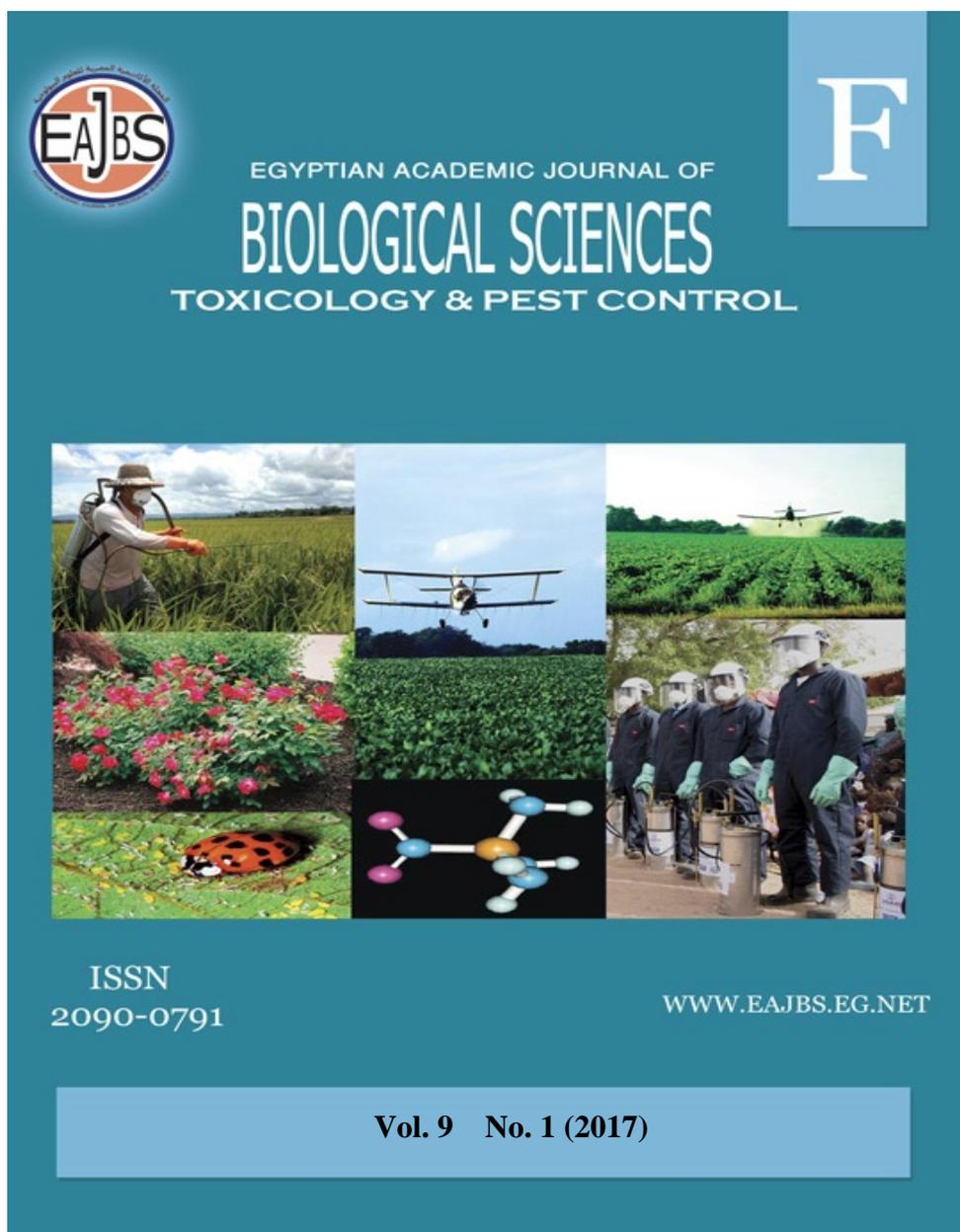


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Larvicidal and Antifeedant Activities of Different Extracts from Leaves and Stems of *Lantana camara* (Verbenaceae) Against the Housefly, *Musca domestica* L.

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ABSTRACT

The effect of ethanolic, acetone and petroleum ether extracts from leaves and stems of *Lantana camara* (Verbenaceae) on some biological aspects of the house fly, *Musca domestica* L were tested. All extracts showed moderate to high toxic effects on *M. domestica* larvae; however, the petroleum ether extract from leaves and stems were more toxic than acetone and ethanolic extracts. The effect of the extracts on the larval and pupal duration, pupal mortality, adult emergence (%) and growth index of *M. domestica* were determined. The antifeedant and repellent activities of the present plant extracts varied depending on solvent, plant parts used in extraction and the dose of extract. The petroleum ether extraction from leaves and stems of *L. camara* was more effective in exhibiting antifeedant and repellent activity against *M. domestica* as compared with the acetone and ethanol extractions. These results may provide an opportunity to develop alternatives to costly organic pesticides with some available cheap plants which are usually safe to the environment and to other living organisms.

