total number of eggs laid especially that treated with *M. azedarach* and Challenger. Generally, these effects reflect the

reduction of some parameter's values for *A. epsilon* population. Also, an increase in (T_C), which is the most useful sign of the reproductive potential for insect populations was noticed. Consequently, results achieved from this study may assist in developing the progress of plant extracts as insecticidal materials in the of future IPM programs for *A. epsilon* control in Egypt.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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