INTRODUCTION

The housefly, *Musca domestica* is cosmopolitan, it makes up 98 percent of flies that invade homes and considered being one of the filthiest insect pests and it breeds in decaying organic matter and feeds in manure, garbage and food left out by humans (Ojianwuna *et al.*, 2011). The house fly is an important medical and veterinary insect pests that causes irritation, spoils food and acts as a vector for more than 100 human and animal pathogenic organisms such as enteropathogenic bacteria, enterovirus and protozoa cysts (Hanan, 2013; Morey and Khandagle, 2012). Unfortunately, housefly has developed resistance to most of chemical insecticides (Khan *et al.*, 2013). In addition, chemical insecticides have adverse effect on environment, health and threat of persistence the biomagnifications through the food chain (Kumar *et al.*, 2012). The application of several medicinal plants products has drawn much attention as effective alternatives to the synthetic pesticides, these plant products are reported to be more effective, less expensive, biodegradable and safe for mankind and environment than their synthetic counterparts (Marston and Hostettmann, 1985; Singh *et al.*, 1996).

Therefore, alternatives to conventional pesticides are required to be developed from the active ingredients of plant origin. These compounds have been shown to affect insect populations by reducing their developmental, survival and reproductive rate (Singh and Jain, 1987; Carlini and Grossi, 2002). Also, these compounds may serve as insecticides, antifeedants, repellents as well as attractants (Murugan *et al.*, 1996; Koul, 2005).

MATERIALS AND METHODS

Musca domestica culture.

The housefly, *Musca domestica* were reared and maintained continuously for several generations in an insectary using the standard procedures described by (Busvine, 1962).

Collection and extraction of plant materials.

Freshly leaves and stems of *Lantana camara* (Verbenaceae) were collected in the month of July 2015 from Sadat city. The leaves and stems were washed and dried in the shade at room temperature (27-31°C) for 7 days till they become brittle, then pulverized to powder in a hammer mill. The extraction was performed using 70% ethanol, acetone and petroleum ether solvents. One hundred grams of powder for each solvent separately were extracted five times with 300 ml of aqueous 70% ethanol, acetone and petroleum ether at room temperature. After 24 h., the supernatants were decanted, filtrated through Whatman filter paper No. 5 and dried in a rotary evaporator at 40°C for (2 -3) hours for ethanol and (40 - 60) minutes to other solvents. The dry extracts were kept in deep freezer (-4°C) till using for experiments (Shehata, 2014).

Larval treatment.

In order to study the toxicity of *L. camara* extracts, the tested material of the ethanolic extracts was dissolved in 0.1ml

of 70% ethanol, while the tested material of acetone and petroleum ether extracts was dissolved in 2 drop of Tween80 as emulsifier to facillate the dissolving of tested material in water. Larval artificial diet mixed with different ranges of concentrations instead of water of each concerned extract was prepared in order to detect mortalities. Then, twenty five of third 3rd instar larvae were put immediately into plastic cups contained media with different concentrations of extracts. Three replicates were usually used for each tested concentration. All plastic cups were incubated under controlled conditions at temperature of 27±2°C, relative humidity 70-75% and 12-12 light-dark regime. Control larvae received 0.1 ml of 70% ethanol or 2 drop of Tween80 in 100ml water. Mortality was recorded daily and dead larvae and pupae were removed until adult emergence. Larval mortality percent was estimated using the following equation (Briggs, 1960): larval mortality % = $A - B / A \times 100$ (where: A = number of tested larvae, B = number of tested pupa). Pupation rate was estimated using the following equation: Pupation % = $A / B \times 100$ (where: A = number of pupae, B = number of tested larvae). The pupal mortality percent was estimated using the following equation: Pupal mortality % = $A - B / A \times 100$ (where: A = number of produced pupae, B = number of observed adults). Adult emergence of males and females were counted and calculated using the following equation: Adult emergence % = $A / B \times 100$ (where: A = number of emerged adults, B = number of tested pupae).

Antifeedant and repellent activity.

Standard cages (20×20×20cm) were used to test the repellent activity of *L. camara* extracts. Cotton pieces soaked in 10% sucrose solution and different concentrations of plant extracts added to the wooden cages containing

certain number of starved individuals (5-7 d-old) for three hours. Control tests were carried out alongside with the treatments using cotton pieces soaked in 10% sucrose solution with 2 drops of 70% ethanol or Tween80. Each test was repeated three times to get a mean value of repellent. Repellency % was calculated according to Abbott, (1925): Repellency % = $[\% A - \% B / 100 - \% B] \times 100$ Where: A = percent of unfed females in treatment, B = percent of unfed females in control.

Statistical analysis.

Statistical analysis of the data was carried out according to the method of lentner *et al.*, (1982). LC50 was calculated using multiple linear regression (Finney, 1971).

RESULTS

Biological activity of plant extracts against the larval stage of *Musca domestica*.

Ethanollic extract of Leaves.

Data given in Table (1) indicated the biological activity of ethanollic extract of *L. camara* (Leaves) against the 3rd instar larvae of *M. domestica*. Complete larval mortality percent (100.0%) was caused at the highest concentration (2600ppm). Meanwhile, the larval mortality % decreased to (16.0%) at the lowest concentration (600ppm) compared to 12.0% for the untreated larvae. The larval duration was significantly ($P < 0.001$) prolonged by ethanollic extract of *L. camara* (Leaves), where the mean duration increased to record 4.5 ± 0.11 and 4.1 ± 0.14 days at the highest concentrations 2200 and 1800ppm; respectively compared to 2.3 ± 0.17 days for the untreated larvae.

Table 1: Effect of 70% ethanol of *Lantana camara* (leaves) on mortality percent, development and growth index of different stages of *Musca domestica*.

Conc. (ppm)	Larval mort. (%)	Mean Larval Period (days)±SD	Pupation (%)	Pupal Mort. (%)	Mean Pupal Period (days)±SD	Larval and Pupal Mort. (%)	Adult Emergence (%) (a)	Mean Development (days) ±SD (b)	Growth Index (a/b)
2600	100.0	---	---	---	---	---	---	---	----
2200	76.0	4.5 ± 0.11^d	24.0	17.0	3.8 ± 0.16^a	93.0	83.0	8.3 ± 0.27^d	10.0
1800	64.0	4.1 ± 0.14^d	36.0	22.4	3.8 ± 0.14^d	86.4	77.6	7.9 ± 0.28^c	9.8
1400	53.3	3.9 ± 0.13^d	46.7	16.8	3.9 ± 0.12^d	70.0	83.2	7.8 ± 0.25^b	10.7
1000	25.0	3.6 ± 0.14^d	75.0	11.1	3.9 ± 0.12^d	36.1	88.9	7.5 ± 0.26^a	11.9
600	16.0	3.1 ± 0.18^d	84.0	9.5	4.0 ± 0.10^c	25.5	90.5	7.1 ± 0.28^a	12.7
Control	12.0	2.3 ± 0.17	88.0	0.0	4.6 ± 0.12	12.0	100.0	6.9 ± 0.29	14.5

No. of tested larvae = 25; Conc. = Concentration; ppm = particle per million; SD = standard deviation; mort. = mortality; a = non-significant ($P > 0.05$); b = significant ($P < 0.05$); c = highly significant ($P < 0.01$); d = very highly significant ($P < 0.001$).

A negative correlation between the pupation % and the concentration was observed, where the pupation % was 0.0 at the highest concentration (2600ppm) and 84.0 at the lowest concentration (600ppm) compared to 88.0 for the untreated group. A toxic effect of ethanollic extract of *L. camara* (Leaves) on pupae resulted from treated larvae was observed. As shown from the

results, the pupal mortality percent was 17.0, 22.4, 16.8, 11.1 and 9.5% at the concentrations 2200, 1800, 1400, 1000 and 600ppm; respectively compared to 0.0% for the control group. The mean pupal duration was significantly ($P < 0.01$) affected by all concentrations as compared to the control group. The total larval and pupal mortality percent was 93.0, 86.4, 70.0, 36.1 and 25.5% at

2200, 1800, 1400, 1000 and 600ppm; respectively compared to 12.0% for the control group. A reduction in the adult emergence percent was observed. The lowest emergence percent was 77.6% at the concentration 1800ppm, while; the highest percent was 90.5% at the lowest concentration 600ppm compared to 100.0% for the control group. The growth index for larvae and pupae was affected by ethanolic extract of *L. camara* (Leaves), where it recorded 10.0, 9.8, 10.7, 11.9 and 12.7 at the concentrations 2200, 1800, 1400, 1000 and 600ppm; respectively compared to 14.5 for the control group.

Acetone extract of Leaves.

Results presented in Table (2) indicated that, the highest larval mortality (100.0%) was caused by the concentration (1600ppm) and the lowest mortality percent (22.8%) was caused by the lowest concentration (600ppm) compared to 16.0% for the untreated larvae. The larval treatment by acetone extract of *L. camara* (Leaves) at the concentrations: 1400 and 1200ppm shortened the larval duration promoting these larvae to develop in a faster rate than that of their control congeners (1.2 ± 0.30 and 1.6 ± 0.14 days; respectively vs. 2.09 ± 0.10 days).

Table 2: Effect of acetone extract of *Lantana camara* (leaves) on mortality percent, development and growth index of different stages of *Musca domestica*.

Conc. (ppm)	Larval mort. (%)	Mean Larval Period (days)±SD	Pupation (%)	Pupal Mort. (%)	Mean Pupal Period (days)±SD	Larval and Pupal Mort. (%)	Adult Emergence (%) (a)	Mean Development (days) ±SD (b)	rowth Index (a/b)
1600	100.0	---	---	---	---	---	---	---	----
1400	80.0	1.2 ± 0.30^c	20.0	41.0	3.9 ± 0.37^a	88.0	59.0	5.1 ± 0.67^a	11.6
1200	69.2	1.6 ± 0.14^a	30.8	25.0	4.4 ± 0.28^a	76.0	75.0	6.0 ± 0.42^a	12.5
1000	56.0	2.1 ± 0.22^a	44.0	18.0	4.1 ± 0.14^a	64.0	82.0	6.2 ± 0.36^a	13.2
800	36.0	2.6 ± 0.13^a	64.0	12.0	4.07 ± 0.16^a	44.0	88.0	6.7 ± 0.29^a	13.1
600	22.8	2.04 ± 0.19^a	77.2	10.0	4.6 ± 0.19^a	28.0	90.0	6.6 ± 0.38^a	13.6
Control	16.0	2.09 ± 0.10	84.0	9.5	4.0 ± 0.15	24.0	90.5	6.1 ± 0.25	14.8

Con., ppm, SD, mort., a and c see foot note of Table (1).

A reduction in pupation % was observed, where it recorded 20.0, 30.8, 44.0, 64.0 and 77.2% at the concentrations: 1400, 1200, 1000, 800 and 600ppm; respectively compared to 84.0% for the untreated group. The lethal effect of acetone extract of *L. camara* (Leaves) was extended to the pupal stage especially at the concentrations: 1400 and 1200ppm, where the pupal mortality percent was 41.0 and 25.0%; respectively, vs. 9.5% for the control. Results in Table (2) showed that, the mean pupal duration was insignificantly ($P > 0.05$) affected at all concentrations used. The total larval and pupal mortality percent was 88.0, 76.0, 64.0, 44.0 and 28.0% at 1400, 1200, 1000, 800 and 600ppm; respectively compared to 24.0% for the control group. As shown from the results in Table (2), a

remarkable reduction in the adult emergence percent was recorded especially at the concentrations (1400 and 1200ppm), where it recorded 59.0 and 75.0%; respectively compared to 90.5% for the untreated group. Results in Table (2) showed that, the growth index for larvae and pupae decreased to 11.6 at the concentration 1400 ppm. Meanwhile it increased to 13.1 and 13.6 at the lowest two concentrations (800 and 600ppm); respectively compared to 14.8 for the untreated group.

Petroleum ether extract of Leaves.

Data given in Table (3) indicated the biological activity of petroleum ether extract of *L. camara* (Leaves) against the 3rd instar larvae of *M. domestica*. The highest mortality percent (100.0%) was recorded at the concentration (1200ppm) and the lowest mortality

percent was (17.2%) at the lowest concentration (200ppm). Meanwhile, at the concentrations: 1000, 800, 600 and 400ppm the mortality percent was 89.2, 66.7, 48.0 and 28.0%; respectively compared to 9.3% for the control group.

Table 3: Effect of Petroleum ether extract of *Lantana camara* (leaves) on mortality percent, development and growth index of different stages of *Musca domestica*.

Conc. (ppm)	Larval mort. (%)	Mean Larval Period (days)±SD	Pupation (%)	Pupal Mort. (%)	Mean Pupal Period (days)±SD	Larval and Pupal Mort. (%)	Adult Emergence (%) (a)	Mean Development (days) ±SD (b)	Growth Index (a/b)
1200	100.0	----	---	---	---	---	---	----	---
1000	89.2	4.8±0.10 ^d	10.8	36.1	3.9±0.17 ^a	92.0	63.9	8.7±0.27 ^d	7.3
800	66.7	4.3±0.14 ^d	33.3	25.3	3.8±0.21 ^a	76.0	74.7	8.1±0.35 ^c	9.2
600	48.0	3.9±0.27 ^d	52.0	15.5	4.0±0.19 ^a	56.0	84.5	7.9±0.46 ^c	10.7
400	28.0	3.6±0.13 ^d	72.0	11.1	3.9±0.24 ^a	36.0	88.9	7.5±0.37 ^b	11.9
200	17.2	3.1±0.10 ^c	82.8	14.3	3.9±0.27 ^a	28.0	85.7	7.0±0.37 ^a	12.2
Control	9.3	2.5±0.18	90.7	13.2	4.0±0.14	21.3	86.8	6.5±0.32	13.4

Con., ppm, SD, mort., a, b, c and d see foot note of Table (1).

Petroleum ether extract of *L. camara* (Leaves) significantly ($P < 0.001$) prolonged the mean larval duration at all concentrations used compared to the control group. The pupation % of treated larvae decreased as the concentration increased, where it recorded 10.8, 33.3, 52.0, 72.0 and 82.8% at the concentrations: 1000, 800, 600, 400 and 200ppm; respectively, compared to 90.7% for the control group. It is cleared from Table (3) that the petroleum ether extract of *L. camara* (Leaves) had a toxic effect against the pupae resulted from the treated larvae especially at the highest concentration 1000ppm, where the pupal mortality percent was 36.1% compared to 13.2% for the control group. The mean pupal duration was insignificantly ($P > 0.05$) affected by all concentrations used as compared with the untreated group. The total larval and pupal mortality percent was 92.0, 76.0, 56.0, 36.0 and 28.0% at the concentrations: 1000, 800, 600, 400 and 200ppm; respectively compared to 21.3% for the untreated group. Results in Table (3) indicated that, the adult

emergence percent was not greatly affected by all concentrations used as compared with the untreated group. The growth index for *M. domestica* was reduced by petroleum ether extract of *L. camara* (Leaves) to 7.3, 9.2, 10.7, 11.9 and 12.2 at the concentrations: 1000, 800, 600, 400 and 200ppm; respectively compared to 13.4 for the control.

Ethanollic extract of Stems.

The biological activity of ethanolic extract of *L. camara* (stems) against the 3rd instar larvae of *M. domestica* is given in Table (4). Results presented in Table (4) indicated that, the highest larval mortality percent (100.0%) was occurred at the highest concentration (3500ppm), while the lowest mortality percent (17.2%) was occurred at the lowest concentration (1000ppm) compared to 12.0% for the control. The control larvae reached the pupal stage in a mean of 1.9±0.12 days, this duration prolonged to 2.1±0.12, 2.3±0.14, 2.6±0.11 and 3.1±0.10 days at the concentrations 2500, 2000, 1500 and 1000ppm; respectively.

Table 4: Effect of 70% ethanol extract of *Lantana camara* (stems) on mortality percent, development and growth index of different stages of *Musca domestica*.

Conc. (ppm)	Larval mort. (%)	Mean Larval Period (days)±SD	Pupation (%)	Pupal Mort. (%)	Mean Pupal Period (days)±SD	Larval and Pupal Mort. (%)	Adult Emergence (%) (a)	Mean Development (days) ±SD (b)	Growth Index (a/b)
3500	100.0	---	---	---	---	---	---	---	---
3000	72.0	1.5±0.13 ^b	28.0	29.0	4.1±0.15 ^d	80.0	71.0	5.6±0.28 ^c	12.7
2500	60.0	2.1±0.12 ^a	40.0	20.1	3.8±0.14 ^d	68.0	79.9	5.9±0.26 ^b	13.5
2000	48.0	2.3±0.14 ^b	52.0	15.5	4.5±0.13 ^a	56.0	84.5	6.8±0.27 ^a	12.4
1500	30.8	2.6±0.11 ^d	69.2	11.8	4.2±0.13 ^c	40.0	88.2	6.8±0.24 ^a	13.0
1000	17.2	3.1±0.10 ^d	82.8	9.5	3.9±0.12 ^d	23.3	90.5	7.0±0.22 ^a	12.9
Control	12.0	1.9±0.12	88.0	9.1	4.7±0.11	16.0	90.9	6.6±0.23	13.8

Con., ppm, SD, mort., a, b, c and d see foot note of Table (1).

The pupation percent decreased as the concentration level of ethanolic extract of *L. camara* (stems) increased. The pupation percent recorded 28.0 % at (3000ppm) and 82.8% at the lowest concentration (1000ppm) compared to 88.0% of the control. Data given in Table (4) revealed that, ethanolic extract of *L. camara* (stems) affect the pupae resulted from treated larvae especially at the highest concentrations (3000 and 2500ppm), where the pupal mortality recorded 29.0 and 20.1%, resp. as compared with 9.1% for untreated larvae. The mean duration of pupae resulted from treated larvae was significantly ($P<0.01$) affected at all used concentrations used except at the moderate concentration (2000ppm) which insignificantly ($P>0.05$) affect the pupal duration as compared with the untreated group. The adult emergence percent was not affected at all concentrations used by ethanolic extract of *L. camara* (stems) as compared with the control. The growth index for *M. domestica* was recorded 12.7, 13.5, 12.4, 13.0 and 12.9 at 3000, 2500, 2000, 1500 and 1000ppm; respectively, vs. 13.8 for the untreated group.

Acetone extract of Stems.

Data given in Table (5) indicate the biological activity of acetone extract of *L. camara* (stems) against the 3rd instar larvae of *M. domestica*. The highest larval mortality percent (100.0%) was

observed at the highest concentration (32500ppm), while the lowest one (24.0%) was observed at (200ppm). The mortality percent for the untreated group was 16.0%. As shown from the data in Table (5), the acetone extract of *L. camara* (stems) significantly ($P<0.001$) prolonged the larval duration as compared with the untreated group. Data presented in Table (5) revealed a remarkable reduction in the percentage of pupation rate at all concentrations used as compared with the control. The pupation % of the control group was 84.0%, decreased to 0.0, 16.0, 28.0, 46.7, 60.0 and 76.0% at 3200, 2600, 2000, 1400, 800 and 200ppm; respectively. It is cleared from Table (5) that, the acetone extract of *L. camara* (stems) had high toxic effect against the pupae resulted from the treated larvae especially at the highest concentrations (2600 and 2000 ppm), where the pupal mortality percent was 100.0 %; respectively compared to 0.0% at the control group. As shown from the data in Table (5) the acetone extract of *L. camara* (stems) significantly ($P<0.001$) shortened the pupal duration as compared with the untreated group. As shown from the results in Table (5), the total mortality of larvae and pupae were: 100.0, 100.0, 64.0, 48.0 and 32.0% at the concentrations 2600, 2000, 1400, 800 and 200 ppm; respectively compared to 16.0 for control group.

Table 5: Effect of acetone extract of *Lantana camara* (stems) on mortality percent, development and growth index of different stages of *Musca domestica*.

Conc. (ppm)	Larval mort. (%)	Mean Larval Period (days)±SD	Pupation (%)	Pupal Mort. (%)	Mean Pupal Period (days)±SD	Larval and Pupal Mort. (%)	Adult Emergence (%) (a)	Mean Development (days) ±SD (b)	Growth Index (a/b)
3200	100.0	----	----	----	----	---	----	----	----
2600	84.0	4.9±0.15 ^d	16.0	100.00	---	---	---	---	---
2000	72.0	4.5±0.10 ^d	28.0	100.00	---	---	---	---	---
1400	53.3	4.0±0.17 ^d	46.7	18.3	3.8±0.16 ^d	64.0	81.7	7.8±0.33 ^a	10.5
800	40.0	3.7±0.14 ^d	60.0	0.0	3.9±0.13 ^d	48.0	100.00	7.6±0.27 ^a	13.2
200	24.0	3.2±0.12 ^d	76.0	0.0	3.8±0.17 ^d	32.0	100.0	7.0±0.29 ^a	14.3
Control	16.0	1.9±0.18	84.0	0.0	5.2±0.12	16.0	100.0	7.1±0.30	14.1

Con., ppm, SD, mort., a and d see foot note of Table (1).

The adult emergence percent (100.0%) was recorded 81.7, 100.0 and 100.0% at the concentrations 1400, 800 and 200ppm; respectively compared to 100.0% for the untreated larvae. The growth index for larvae and pupae record 10.5, 13.2 and 14.3 at the concentrations 1400, 800 and 200ppm; respectively compared with 14.81 for untreated group.

Petroleum ether extract of Stems.

Data recorded in Table (6) indicate the biological activity of acetone extract of petroleum ether extract of *L. camara* (stems) against the 3rd instar larvae of *M. domestica*. Complete larval mortality

(100.0%) was occurred at the highest concentration (2000ppm), meanwhile the lowest value (18.7%) was occurred at the lowest concentration (500ppm) compared to 12.0% for the control group. As shown from the data in Table (6), the petroleum ether extract of *L. camara* (stems) significantly ($P < 0.001$) prolonged the larval duration as compared with the untreated group. The pupation % of the treated larvae with petroleum ether extract of *L. camara* (stems) decreased as the concentration increased.

Table 6: Effect of Petroleum ether extract of *Lantana camara* (stems) on mortality percent, development and growth index of different stages of *Musca domestica*.

Conc. (ppm)	Larval mort. (%)	Mean Larval Period (days)±SD	Pupation (%)	Pupal Mort. (%)	Mean Pupal Period (days)±SD	Larval and Pupal Mort. (%)	Adult Emergence (%) (a)	Mean Development (days) ±SD (b)	Growth Index (a/b)
2000	100.0	---	---	---	---	---	---	---	---
1700	80.0	4.9±0.17 ^d	20.0	7.2	3.9±0.11 ^d	87.2	92.8	8.8±0.28 ^d	10.5
1400	60.0	4.1±0.12 ^d	40.0	4.8	3.8±0.15 ^d	64.8	95.2	7.9±0.27 ^a	12.1
1100	44.0	3.6±0.11 ^d	56.0	0.0	3.9±0.13 ^d	44.0	100.0	7.5±0.24 ^a	13.3
800	24.0	3.2±0.13 ^d	76.0	0.0	3.9±0.10 ^d	24.0	100.0	7.1±0.23 ^a	14.1
500	18.7	3.1±0.11 ^d	81.3	0.0	4.0±0.11 ^d	18.7	100.0	7.1±0.22 ^a	14.1
Control	12.0	1.8±0.10	88.0	4.5	5.6±0.12	16.0	95.5	7.4±0.22	12.9

Con., ppm, SD, mort., a and d see foot note of Table (1).

At the highest and lowest concentration: 1700 and 500ppm the pupation percent was 20.0 and 81.3%; respectively vs. 88.0% for the untreated group. The pupal mortality percent was found to be not affected by petroleum ether extract of *L. camara* (stems) as compared with the control group. As regards to the pupal duration, Table (6) showed that, treatment of larvae with

petroleum ether extract of *L. camara* (stems) at all the concentrations shortened the duration promoting these pupae to develop in a faster rate than that of their control congeners. As shown from the data given in Table (6), the total mortality of larvae and pupae was approximately equal to the mortality of larvae because the petroleum ether extract of *L. camara* (stems) did not

cause pupal mortality among the pupae resulted from the treated larvae. The percentage of adult emergence from pupae resulted from treated larvae with the petroleum ether extract of *L. camara* (stems) did not greatly affect as compared with the untreated group. The growth index recorded 10.5, 12.1, 13.3, 14.1 and 14.1 at the concentrations (1700, 1400, 1100, 800 and 500ppm);

respectively vs. 12.9 for the untreated group.

From the aforementioned results it is obvious that the toxicity values of the tested ethanolic, acetone and petroleum ether extracts of different plant parts of *L. camara* based on LC_{50} values (Table 7) may be arranged in a descending order as follows: leaves > stems.

Table 7: Relative efficiency of 70%ethanol, acetone and petroleum ether extracts from *Lantana camara* (leaves and stems) against *Musca domestica* larvae.

Extract	Plant Part	LC_{50} (ppm)	Slope (b)	Correlation Coefficient (r)
70% Ethanol	Leaves	1462.6	0.0417	0.9798
	Stems	2101.8	0.0314	0.9803
Acetone	Leaves	959.3	0.0759	0.9934
	Stems	1215.2	0.0253	0.998
Petroleum ether	Leaves	607.3	0.088	0.9906
	Stems	1171.7	0.0562	0.9819

Antifeedant and repellency effects of tested plant extracts on *Musca domestica* adults.

The antifeedant or repellent activity of ethanolic, acetone and petroleum ether extracts of *L. camara* (leaves and stems) against starved *M. domestica* adults was varied according to the solvent used in extraction (Table 8). LC_{50} of the ethanolic,

acetone and petroleum ether extracts from *L. camara* (leaves) induced a degree of repellency equal to 50.8, 59.7 and 80.7%; while, the repellency was 41.4, 53.5 and 87.9% for the petroleum ether extract, while it recorded 41.4 and 53.5% for ethanolic, acetone and petroleum ether extracts from *L. camara* (stems); respectively, compared to 0.0% repellency for the control group.

Table 8: Effect of LC_{50} concentration from 70% Ethanol, Acetone and Petroleum ether extracts of *Lantana camara* (leaves and stems) as antifeedant or repellent for *Musca domestica*.

Extract	Plant Part	LC_{50} value (ppm)	No. of Fed flies	% of Fed flies	No. of Non-fed flies	% of Non-fed flies	Repellency action (%)
70% Ethanol	Leaves	1462.6	9.3 ± 1.24	46.7 ± 5.81	10.7 ± 1.23	53.3 ± 5.80	50.8
	Stems	2101.8	11.3 ± 1.20	56.7 ± 5.80	8.7 ± 1.21	43.3 ± 5.84	41.4
Acetone	Leaves	959.3	7.7 ± 1.52	38.3 ± 7.63	12.3 ± 1.52	61.7 ± 7.60	59.7
	Stems	1215.2	9.0 ± 1.11	45.0 ± 5.02	11.0 ± 1.21	55.0 ± 5.01	53.5
Petroleum Ether	Leaves	607.3	3.7 ± 1.53	18.3 ± 7.62	16.3 ± 1.50	81.7 ± 7.61	80.7
	Stems	1171.7	2.3 ± 1.20	11.7 ± 5.83	17.7 ± 1.22	88.3 ± 5.82	87.9
Control		0.0	19.0 ± 1.72	95.0 ± 8.70	1.0 ± 1.71	5.0 ± 8.72	0.0

No. of Tested individuals = 20; ppm: see the footnote of Table (1).

DISCUSSION

The accumulation and biomagnifications of synthetic compounds into different non-target organisms, including humans through food chain with increased risk of the development of diseases or disease syndromes has prompted to explore for relatively safer and more potential molecules for better insects-pests management (Begum *et al.*, 2011). Many institutions have been engaged with the search for some environmentally safe control agents in order to avoid the disadvantages and hazards of the synthetic insecticides; A great part of efforts have been achieved for the investigation and re-examination of plant sources to obtain natural compounds which may have toxic, repellent or antifeedant characteristics (Thomas and Callaghan, 1999). The plant tested in the present study is known to be eco-friendly and are not toxic to vertebrates. Moreover, it is clearly proved that crude or partially purified plant extracts are less expensive and highly efficacious for the control of *Musca domestica* rather than the purified compounds or extracts (Jang *et al.*, 2002; Cavalcanti *et al.*, 2004). The results of this study may offer an opportunity for developing alternatives to rather expensive and environmentally hazardous organic insecticides. In the present study, leaves and stems of *Lantana camara* (Verbenaceae) were extracted by 70% ethanol, acetone and petroleum ether for investigating their effect against the housefly *Musca domestica*.

The toxicity of the tested *L. camara* extracts against 3rd instar larvae of *M. domestica* was varied according to plant part, solvent used in extraction and concentration of the extract. The larval mortality percent was increased by increasing extract concentration for all plant extracts tested. Based on LC₅₀

values, the toxicity tested of ethanolic, acetone and petroleum ether extracts of leaves were most effective than those of stems. Also, the petroleum ether extracts were most effective than acetone and ethanolic extracts for both plant parts used. These results are in agreement with the previously mentioned suggestions of (Maurya *et al.*, 2009; Shehata, 2014). The effect of tested plant extracts on larval mortality of *M. domestica* is in consistent with the effect of other plant extracts evaluated by many authors on *M. domestica*. The obtained results agree with results obtained by Begum *et al.*, (2010) for the crude ethanolic leaves extracts of *Calotropis procera* and *Annona squamosa*. (The LC₅₀ values were 282.5 and 550ppm), Sinthusiri *et al.*, (2013) for essential oils from *Cinnamomum verum*, *Myristica fragrans* and *Syzygium aromaticum* against *M. domestica*, Pangnakorn and Kanlaya, (2014) for *Cymbopogon nardus*, *Azadirachta indica* and *Pachyrhizus erosus* against *M. domestica* larvae, Aktar and Islam, (2015) for whole-plant boiled extracts of three indigenous plant species *Calotropis procera*, *Piper longum* and *Polygonum hydropiper* against *M. domestica*, where the LC₅₀ values were 557.89, 981.02 and 773.27µL and Morey, (2016) for the crude extracts of *Citrus limon* and *Ocimum basilicum* against *M. domestica* with LC₅₀ (110ppm) shown by *O. basilicum*. Also, these results confirm those obtained by many authors for the larvicidal activity of plant extracts against several insect species, it is sufficient to look on the following few examples: Akpotu *et al.*, (2017) for the toxicity of the *Citrullus colocynthis* and *Citrullus vulgaris* seed oils on the larvae of *Dermestes maculatus* and Setiawan *et al.*, (2017) who studied the bioinsecticide effect of *Pinus merkusii* extract on *Aedes aegypti* larvae. where, the ethanol extract of

Pinus merkusii tree bark extract showed highest larval mortality against the larvae of *A. aegypti* with $LC_{50} = 96.3\text{ppm}$; $LC_{90} = 298.4\text{ppm}$ after 12h and $LC_{50} = 58.4\text{ppm}$; $LC_{90} = 125.7\text{ppm}$ after 24h.

Results of present study revealed that, treating *M. domestica* larvae with 70% ethanol, acetone and petroleum ether extracts of *L. camara* (leaves and stems) varied greatly with regard to larval and pupal duration, depending on plant part, solvent and concentration of the extract. Some plant extracts significantly shortened or prolonged the duration of larvae and resulted pupae. Meanwhile, others insignificantly affected the larval or pupal duration. In the present study, prolongation of the larval duration with tested plants was similar to that reported in *M. domestica* by Bakr *et al.*, (2003) using *Artemisia monosperma*, *Conyza dioscoridis*, *Clerodendron inerme*, *Clocasia antiqorum*, Abdel Kadder, (2005) using white and black mustard and Elkattan *et al.*, (2011) for *L. camara* and *Cupressus macrocarpa* (leaves) powders. Also, the shortened larval period after treatment was in accordance with Shaalan *et al.*, (2005) in *Aedes aegypti* larvae treated with *Callitris glaucophylla*. They mentioned that, the larvae observed to pupate faster as their environment increased in toxicity and Shehata, (2010) in *Culex pipiens* larvae treated with ethanolic, acetone, chloroform and petroleum ether extracts of *Cupressus sempervirens* and *Cestrum nocturnum*. Where, the tested extracts shortened larval duration. Also, the present results showed prolongation in the pupal duration. Similar observation was also recorded on *M. domestica* by Bakr *et al.*, (2003) using *Artemisia monosperma*, *Conyza dioscoridis*, *Eichhornia crassipes*, *Clerodendron inerme*, *Clocasia antiqorum*, and *Farestia aegyptia*. Similar observations were recorded by Shehata, (2010) using *C. sempervirens*

and *Ces. nocturnum* extracts against *C. pipiens*. However, on the contrary, other studies recorded that, other plants reduced pupal duration such those recorded by Bakr *et al.*, (2003) using *Zygophyllum coccineum* on *M. domestica* and El- Sheikh *et al.*, (2012) using methanolic extract of *Tribulus terrestris* on the malarial vector *Anopheles arabiensis*.

The pupation rate was varied according to plant part and solvent used in extraction. Moreover, the percent of pupation was decreased as the concentration of plant extract increased. Similar effects of some botanical plant extracts have been reported on *M. domestica* by Assar (2002 and 2003), Bakr *et al.*, (2003) and Elkattan *et al.*, (2011). Similar observation for reduction of pupation percentage were reported by Shehata, (2010) after treatment of 3rd larval instar of *C. pipiens* with *C. sempervirens* and *Ces. nocturnum* extracts. The decrease in the percentage of adult emergence of *M. domestica* due to treatment with the tested plant extracts was similar to data reported previously by plant extracts on other dipteran species. The total mean number of males and females of blowfly, *Chrysomya chloropyga* emerging from larvae feeding diet containing 5% of *L. camara* powder, were significantly less than those of the control (Muse *et al.*, 2003), High reduction in *Synthesiomyia nudiseta* adult emergence was induced by larval treatment with *C. macrocarpa* and *A. officinarum* volatile oils (Khalaf *et al.*, 2009). A reduction in *C. pipiens* adult emergence was achieved by larval treatment with *C. sempervirens* and *Ces. nocturnum* extracts (El- Sheikh *et al.*, 2011).

The growth index of *M. domestica* was clearly affected by the present plant extracts tested. It decreased as the concentration of the extract increased. Retardation in growth was induced by

different parts of many plant tested. Such results are in agreement with earlier studies using different plant extracts against other dipteran species by Nathan *et al.*, (2006) using *Melia azedarach* on *Anopheles stephensi*, Sharma *et al.*, (2006) using *Artemisia annua* extract against *Culex autnauetesctetus* and Shehata, (2010) using *C. sempervirens* and *Ces. nocturnum* extracts against *C. pipiens*.

The present results suggest that, the tested *L. camara* extracts displayed various degree of repellency at various concentrations against *M. domestica* and this may reflect the complexity of the chemical composition of their constituents. These results revealed that, the petroleum ether extraction was more effective in repellent action against *M. domestica* as compared with the acetone and ethanol extractions. These results are in consistence with the earlier results of Wimalaratne *at al.*, (1996) using *Schinus molle* on *M. domestica* and Bisseleua *et al.*, (2008) using petroleum ether extracts of *Griffonia simplicifolia* and *Zanthoxylum xanthoxyloides* against *M. domestica*.

CONCLUSION

Toxicity of *Lantana camara* extracts tested against the 3rd instar larvae of *Musca domestica* was varied according to plant part, solvent used in extraction and concentration of the extract. Based on LC50, the toxicity values of *L. camara* extracts were arranged as follows: leaves > stems. Extracts from *L. camara* leaves of all plants tested were effective in exhibiting the antifeedant and repellent actions against the housefly starved adults than those from stems. So, the plant extracts used may be considered as new promising controlling agents for the housefly, *M. domestica*.

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